Peoples Democratic Republic of Algeria
Ministry of Higher Education and Scientific Research

University Des Frères Mentouri - Constantine
Faculty of Letters and Languages
Department of Letters and English Language

The Impact of Language Aptitude, Working Memory and Verbal Reasoning as Aspects of Linguistic Intelligence on Language Learning Achievement

The Case of First Year Students at the Department of Letters and English language, University Des Frères Mentouri, Constantine

Thesis submitted to the department of Letters and English Language in candidacy for the degree of Doctorat LMD in Didactics of Foreign languages

Submitted by
Mrs. Lamia ELMECHTA

Supervised by
Pr. Hacène SAADI

Board of Examiners

Chairman: Pr. Samir LARABA	**University Des Frères Mentouri- Constantine**
Supervisor: Pr. Hacène SAADI	**University Des Frères Mentouri- Constantine**
Member: Pr. Abdelhak NEMOUCHI	**University Larbi Ben M'hidi- Oum El Bouaghi**
Member: Pr. Omar GHOUAR	**University Hadj Lakhdar- Batna**
Member:Dr. El Houas AHMED SID	**University Des Frères Mentouri- Constantine**
Member: Dr. Nadir KAOULI	**University Hadj Lakhdar- Batna**

2015-2016

DEDICATION

To my beloved mother and father for their never-ending love, care and support;

To my dearest husband for his constant assistance. Tank You Amar for being a source of inspiration;

To my brothers and sister;

To all my family;

To my in-laws;

To my friends and colleagues;

ACKNOWLEDGEMENTS

First and foremost, I would like to express my total gratitude to my supervisor Professor Hacéne SAADI for his precious advice, intellectual guidance, encouragement, and assistance. His motivational support pushed me forward to carry out the task despite its complexity. He was the person without whom the work would never be achieved.

I owe a special gratitude to the psychologists Jennifer MICHAUD and David CAPLAN for being kind enough to respond to my constant questions and for having provided me with software containing automated working memory tasks.

A special thank goes to the students who took part in this study. Thank you all for your patience and honesty to produce serious answers.

ABSTRACT

The present study addresses some cognitive aspects of individual differences that influence foreign language learning. The research attempts to investigate the relationship between one type of intelligence that is referred to as linguistic intelligence and language learning achievement. Since linguistic intelligence is just a theoretical concept, we felt the need to look for a set of cognitive abilities as its constituent factors. Language aptitude, working memory, and verbal reasoning were, thus, elected to be the main factors of linguistic intelligence and the major components of the test intended for that broad ability. Three measures of the three aforementioned capacities (working memory measure, language aptitude measure, and verbal reasoning measure) were, in effect, administered to a sample of seventy subjects from a population of 300 first-year students at the department of Letters and English, University Des Frères Mentouri, Constantine. Correlations were made between the obtained scores in these measures, and factor analysis was conducted to determine the final factors of Linguistic intelligence. The results confirm the existence of three factors, albeit with a precision in the designation of the hypothesized abilities. Grammatical ability is substituted for language aptitude, while working memory and verbal reasoning remain intact. On the basis of these findings, a further correlational study was conducted between the overall Linguistic intelligence score, as with the score of its final factors, and language learning achievement score. Again, the results prove a significant relationship between the overall Linguistic intelligence and language learning achievement. As for the relationship between this latter and the final factors of Linguistic intelligence, two factors reveal a significant moderate correlation (grammatical ability and verbal reasoning), while the third factor (working memory) indicate a weak association. The study would, hence, encourage the implementation of Linguistic intelligence test as the basis for selection in learning English as a foreign language.

LIST OF ABREVIATIONS

FL	foreign language
Gf	fluid intelligence
G factor	general factor
Gc	crystallized intelligence
IQ	intelligence quotient
K :m	spatial practical ability
LSPAN	listening span tasks
LTM	long term memory
LTS	long term store
MLAT	Modern Language Aptitude Test
OSPAN	operation span tasks
PLAB	Pimsleur Language Aptitude Battery
RSPAN	reading span tasks
SLA	second language acquisition
STM	short term memory
STS	short term store
V :ed	verbal educational ability
WM	working memory
WMC	working memory capacity

LIST OF TABLES

LIST OF FIGURES

CONTENTS

General Introduction

1. **Aim of the study**
2. **Statement of the problem and hypotheses**
3. **Research methodology**
4. **Structure of the study**

General Introduction

1. Aim of the study

The primary aim of the present research is to examine learners who seem able to learn a foreign language and identify others who show a disability. The concepts of ability and disability are implied when addressing the issue of cognition. The current study, hence, attempts to investigate the role of this latter in foreign language learning. A set of cognitive abilities that are claimed to affect learning a foreign language are highlighted in this investigation. Linguistic intelligence receives the lion's share of attention. The effects of this construct on foreign language learning achievement are scrutinized in some detail.

Linguistic intelligence has been extensively dealt with in the history of intelligence testing (e.g. Binet's tests of intelligence, Wechsler's scales, Raven's battery and Woodcock Johnson's test) (c.f. chapter 1.1.3). Nowadays, Gardner (1983; 2011) and Sternberg (1985; 2011) provide a more explicit treatment of the construct. However, Gardner's Multiple Intelligences Theory (1983) did not supply enough evidence for what is called 'Linguistic intelligence' in terms of substantial research, throughout the world, about that important aspect of intelligence. To this end, the present study attempts to provide a practical definition of the term through hypothesizing a set of cognitive skills to be its factors. Language aptitude, working memory capacity and verbal reasoning skill will be highlighted as different predicted factors of this ability if high correlations are proved.

Language aptitude is claimed to be an important factor of Linguistic intelligence for the fact that the term 'aptitude' is perceived by some researchers (e.g. Dӧrnyei, 2005) as an essential aspect of the broad term 'intelligence'. Since aptitude is a critical aspect of intelligence, and since Linguistic intelligence is just a feature, language aptitude would, necessarily, be an aspect of linguistic intelligence. It is noteworthy that language aptitude is opted for in this study to provide a linguistic explanation of the term 'Linguistic intelligence'.

Working memory capacity is another construct believed to be a momentous aspect of Linguistic intelligence, on the basis of recent research evidence (e.g. Engle, 2002) which provided a close relationship between this ability and general intelligence. For this reason, we highlight an aspect of working memory, that is, verbal working memory as a predicted factor of linguistic intelligence. While aptitude is used to provide a linguistic explanation of linguistic intelligence, working memory is chosen to offer a psychological account of the concept.

Verbal reasoning is the third hypothesized factor of Linguistic intelligence as most, if not all, research evidence consider reasoning ability as an important aspect of general intelligence. Since we have considered the linguistic type of intelligence in the present work, verbal reasoning will be focused on over other types. Similar to working memory, verbal reasoning provides a psychological explication of Linguistic intelligence as well.

Language aptitude, working memory and verbal reasoning are claimed to be very important skills that facilitate learning different aspects of a foreign language. Language aptitude, for example, is necessary, especially for the phonological processing and the acquisition of the syntax of a foreign language. Working memory processes are essential for learning all aspects of the foreign language, i.e. phonology, vocabulary and syntax, especially at beginning levels when high attention is required. Verbal reasoning skill is helpful mainly in internalizing foreign language structures (the theoretical chapters provide a thorough explanation of the influence of these abilities on foreign language learning). This has pushed us to pair up these abilities under an overall capacity naming it 'linguistic intelligence'; and directed us to investigate the effects of this latter on learning English as a foreign language.

In the light of the notable effects of the previously mentioned cognitive abilities on foreign language learning, we should note that the primary aim of the present investigation is to design an entrance test for learners who opt to learn English as a foreign language at university. The test is referred to as 'Linguistic intelligence test' and is carefully designed with the consideration of a number of cognitive and linguistic skills (language aptitude, working memory, and verbal reasoning). This measure will be considered as "a ticket for access" that allows learners without cognitive and linguistic problems to engage in learning English at university to ensure success. Unlike IQ tests that are required in many universities all over the world, forcing learners to choose the field that seems most appropriate to their cognitive abilities, this measure seeks to reveal different areas of strength and weakness and might, subsequently, direct teachers to use intensive courses to overcome mainly the areas of weakness. In addition, the results of Linguistic intelligence measure might reveal individual differences in different aspects of linguistic ability and might, hence, give insights to teachers in placing learners with equal abilities using corresponding courses. Besides, the test results might urge teachers to use different strategies that are believed to relate to Linguistic intelligence (e.g. memory strategies and reasoning strategies) and are, accordingly, predicted to affect foreign language learning.

Owing to the assessment purpose of the present investigation, and since we have chosen three cognitive linguistic abilities as distinguishable factors of Linguistic intelligence, and as predictable components of Linguistic intelligence test, it is necessary to provide an appropriate measure for each of these capacities. For this purpose, language aptitude measure, working memory measure and verbal reasoning measure should be carefully designed according to learners' ability, proficiency, and culture (a description of each measure is presented in chapter five).

2. Statement of the problem and hypotheses

Human beings acquire their first language in a similar way. The same level of proficiency is achieved by all human beings if appropriate conditions are provided (e.g. being integrated in the society and not having any impairment in the brain regions that are related to language). However, when it comes to learning a foreign language, things become different. People achieve different levels of proficiency. Individual differences in foreign language learning are attributed to a variety of factors: cognitive, affective, linguistic, social, to include but a few.

Some people learn the language easier, better and faster than others. Having been teaching the module of grammar for three consecutive years, we have observed that individual differences in understanding and internalizing grammatical rules do exist. While some learners learn complex structures with a great facility, some others struggle even with the simplest rules. Similarly, when it comes to processing input, i.e. when learners are asked to take notes while the teacher presents the lesson, some learners are noticed to struggle to produce a single sentence, while some others do the task with a great facility. The same remarkable observation is even made in stimulus presentation. When dictating, for example, some learners go rapidly with the teacher's pace with a quick perception and processing of stimuli, while some others fail to proceed and interrupt the teacher with perpetual repetition of every single word.

Recent studies in Second Language Acquisition are increasingly underestimating the role of cognition in foreign language learning, and shift attention to alternative views in which affective factors are gaining a wide popularity (e.g. affective filter hypothesis for Krashen, 1985). The reason might be attributed to the failure of cognitive measures in appropriately evaluating real cognitive abilities. The current study comes with an attempt to provide, hopefully, a reliable measure of one aspect of cognitive ability, which we refer to as 'linguistic intelligence', and endeavours to prove significant relationship with foreign language learning achievement. Three major questions are raised in this investigation:

1. Are language aptitude, working memory and verbal reasoning significantly interrelated?
2. Would these capacities be considered as the final constituent factors of linguistic intelligence?
3. Does Linguistic intelligence affect foreign language learning achievement?

In answering these questions, we would make up the following hypotheses:

- ❖ **Hypothesis one**

There would be a close association between language aptitude, working memory, and verbal reasoning, and these variables would, accordingly, be considered the main factors of Linguistic intelligence and the basic components of Linguistic intelligence test.

A number of sub-hypotheses would be extracted from hypothesis one, and would be stated as follows:

- Language aptitude would have a strong correlation with working memory capacity.
- Language aptitude would be closely related with verbal reasoning ability.
- Working memory and verbal reasoning would show a significant correlation.

- **Hypothesis two**

We predict that the overall Linguistic intelligence would have a noticeable impact on foreign language learning achievement. This broad statement could also be divided into three main sub-hypotheses:

- The first predicted factor of linguistic intelligence, language aptitude, is expected to show a strong relationship with foreign language learning achievement.
- Working memory, as the second hypothesized factor of linguistic intelligence, would be closely related to language learning achievement.
- The third hypothesized factor of linguistic intelligence, verbal reasoning, would have a significant correlation with language learning achievement.

3. Research methodology

The population of interest for the current study are freshman students learning English as a Foreign Language at the department of Letters and English Language, University of Mentouri Brothers- Constantine. Four groups including approximately seventy students (c.f. chapter 5.1.6) are extracted from the population of 300 for this investigation. The subjects will be given a battery of tests in order to assess their language aptitude, working memory capacity and verbal reasoning skill.

Language aptitude test (c.f. appendix 2) will measure a set of abilities that facilitate foreign language learning. This measure contains three sub-measures that assess basically phonetic ability, grammatical sensitivity and inductive learning ability. Phonetic ability tasks will assess the learners’ capability to acquire the different sounds of the foreign language. Grammatical sensitivity tasks will evaluate their capacity to recognize the different functions of the foreign language. And inductive learning tasks will measure their facility in internalizing foreign language structures.

Working memory test (c.f. appendix 2) will be administered to measure the learners' verbal working memory capacity. Four tasks will be given to assess different aspects of this ability, namely Reading Span Tasks (RSPAN), Operation Span Tasks (OSPAN), anagrams, and Listening Span Tasks (LSPAN). RSPAN will measure mainly the visual-verbal working memory capacity; OSPAN will assess the numerical and verbal working memory capacity; anagrams will assess verbal working memory in addition to inductive reasoning; and LSPAN will evaluate the auditory-verbal working memory capacity.

Five main subtests will be the components of verbal reasoning measure, viz. knowledge subtest, similarity subtest, syllogisms subtest, understanding relations subtest, and analogies subtest (c.f. appendix 2). The subtests purport to assess different types of reasoning: inductive, deductive and analogical. In addition to verbal reasoning skill, these tasks intend to measure the subjects' vocabulary proficiency as well.

4. Structure of the study

The present doctoral dissertation is divided into eight chapters. The first four chapters provide a theoretical overview of the different hypothesized components of Linguistic intelligence, together with the construct of language learning achievement; the three following chapters present a detailed description of data collection, procedure, data analysis and interpretation. The thesis concludes with stating the research recommendations, limitations and suggestions for future investigations.

The first chapter presents a general overview of intelligence- the ability which is the core of our investigation. This chapter is divided into two main sections: the first section is devoted to intelligence in general and Linguistic intelligence in particular, and the second section is devoted to reasoning that is claimed to be an important aspect of intelligence. In the first section, different definitions are provided, reflecting different researchers' views and, consequently, the controversial nature of the construct. Gardner's Multiple Intelligences theory is thoroughly dealt with as being considered a source of insight to the whole work. Linguistic intelligence is introduced and explained in details in this section. Major psychometric tests which attempt to measure human intelligence are also reviewed. The section concludes with highlighting the importance of intelligence in learning in general and more specifically foreign language learning.

The second section of chapter one presents the concept of reasoning which is considered as a crucial aspect of intelligence. A clarification of the term is provided, and different types of this ability are discussed with corresponding measures. The section is primarily concerned with verbal reasoning which is a predicted factor of linguistic intelligence. Theoretical findings on the relationship between reasoning and intelligence are worth to highlight in this section.

Chapter two deals with language aptitude- the second hypothesized ability of Linguistic intelligence. The chapter starts with presenting different definitions of the term with the consideration of the psychological definition, mainly focusing on the cognitive perspective. Different views concerning the nature and the components of this capacity are reviewed in this chapter. For the assessment rationale of the present study, and because providing an appropriate measure of language aptitude is placed among our research purposes, we have highlighted two prominent language aptitude measures we relied on in designing the current language aptitude measure, namely the Modern Language Aptitude

Test, in other words the MLAT (Carroll & Sapon, 1959), and The Pimsleur Language Aptitude Battery, or the PLAB (Pimsler, 1966). The chapter offers a review of literature of the relationship between intelligence and language aptitude, and emphasizes the role of this latter on foreign language learning.

The third chapter deals, in detail, with the third hypothesized ability of linguistic intelligence. The chapter includes four sections. The first section is the gateway of the chapter as it identifies different information processes and memory stages, and in which the term working memory is first introduced. The second section deals entirely with working memory and working memory capacity. Different models are presented clarifying the term, and different theories of the nature of working memory capacity are reviewed in this chapter. The third section is concerned with providing an overview of different tests of working memory as well as short term memory. The fourth section offers a theoretical review of the relationship between this capacity and the discussed abilities: intelligence, reasoning and language aptitude, and highlights the role of this ability in foreign language learning.

The fourth chapter sheds some light on a number of issues that are necessary for the present investigation. The chapter includes three main sections. The first section is concerned with foreign language learning. In this section, a number of definitions are provided, and different theories are reviewed. The second section is devoted to a clarification of the concept of language learning achievement in which different tests are presented. The last section tackles the issue of testing, and mainly psychological testing.

The fifth chapter is the first empirical chapter of the research. This chapter is divided into two main sections. The first section provides a detailed description of the administered measures: language aptitude measure, working memory measure, and verbal reasoning measure. The second section discusses the analysis of the pilot tests in terms of understanding the questions and the reliability of the measures.

The sixth and seventh chapters are entirely concerned with the analysis of the tests findings. The sixth chapter provides analysis of the obtained results in the three administered measures. Assessing the reliability of the final measures is also dealt with in this chapter to warrant the consistency of the measures and, subsequently, allow us to carry out the analysis with confidence. The seventh chapter is the final and the main part of the investigation. The testing of the research hypotheses is carried out in this chapter through a number of correlational and factor analysis studies. The results of these correlations and factor analysis lead to the confirmation or rejection of the research hypotheses, and offer some pedagogical implications which are presented in chapter eight.

The eighth chapter is the concluding chapter of the thesis. It provides a summary of the whole work. A set of pedagogical recommendations are highlighted in this chapter. The chapter draws attention to the limitations of the study and offers some suggestions for future research.

The appendices contain the raw data of the three pilot tests (Appendix 1) as with the final tests (Appendix 2). The participants' obtained scores in language aptitude test, including its three subtests; working memory test, involving its four subtests; and verbal reasoning test, including its five subtests, are presented in Appendix 3 (c.f. Table A. 4, A5, and A6). The subjects reproduced scores in the final Linguistic intelligence factors are indicated in Appendix 4 (Table A. 8). Language learning achievement raw and reproduced scores are presented in Appendix 5 (Table A. 9).

Chapter One

Intelligence and Reasoning

Introduction

1.1.Intelligence

1.1.1. Definition of intelligence

1.1.2. Theories of intelligence

1.1.2.1. Early views

1.1.2.2. Psychometric theories of intelligence

a. Spearman’s g factor theory

b. Thurstone’s primary mental abilities theory

c. Vernon’s factor analysis theory

d. Guillford’s structure of intellect theory

e. Cattell and Horn fluid and crystallized intelligence theory

1.1.2.3. Information processing theory

1.1.2.4. Developmental theory

1.1.2.5. Modern views

a. Gardner’s Multiple Intelligences Theory

1. Linguistic intelligence

2. Other intelligences

3. Sternberg’s Triarchic theory of intelligence

1.1.3. Tests of intelligence

1.1.3.1. Binet’s tests

1.1.3.2. Wechsler tests

1.1.3.3. Raven’s Progressive Matrices

Intelligence and Reasoning

Introduction

Human beings do not grow the same way; they do not think the same way; neither do they learn the same way. Height, body shape, personality, intelligence, to name but a few, are instances of individual differences. In psychology, the term 'individual differences' is deployed to involve a variety of issues such as aptitude, memory, motivation, learning styles, and learning strategies. Intelligence is a further sphere of individual differences (ID) research that is the focal point of the present investigation. It does not make sense to talk about intelligence without referring to the ability to think. Reasoning and intelligence are, hence, inseparable constructs. Reasoning is another concept that receives a considerable attention in this chapter.

The present chapter is divided into two main sections. The first section deals with the concept of intelligence. Various definitions reflecting a variety of perceptions of the construct are presented, and some standardized tests that attempt to measure this ability are reviewed. In this section, we draw attention to the role of intelligence in learning in general and language learning in particular. The second section is devoted to the concept of reasoning. A definition of the term is provided and different types are identified. The section provides an overview of the relationship between reasoning and intelligence.

1.1. Intelligence

1.1.1. Definition of intelligence

In everyday language intelligence is perceived as a gift. If someone goes to the street and questions people about what it means to be intelligent, he would receive answers like:

an intelligent person is the one who is able to find solutions to any problem, who understands complex ideas easily, who has the capacity to answer complex mathematical problems rapidly, and who gives creative answers to ordinary questions. Commonsense definitions, in spite of their lack of scientific explanation, give insights to experts in studying the construct of intelligence.

In psychology the concept is rather complex than it seems. Definitions of intelligence vary for the nature of the construct per se. In the early 1920s, in the Journal of educational psychology, a number of experts provided different definitions for the term intelligence. Among these definitions:

- The power of good responses from the point of view of truth or facts. (E. L. Thorndike);
- The ability to carry on abstract thinking. (L. M. Terman);
- Having learned or ability to learn to adjust oneself to the environment. (S. S. Colvin);
- Ability to adapt oneself adequately to relatively new situations in life. (R. Pintner);
- The capacity for knowledge and knowledge possessed (B. A. C. Henmon);
- A biological mechanism by which the effects of a complexity of stimuli are brought together and given a somewhat unified effect in behaviour. (J. Peterson);
- The capacity to inhibit an instinctive adjustment, the capacity to redefine the inhibited instinctive adjustment in the light of imaginally experienced trial and error, and the capacity to realize the modified instinctive adjustment in overt behaviour to the advantage of the individual as a social animal. (L. L. Thurstone);
- The capacity to learn or to profit from experience. (W. F. Dearborn);

- Sensation, perception, association, memory, imagination, discrimination, judgment, and reasoning. (N. E. Haggerty) (stated in Leighton & Sternberg, 2004, p. 450)

The above notions do reflect various perceptions of the concept of intelligence. Despite this variety, two main aspects are highlighted by almost all experts, viz. adaptation and learning. Similarly, the aspect of reasoning is also dealt with, whether explicitly or implicitly, when explaining intelligence.

According to psychometricians (e.g. Binet, 1905; Thurstone, 1938; etc.), intelligence is what intelligence (IQ) tests measure. An intelligent person is someone who obtains a score of 120 or more in an IQ test.

The notion of intelligence in contemporary research is dissimilar to the one of psychometricians. Modern psychologists define intelligence through associating it with a set of abilities rather than considering its measurement. Howard Gardner (1983) announces that intelligence is a 'bio-psychological' potential that functions in solving problems and adapting to the environment. He highlights eight distinct types of intelligence that go beyond school achievement and extend to daily life requirements. These abilities are: linguistic, logical-mathematical, musical, bodily-kinesthetic, spatial, interpersonal, intrapersonal, and natural intelligence. Sternberg (1985) is another contemporary psychologist who views intelligence as "purposive adaptation to, and selection and shaping of real-world environments relevant to one's life" (p. 45). He distinguishes between three types of intelligence: analytical, that is related to IQ testing; practical, that involves real-life competence; and creative, that entails novelty.

From the aforementioned definitions, all researchers seem to agree that adaptation is an important characteristic of intelligence. The term adaptation will be discussed later in the section (c.f. section 1.2.4.).

To summarize, most of past attempts to define intelligence can be said to globally turn around: 1. the capacity to learn from experience, and 2. the ability to adapt to the surrounding environment. It is very hard to arrive to a consensus about defining intelligence. Bearing in mind earlier definitions of the construct and some prominent contemporary ones (e.g. Sternberg, Gardner), one can reach a kind of synthesis by saying that: intelligence is a general aptitude for learning, often measured by the ability to deal with abstractions and solve problems. As an operational definition, we would limit the concept of intelligence to the ability to reason logically. This is because all definitions of intelligence consider this ability as an indispensable aspect (e.g. Spearman, 1904; Thurstone, 1938; Vernon, 1961; Horn and Cattell, 1967; Piaget, 1958; Gardner, 1983; Sternberg, 1985). Reasoning would be itself defined as the ability to come to a conclusion inductively or deductively. The second section will be entirely dedicated to the clarification of the concept of reasoning and reviewing its relationship with intelligence.

1.1.2. Theories of intelligence

"Discussions concerning the theory, nature, and measurement of intelligence historically have resulted more in disagreement than in agreement, more in smoke than in illumination." (Eysenck, 1986, in Miyake & Shah, 1999, p. 2). This quote quite indicates the complexity of the concept of intelligence. The following section presents how the term intelligence is used differently in different points of time by different psychologists.

1.1.2.1. Early views

In the early past, and during the appearance of scientific psychology, intelligence was looked at in terms of sensation and perception. The leader of early views is the British Scientist Francis Galton (1884). Being interested in human evolution and differences between species and the same species, like his cousin Charles Darwin, Galton believes that intelligence differs in humans in differing sensory abilities. In his book 'Hereditary Genius' (1889), Galton specifies that these abilities are innate and stable. Galton was the first to measure mental abilities through tests of sensory discrimination, i.e. differentiation between heights and weights (Anderson & Reid, 2005). He further employed the concept of correlation coefficient in explaining intelligence. This correlation was made between physical characteristics and mental abilities. Galton's correlation gives insights to contemporary testing of intelligence, yet his mental ability was measured through simple tasks like sensory discrimination. (Pellegrino & Kail, 1985)

1.1.2.2. Psychometric theories of intelligence

a. Spearman's g factor theory

In the early 20th century, Spearman came after Galton in the sphere of intelligence and intelligence testing. Galton's sensory discrimination was included at initial levels of Spearman's general intelligence; then it started to diminish and turned to be totally ignored later in Spearman's mental tests. (Carroll, 1993)

Spearman was attracted to the link between achievement inside and outside school. His experiments informed him about the correlation between mathematical skills and literary competence. As a consequence, he made a number of statistical studies, mainly factor analysis, for all intellectual abilities or cognitive aptitudes. The results of factor analysis substantiated a perfect correlation between some cognitive abilities and some weak correlations between other abilities. The elements showing a high correlation were termed general factor or 'g factor', and those revealing low correlations were labelled specific factor or 's factor'. Spearman's interest was centred on 'g factor' over 's factor'.

Similar to Galton, Spearman claims that intelligence, and mainly g factor, is innate and universal. He further speculates that it is the general factor that underlies all cognitive abilities and intellectual performances. Spearman was the first to provide a psychometric definition of intelligence through stating that:

> As regards the delicate matter of estimating 'Intelligence,' the guiding principle has been not to make any *a priori* assumptions as to what kind of mental activity may be thus termed with greatest propriety. Provisionally, at any rate, the aim was empirically to examine all the various abilities having any *prima facie* claims to such title, ascertaining their relations to one another and to other functions (Spearman, 1904, pp. 249-250).

Spearman (1927) explained the existence of 'g factor' and 's factor' mathematically, indicating that the former is just a "value of magnitude" rather than a concrete ability. He further referred to this ability in terms of "the power of attention". Besides, he believed in a strong existing correlation between this latter and the power of reasoning, and reviewed some researchers findings of the relationship between the two, e.g. H. A. Peterson study (.80); McCrae study (.86); Stockton study on the correlation between intelligence and arithmetic reasoning (.63), and intelligence and analogical reasoning (.68).

b. **Thurstone's primary mental abilities theory**

Thurstone's theory emerged as a result of a number of test batteries and factor analysis studies. The American psychometrician Louis Leon Thursone (1938) conducted a battery of fifty seven tests to university students and similar studies to children to determine the number of primary mental abilities (PMA) in different age groups. The results of factor analysis reveal the existence of nine unrelated factors: ‘S’ space, ‘P’ perceptual speed, ‘N’ number facility, ‘V’ verbal relations, ‘W’ word fluency, ‘M’ memory, ‘I’ induction, ‘R’ restriction, and ‘D’ deduction. (Carroll, 1993)

Thurstone proposed a set of measures to his PMA. The space factor is assessed through judging whether objects (e.g. letters, shapes, etc.) rotated in space are the same or different. Mental speed factor is measured through rapidly and correctly judging whether items are the same or different (e.g. ahfgjel- ahfpjel). Verbal comprehension is tested through checking the right synonym or antonym (e.g. “ancient”: *dry, long, happy, old, sloppy).* Number facility is assessed through solving mathematical calculations (16*99). Induction factor requires individuals to induce a rule from perceived data like inducing a rule from the following series of letters: abcacdadea. And deduction factor requires coming to a logical conclusion from given premises [1](e.g. Bill is taller than Jim, Jim is taller than John, who is the shortest?). (Pellegrino & Kail, 1985)

c. Vernon’s Factor Analysis Theory

Vernon (1961) is another clinician who assembled Spearman’s and Thurstone’s views to propose a “Factor Analysis Theory”. He defines a factor as a group of performances that are proved to correlate as a result of a test. A factor is so called if a high positive correlation exists between different abilities. Vernon’s factor analysis theory is presented in the form of a scale following the top-down approach [2], starting with a general factor (g) and moving to more specific factors: verbal educational ability (v :ed) and spatial

[1] See deductive reasoning

[2] A top down approach is presented in the form of a hierarchy whereby higher abilities are placed on the top, i.e. the general factor is on the top, and these abilities are broken down into more specific factors like numerical ability or speed of processing. (Vernon, 1961)

practical ability (k :m). These factors are themselves divided into more specific capacities. Verbal educational ability, for instance, is divided into verbal fluency, comprehension, and rote memory; while spatial mechanical ability is caught into spatial perception and perceptual speed. Vernon claims that age affects spatial practical ability, i.e. it decreases it, but has no influence on verbal educational capacity. He adds that it is the latter ability that is more culture-bound. Vernon was the first to provide a hierarchical model of human cognitive ability. His hierarchy of cognitive abilities is presented in the following diagram.

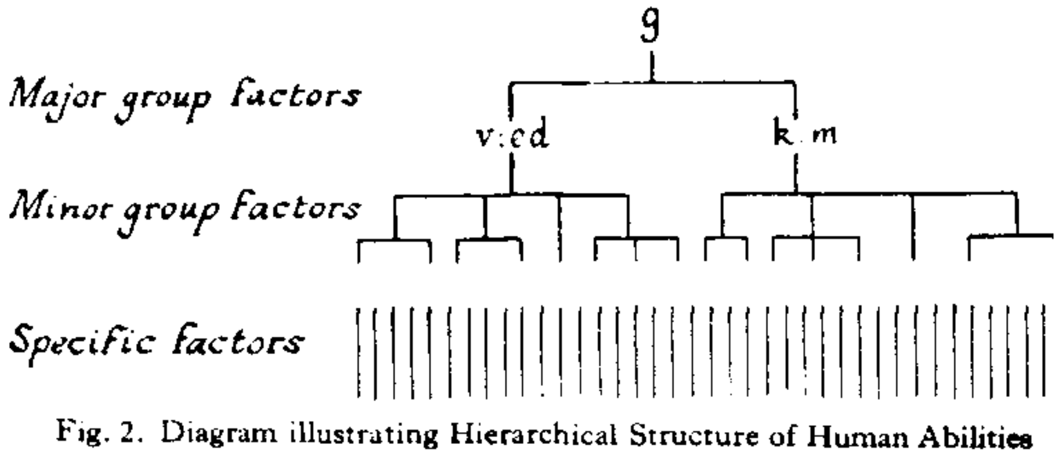

Figure 1. Diagram Illustrating Hierarchical Structure of Human abilities (Vernon, 1961, p. 22)

d. Guilford's structure of intellect theory

Guilford's theory emerged as a reaction to Spearman's g factor. The American psychologist John Paul Guilford ignored the fame of IQ in academic settings and felt the need to develop a system of mental abilities that were being increasingly discovered. In 1958, his "Structure of Intellect" (SOI) system represented 120 distinct mental abilities placed in a form of a cube. The number increased to reach 150 separate factors by the end of 1980. (Carroll, 1993)

Guilford believes that human abilities develop through education. His work "intelligence education is intelligent education" explained the influence of learning in developing intelligence. (Comrey, 2000)

In his SOI model, Guilford classified all the assumed factors in a taxonomic model. He opines that one factor takes three aspects called parameters: content, operation and product. This means that any test of any factor requires from the participants "…to deal with some kind of content, perform some operation on this content, and have some kind of product as an outcome". (Carroll, 1993, p. 58)

e. Cattell and Horn fluid and crystallized intelligence theory

Another figure in the psychometric approach is Raymond Cattell. This eminent researcher conducted a Multiple Factor Theory for approximately eight years (from 1963 to 1971) with the help of his student John Horn. Cattell's model contained two main, general, and distinct types of intelligence: Fluid (Gf) and crystallized intelligence (Gc) (Pellegrino & Kail, 1985). Cattell and Horn view emerged as a result of a number of studies on intellectual performance such as studies on brain damage in early and late years; studies on the relationship between test scores and the capacity to acquire new information and skills; the structure of intelligence tests and the sub-components of these tests; as well as the change in intellectual abilities and aging. (Horn and Cattell, 1967)

'Gf' and 'Gc' are argued to affect human development differently. While the former is considered education-free ability and decreases in the development of age, the latter is considered education-and-culture-bound capacity and increases during the whole lifespan. The separation between Horn and Cattell's Gf and Gc is illustrated through being able to solve very complex mathematical problems but failing with the easiest language tasks because of insufficient knowledge. These researchers identified a number of factors for both types of intelligence. The factors that underlie Gf are inductive reasoning, figural relations, semantic relations and associative memory. These factors are respectively measured through letter grouping, figure classification, common word analogies and paired associates. It is noteworthy that measures of Gf do not require a level of education. For example, letter series only requires knowledge of the order of alphabets. The factors that are involved in Gc are verbal comprehension, formal reasoning, experiential evaluation, general reasoning, and ideational fluency. Measures of these factors are vocabulary knowledge, syllogistic reasoning, social situations, arithmetic reasoning, etc.. (Horn and Cattell, 1967)

In addition to Gf and Gc, Cattell and Horn (1967) propose four other general factors: General visualization factor (or Gv), Speed factor (or Gs), Carefulness factor (or C), and Function factor (or F). The first factor involves tasks that deal with changing objects in space; the second represents the time taken in solving problems; the third refers to the unintention for giving incorrect answers; and the fourth refers to the speed of giving names to words from long term memory and immediate awareness. Horn and Cattell indicate that the three last factors seem similar, yet they are different. (Horn and Cattell, 1967)

1.1.2.3. Information processing theory

Information processing view is referred to as the Cognitive Approach by Sternberg (1985). This approach gets insights from Galton's view of intelligence. Unlike psychometric views that apply statistical procedures to measure intellectual capacity, this theory seeks to investigate the different mental behaviours adopted when accomplishing certain tasks. Proponents of this view consider the brain as a machine that processes information, yet they claim that the human brain is more flexible, that is, it changes in changing situations. Luria (1966, as cited in Riccio et al, 2005) has introduced four processes used by human beings in undertaking cognitive behaviour: *simultaneous processing*, which refers to the use of different types of information at the same time; *sequential processing*, which depends on the organization of information*; attention*, which refers to the activation of different brain mechanisms; and *planning*, which relies on the use of assuming effects procedure and controls cognitive processes. Gardner (1983) speculates that information processing approach is interested in motor skills in general, and motor acts in particular, hence, it studies the millisecond by millisecond mental steps.

Pellegrino and Kail (1985) as well as Gardner (1983) have classified mental processes under two categories: lower-order and higher-order processes. The former are illustrated through sensation and perception and the latter through creativity and problem solving. Pellegrino and Kail (1985) went on to indicate that lower-order processes affect higher-order functions, whereas these latter ones have no influence on the former processes. Adults are proved to be more intelligent than children for they own greater knowledge base. This knowledge base contains human knowledge, how this knowledge is organized in the mind, and what procedures used to access it when needed.

The speed of information processing is another so highlighted issue in the explanation of intelligence. Jensen (1970, in Anderson & Reid, 2005) adopted the technique of *reaction time* (RT) to measure the speed of individuals' answers in certain tasks. He found that people with higher IQ scores were quicker in reacting than those with less IQ. Jensen (1982, in Anderson & Reid, 2005) came to a conclusion that individual differences in intelligence are due to individual differences in the speed of processing information. However, this view was criticized for being a strategy rather than a pure measure of intelligence. In other words, Jensen did not take individuals cognitive styles where impulsive individuals are quicker than reflective ones in responding. Vickers (1970s, as cited in Anderson & Reid, 2005) came, accordingly, with another technique called '*inspection time'* (IT) in explaining intelligence. Unlike the previous technique, IT considers the speed of processing information rather than reaction time. Vickers reduced exposure time and measured the response of individuals. The results confirmed his view in that those with higher IQ made discriminations with shorter exposure time. Many studies were, then, conducted to investigate the relationship between inspection time and intelligence. While some findings (e.g. Nettelbeck, 1987; Kranzler and Jensen, 1989, cited in Anderson & Reid, 2005) found a negative correlation (-0.5), others (e.g. Lalley, 1976, in Sternberg& Kaufman, 2011) showed a very high correlation (.92).

1.1.2.4. Developmental theory

This approach is concerned with the study of the development of intelligence from infancy to late adolescence. The Swiss psychologist Jean Piaget is considered the leader of this theory. Piaget's career began in the 1920s with the designation of Binet's tests (Gardner, 1983). Nevertheless, committed mistakes by the participants attracted him more than obtained scores. As a consequence, Piaget commenced by studying his own children. This psychologist claims that the mistakes made by children are universal. He rather views them as indicators of the child's development (Anderson & Reid, 2005).

In the book of *The Psychology of Intelligence,* Piaget (1950) defines the concept of intelligence as the balance between existing cognitive processes and adaptation. Adaptation, according to him, refers to the use of active cognitive functions to assimilate and accommodate new stimuli. Assimilation is the generalization of one element from a previous similar element, such as naming a butterfly a bird, whereas accommodation refers to some changes made by cognitive structures to fit the actual stimuli, like correcting the name of a butterfly. Piaget's *mental operations* are assumed to develop through age until the child reaches the 'formal operational period', i.e. when he becomes approximately 16 years old.

In addition to adaptation, assimilation and accommodation, Piaget introduced three further key concepts: functions, structures and contents. He advocated that both contents and structures change through age, whereas functions (i.e. assimilation, accommodation, and adaptation) remain stable over the lifespan. Piaget labelled these latter ones as 'functional invariants' (Pellegrino & Kail, 1985).

Piaget's experiments showed that young children commit mistakes that old individuals avoid. His focus on similarities over differences led him to generate four universal stages of cognitive development: sensory motor stage, preoperational stage, concrete operational stage, and formal operational stage. A description of each stage is provided below.

- **Sensory motor stage**

This stage starts from birth and lasts until the age of two. It is characterized by reflexes such as sucking in the first month, and a combination of new schemes like toys from 8 to 12 months. The first months of the individual's life are associated with physical rather than mental actions. It is only when the infant reaches 18 months that he starts to use symbols rather than behaviour to get desired objects.

- **Preoperational stage**

The second stage of cognitive development takes place when the child reaches two years old and lasts until the age of seven. Egocentricity is a dominant characteristic at this stage. Children are restricted by the ability to look at problems from only one angle. Language development is also apparent at the beginning of this stage. Piaget's conservation problems cannot be solved at this level.

- **Concrete operational thought**

This stage emerges at the age of seven and lasts to eleven years old. Thinking goes beyond egocentricity. Children, at this level, develop their perception of problems to different perspectives. Thinking is relative to concrete objects. In other words, children associate their thinking with objects surrounding them.

- **Formal operational stage**

This stage is classified the last in human cognitive development. It starts when the child is eleven years old and lasts until adulthood. Thinking, at this stage, goes beyond concrete objects to reach abstract levels. Children develop the ability to think in the past, present and future. They can further formulate hypotheses, test them, and generalize outcomes. (Pellegrino and Kail, 1985)

Piaget's theory of cognitive development reached a great popularity. Many books have been published to describe and explain it (Brainerd, 1978; Flavell, 1963; 1977; Phillips, 1975; Ginsberg & Opper, 1979, in Pellegrino & Kail, 1985). However, generalizations from a sample to a whole population cannot be always reliable. Some studies (Neimark, 1975; Shayer, Kuchemann & Wylam, 1976, in Anderson and Reid, 2005) showed that not all adults can develop a full ability of formal operational reasoning. In addition, this theory focuses on the use of logical and mathematical tasks without considering the creativity of individuals. This has led Gardner (1983) and Sternberg (1985) to introduce other theories to explain intelligence.

1.1.2.5. Modern views of intelligence

Modern theories of intelligence emerged in the 1980s as a reaction to psychometric views that put focus on the measurement of intelligence. These theories linked human cognitive ability with a set of capacities. The pioneers of these views are the American psychologists Gardner (1983) and Sternberg (1985).

a. Gardner's Multiple Intelligences Theory

Far from psychometric, information processing, and developmental theories of intelligence, Gardner's theory claims that people use several intelligences rather than one type to adapt to the environment. Gardner (1983) defines intelligence as a *bio-psychological potential* that functions to solve problems and interact with the environment. Although Gardner admitted that it is impossible to determine all the characteristics of human intelligence, he identified two prerequisites agreed by all researchers that underlie intelligent behaviour. These characteristics are problem solving and the acquisition of new knowledge.

In his book of *Frames of Mind: the Theory of Multiple Intelligences*, Gardner (1983) introduced seven independent types of intelligence. These intelligences are: linguistic, logical-mathematical, bodily-kinaesthetic, musical, spatial, interpersonal and intrapersonal. He supported his theory by the following arguments:

- the existence of exceptional individuals (*idiot savants*), i.e. those who are extraordinarily developed in one area and have mental disabilities in other areas;
- brain damaged areas and their influence on some abilities;
- the distinction between different attitudes in the development of societies;
- and the weak correlation between all abilities in psychometric tests.

Recently, three further intelligences have been added to the list to reach ten, viz. Natural intelligence, existential intelligence, and spiritual intelligence (Gardner, 2011). Here is an explanation of Gardner's intelligences.

1. Linguistic intelligence

Linguistic intelligence is used to refer to the ability to use language in speech and writing. Gardner (2011) highlights three aspects of this ability: Sensitivity to Meaning (i.e. semantics and pragmatics), auditory sensitivity (i.e. sensitivity to phonology), and mastery of syntax (i.e. rule for structuring words in sentences and mastery of morphology). However, he speculates that Linguistic intelligence is more related to phonology and syntax than semantics and pragmatics, claiming that these two latter aspects are related to other types of intelligence like interpersonal or logical-mathematical. Memory is another important aspect of linguistic intelligence. According to Spender (in Gardner, 2011), memory for experience is crucial for language mastery.

In addition to that, Gardner considers linguistic competence as synonymous to linguistic intelligence. He supports his opinion by announcing that human beings possess the three linguistic sensitivities (i.e. meaning, phonology and syntax) in varying degrees.

Gardner's linguistic intelligence gives us insights to the present investigation. Having considered the abilities believed by Gardner to be aspects of linguistic intelligence, we would define the current Linguistic intelligence in relation to memory ability, language aptitude (mainly phonology and syntax), and verbal reasoning. An investigation of the degree of the association between these three abilities will be conducted, and a practical definition of the term Linguistic intelligence will be provided. These abilities will be highlighted in the coming chapters as they are considered the core of the present work.

Gardner stresses the separation of Linguistic intelligence from other intelligences through noting that “While evidence from brain damage confers a “face validity” upon the analysis of the components of language faculty I have proposed, we must still address its implications for the existence of language as a separate, semi-autonomous faculty—in our terms, a separate intelligence” (Gardner, 2011, p. 93). An example of this dissociation is Einstein’s case. Einstein could not speak until later in his childhood, yet he proved to be a brilliant physician. Another example is that some normal children show difficulties in language learning. Gardner adds neurological evidence for the separation between Linguistic intelligence and other abilities through illustrating that language resides in the left hemisphere, while visual and spatial abilities centre in the right hemisphere. He further avers that the ability to process verbal material quickly depends on an intact left frontal lobe, and that damage in this area causes difficulties in language. Another evidence is that some young children (below the age of 5) with injuries in the left hemisphere (e.g. when this hemisphere is removed totally) show normal language abilities. This is because of the plasticity of the brain which allows language to move to the right hemisphere instead. Similarly, Gardner indicates that children who process language in the right hemisphere show differences in the use of language strategies. For example, they rely more on semantic strategies to understand a sentence, while those who process language in the left hemisphere rely more on syntactic cues like word order. Furthermore, Children who process language in the right hemisphere show difficulties in speech production and vocabulary comprehension than those who process it with the left hemisphere. Further evidence is that aphasic patients do not show difficulties in solving problems separate from language. (Gardner, 2011)

Concerning the development of language, Gardner advocates that linguistic skills appear in the early years of the infant’s life, at the stage of babbling. Babbling, however, is different from the language that appears in the second year. This latter is characterised by single words (e.g. mommy, cookies, etc.), then moves to meaningful phrases (bye-bye mommy), to include some complexities like asking questions (e.g. when I get up?) and negatives (e.g. I no want to go to sleep) at the age of three. During four and five years, the child's language becomes somehow similar to the one of adults in that he corrects syntactic errors and becomes more fluent and able to tell stories about his adventures.

Linguistic ability starts by the emergence of some processes of acquisition. Gardner (2011) reviewed Chomsky's claim that human beings are born with these processes calling them (LAD= Language Acquisition Device). He supported this view through stating that we must have this innate ability which allows us to understand the structures of language and speak any natural language. He used the argument that language is acquired with high speed and accuracy despite its complex nature. He further reviewed Wexler and Culicover (1980) claim that learners must possess the skills of decoding so that they can acquire language.

Despite the sound evidence Gardner used to prove the existence of Linguistic intelligence and show its dissociation from other capabilities, he took the genius side. According to him, a linguistically intelligent person is a poet or a writer. In other words, Gardner didn't explain this ability in normal and non-exceptional individuals. Our study, however, discusses linguistic ability in normal people not exceptional ones.

2. Other intelligences

2.1. Musical intelligence

This intelligence is argued to reside in the right hemisphere. The ability to understand different musical compositions characterizes it. Singers and composers are some examples of this type.

2.2. Logical-mathematical intelligence

This type refers to the ability to reason logically, to transfer objects into numbers, to judge the difference between two entities, to solve mathematical problems, and to make deductions and inductions. The left hemisphere is claimed to be responsible for recognizing mathematical symbols, whereas the right hemisphere is relied on for understanding numerical calculations. Scientists, mathematicians and statisticians are instances of this intelligence.

2.3. Spatial intelligence

Spatial intelligence is used to refer to the ability to draw, transform, and imagine the *absent world*. The right hemisphere is dominant for this ability. Spatial intelligence is associated with a "perfect" remembering of faces from the first time of seeing them. Architects and engineers illustrate it.

2.4. Bodily-kinaesthetic intelligence

This intelligence dominates many areas in the brain such as the cerebral cortex, thalamus, basal ganglia and cerebellum. It refers to the ability to use one's body in a skilful way to solve problems, and to hold objects skilfully. Dancers, swimmers, and ball players illustrate it.

2.5. Personal intelligence

Personal intelligence is divided into two other types: interpersonal intelligence and intrapersonal intelligence. The former refers to the ability to understand others' motivations, intentions and feelings, whereas the latter is the capacity to know one's intentions, beliefs and emotions. Examples of the first type are therapists, politicians, teachers, and those of the second type are novel or story writers.

Gardner's Multiple Intelligences is considered by some researchers (e.g. White, 2004) as a sound theory. White (2004) claims that British schools adopt this theory in their teaching applications through the consideration of different styles of learners and planning different ways to teach materials. Besides, MI is argued to increase students' self- esteem by a consideration of their areas of strength to apply them in their learning process for a better progress. Nevertheless, as stated earlier, Gardner has focused on exceptional people in the explanation of his intelligences. Some of the previously mentioned intelligences (e.g. personal, musical, bodily kinaesthetic, and spatial) are only talents and could not be put into practice in teaching. This makes the majority of researchers in the realm of intelligence consider multiple intelligences as just a beautiful theory.

b. Sternberg's Triarchic theory of intelligence

Sternberg's theory of intelligence was developed at about the same time of Gardner's multiple intelligences theory. Both views exceed the narrow definition of intelligence through extending this ability to a number of capacities. The American psychologist Robert Sternberg criticised Gardner's MI in that some of these intelligences are only talents (e.g. musical, bodily-kinesthetic). Sternberg (1985, p. 45) views intelligence as a "mental activity directed toward purposive adaptation to, selection and shaping of, real world environments relevant to one's life." In 1985, he introduced his triarchic theory of human intelligence. This theory includes three facets of intelligence: contextual sub-theory, experiential sub-theory, and componential sub-theory.

1. Contextual sub-theory

This sub-theory looks at intelligence in relation to a certain cultural environment. There are three elements that reflect intelligent behaviours: adaptation, selection, and shaping of the environment. These steps operate as follows: a person adapts to a particular context; if this context is not what he wishes, the step of selection takes place, in which the desired context is selected; if this selection fails, shaping or “reselection” appears. To illustrate these steps, an employee adopts himself to a certain job, if he does not like the rules, he looks for another occupation (selection), and if the opportunity of finding this occupation is not available, he/she has to return back to his/her previous job (shaping). This facet is related to the first type of intelligence which is referred to as practical intelligence.

2. Automatization and novelty sub-theory

Automatization and novelty elements explain intelligence in the sense that an organism should be able to deal with novel situations, as it should be automatic in processing information. These novel situations are not extremely unfamiliar; rather, they require the use of similar cognitive functions. Examples of tasks that measure this quality are reaction time and finding missing letters. One should note that novelty is a relative quality, i.e. what seems new to someone might not be new to another. Sternberg emphasizes that intelligence tests should consider this quality. Automatization takes place when learners, who are exposed to a new situation, are given certain instructions and practice. While reading a story or watching a movie, making inferences to what will happen signifies our automatization. These two processes are interrelated. In other words, dealing with novelty and practising it leads to automotization. Sternberg defines Intelligence in terms of problem solving (reasoning, analogies) and verbal ability (e.g. vocabulary knowledge). His novelty is related to Cattell’s Gf and automatization to Gc. The type of intelligence that is associated with novelty and automatization sub-theory is creative intelligence.

3. Componential sub-theory

This facet highlights the mental processes underlying intelligent behaviour. It reveals the components involved in information processing. Mental processes start by perceiving sensory input and end by transferring it into abstract knowledge or action (output). Each component is argued to hold three properties: duration (i.e. the length of time allocated for doing operations), difficulty, and probability of execution. The type of intelligence related to this facet is analytical intelligence. Sternberg speculates that IQ tests measure this aspect as well.

Sternberg's theory has drawn the attention of many researchers for tackling social skills and contextual factors in addition to psychometric issues. When traditional teaching methods put emphasis on learners' linguistic and mathematical skills, this theory allows for analysis, creation and application of their knowledge. Grigorenko and Sternberg (2001) point out that in order for a teaching instruction to be successful, it should vary between analytical, creative and practical practices. In spite of its fame, this theory has received criticism for considering practical and social skills more than cognitive abilities. In addition, it does not provide a new explanation of the concept of intelligence as Sternberg's three sub-theories are related to previous views. For example his componential sub-theory is related to g factor, and automatization and novelty sub-theory is related to information processing views. Besides, similar to Gardner's MI, Stenberg's intelligences remain a theory as there has been no evidence to prove them.

Despite the wide popularity of Gardner's MI and Sternberg's Triachic theories of intelligence, there has been a shift back to the general factor. Linda Gottfredson (in Yam, 1998) is another researcher who revived the existence of the *g* factor. She strongly affirms the existence of a general ability underlying all human cognitive behaviour. She defends her position by reviewing all previous researchers views of the existence of *g*; for example, Spearman's *g*, Horn and Cattell fluid and crystallized intelligences which are themselves correlated highly with *g*, Carroll's three stratum theory in which stratum III that consists of *g* is the major component of both stratum I and II. All these varying views do reflect the controversial nature of intelligence and might be a sign of a never-ending debate concerning this construct.

1.1.3. Tests of intelligence

Early attempts to measure human intelligence started with the work of Galton in the 1880s. The British scientist Francis Galton developed the first test that discriminates between adults and children in intellectual ability. However, his tests did not go beyond simple physical tools (e.g. the discrimination between weights using senses). Although this scientist is the first to develop a mental test, the term 'mental test' was not adopted until the coming of the American researcher James McKeen Cattell. (Urbina, 2004)

Nowadays, various and more developed standardized psychometric measures of intelligence have been developed to be the most opted tools that determine individuals' cognitive ability. The most widely known measures are: Binet's tests, Wechsler's scales, Raven's tests, and Woodcock Johnson measures.

1.1.3.1. Binet's tests

The French psychologist Alfred Binet is known as the creator of the first intelligence test. He is also considered an eminent researcher in the realm of intelligence in normal and retarded pupils. Binet (1904) was interested in the study of French retarded pupils who were incapable of grasping the educational curriculum, and managed a program that was beneficial to their abilities. His work started with his student Simon to conduct a test that discriminated between these children's abilities (1905 Scale). Binet and Simon scale was composed of 30 tasks independent of school tests like vocabulary, understanding, differentiation between objects, items completion, and drawings. These tasks varied in performing skills and the degree of difficulty. The first task was accessible to all levels, even retarded pupils (for instance touching nose or eyes); however, the last task was too demanding and required explanation of abstract concepts. Binet's test was first given to a sample of 50 normal children ageing between 3 and 11 years old. A significant observation indicated that there were tasks that 7 but not 5 years old can solve. The same test was given to retarded pupils and the results were compared.

Unlike Galton, Binet believes that intelligence is not stable, but rather develops through education and social interactions. Moreover, he assures that it is associated with higher processes like memory, comprehension, judgement and imagery (Pellegrino & Kail, 1985). Binet was the founder of the concept 'mental age', or 'level of intellectual functioning' that corresponds to the number and level of difficulty of the problems solved by a group of children of the same age. His scale received some modifications until 1916 where it was published by Terman as the "Standford Binet Test". The term IQ was first introduced by Stern to be later used by Terman to mean the difference between mental age (MA) and chronological age (CA). The formula used is: $\frac{MA}{CA} \times 100$, taking this 100 as an average level, so that scores below it refer to the low average ability and scores above it to above average ability. (Pellegrino & Kail, 1985)

Concerning the theoretical foundations of this test, one would judge that Binet's test is not designed from a clear theoretical basis. "Neither Binet's nor Spearman's "theories" could really be said to provide a satisfactory explanation of what it is to be more or less intelligent." (Sternberg & Kaufman, 2011, p. 9)

Binet's intelligence test has received a number of adaptations. Five editions have been presented with an increasing number of items. As has been mentioned, the first edition of Binet's scale of intelligence (SBIC I) was published by the American psychologist Lewis Terman in 1916. The second and third following editions (SB II & III) were published respectively in 1937 and 1960 by Terman & Merrill. After more than twenty years, the fourth edition (SB IV) was published by Robert Thorndike, Hagen, &Sattler in 1986. The focus in the three last editions shifted to point scale[3] over age scale. In 2003, the fifth edition of Binet's test (SB V) was introduced by Roid. This edition reintroduced the factor of age and shed light on age differences and cognitive abilities. In addition, in this edition, a balance between verbal and non-verbal subscales was used. Examples of non-verbal items are Object Series/Matrices, Procedural Knowledge, Picture Absurdities, Quantitative Reasoning, Form Patterns, Block Span, etc... Six items were presented in the last edition: Knowledge, Fluid Reasoning, Visual-Spatial Processing, Quantitative Reasoning, Working Memory, and Short-Term Memory (Becker, 2003). Binet's intelligence scales are appropriate from age 2 till adulthood (Ary, Jacobs, &Sorensen, 2010).

As far as Linguistic intelligence is concerned, the term per se was not applied in Binet's scales; however, his six subscales focus on measuring this ability. In the first subscale (i.e. fluid reasoning), verbal ability is assessed through tasks like verbal absurdities and verbal analogies; in knowledge subscale through vocabulary; in quantitative reasoning subscale through verbal quantitative reasoning items, tapping

[3] A point scale concentrated on the components of intelligence rather than age differences, while age scale considers age differences more than items in a test.

number concepts, problem solving, and figural geometric measurement-estimation; in visual spatial reasoning subscale through verbal spatial problems that require understanding of directions, identifying spatial relations in pictures, and understanding complex statements of spatial orientations; and in working memory subscale through memory for sentences. (Roid, 2003)

1.1.3.2. Wechsler tests

Another figure that caused an overwhelming influence on intelligence testing is the American psychologist David Wechsler. Wechsler tests started to develop in the thirties to become widely used for several decades. Wechsler's study with Spearman, Cattell and Thorndike aided him to develop his intelligence test with the consideration of their differing views.

In his article "Intelligence defined and undefined: A relativistic appraisal", Wechsler (1975) asserts that his tests of intelligence do not measure reasoning or perception, yet they measure the ability of an individual to solve problems and adapt to novelty. He announces that:

> What we measure with tests is not what tests measure – not information, not spatial perception, not reasoning ability. These are only means to an end. What intelligence tests measure, what we hope they measure, is something much more important: the capacity of an individual to understand the world about him and his resourcefulness to cope with its challenges. (Cited in Sternberg and Kaufman, 2011, p. 26)

The first Wechsler intelligence measure was labelled ‘The Wechsler Bellevue I’. This was published in 1939 and became known as the Wechsler Adult Intelligence Scale (WAIS) (Urbina, 2004). The second edition, the Wechsler Adult Intelligence Scale Revised (WAIS-R), appeared in 1981. A new version of Wechsler (WAIS III) appeared in 1997. This scale consists of 14 subscales that measure verbal IQ, performance IQ and full scale IQ. Wechsler scales were developed to tackle intelligence for different age groups like the Wechsler Intelligence Scale for Children (WISC). (Axelrod, 2001)

Two major scales were included in Wechsler measures: verbal scale and performance scale. Verbal scale, or as we refer to as Linguistic intelligence scale contains a variety of subtests: Vocabulary, Similarities, Arithmetic, Digit Span, Information, and Comprehension. Performance scale includes the following subtests: Picture Completion, Digit Symbol (Coding), Block Design, Matrix Reasoning, and Picture Arrangement. (Axelrod, 2001)

Concerning the theoretical foundation of this test, Wechsler scales were based on Vernon’s (1950) view of intelligence where ‘g factor’ is placed on the top of the hierarchy and three sub-factors were derived from it such as: verbal factor and spatial factor at the second level. Wechsler considered Horn and Cattell Gf and Gc (1966) as well. His verbal IQ test is an example of crystallized intelligence, while his performance IQ is an illustration of fluid intelligence. (Grégoire, 2004)

Unlike Binet’s IQ score which is obtained by the formula MA/CA*100, Wechsler adopted the technique of ‘deviation IQ’. This score is calculated by adding all the scores obtained in the subscales and calculating the sum of these scores in a normative table. (Urbina, 2004)

1.1.3.3. Raven's Progressive Matrices

Another widespread measure that considers narrow abilities of general intelligence is the Raven Progressive Matrices test (RPM). Raven (1936) sought to develop easier intelligence tests from a strong theoretical background. Raven's tests rely primarily on Spearman's g factor as well as Horn and Cattell Gf. Different from the two previous tests which are considered culture-bound, the Raven's Progressive Matrices culture-free nature enables the test takers from all over the world to take it. The tasks in this test measure basically visual problem solving like visual similarity and analogy.

Raven developed another test for verbal ability which is referred to as Raven's Mill Hill Vocabulary Scale (MHV). The participants in this test are given a list of words with increasing difficulty to define. 50% are multiple choice questions and 50% are open ended questions. (Raven, 2000)

1.1.3.4. Woodcock-Johnson Tests of Cognitive Abilities

This is another current measure of individual's mental ability. This test contains a set of items that assess cognitive ability, achievement and interest level. Woodcock Johnson tests measure both Cattell's Gf and Gc. The different sub-scales of cognitive ability are: comprehension knowledge, long-term retrieval, visual and spatial thinking, auditory processing, fluid reasoning, processing speed, and short-term memory. (Schrank, 2010)

1.3. The influence of intelligence on language learning

Intelligence, aptitude and ability all refer to cognitive skills and processes. While aptitude denotes one particular skill associated with language, i.e. language aptitude, intelligence is a broader term that involves a set of skills such as spatial, musical and mathematical abilities. People, whether adults or children, differ in their capacity to learn a language. These individual differences could be explained with reference to intelligence in general and language aptitude in particular. (Dòrnyei, 2005)

Psychometric theories of intelligence associate this ability with the capacity to learn. Spearman claims that achievement inside and outside school is an illustration of his *g factor*. Binet as well associates success in learning with intelligence. Similarly, all Thurstone's mental abilities were found to affect learning. Vernon's verbal educational ability is also associated with learning. Add to this, Cattell's crystallized intelligence is believed to develop through education.

In spite of the fact that all psychometricians stress the importance of learning in explaining intelligence, IQ findings (in Dòrnyei, 2005) did not show a strong relationship between intelligence and language learning which is a facet of learning. Rather, success in language learning, and particularly foreign language learning, is believed to be influenced by a number of cognitive abilities and not general intelligence. Carroll and Sapon (1959) identified four main cognitive abilities which are grouped under the umbrella term 'language aptitude', claiming that they affect language learning (Dòrnyei, 2005). These abilities were referred to as: phonemic ability, grammatical sensitivity, inductive language learning ability and memory ability. The influence of these cognitive abilities on foreign language learning will be reviewed in the coming chapter (c.f. chapter 2.4).

Modern views, however, showed a significant relationship between intelligence and the ability to learn a foreign language. Sternberg's triarchic theory and Gardner's MI theory are examples of these views. On the importance of MI theory in learning, Gardner (2001, in Gardner, 2011, p. xxxviii) points out that:

> Seven kinds of intelligence would allow seven ways to teach, rather than one. And any powerful constraints that exist in the mind can be mobilized to introduce a particular concept (or a whole system of thinking) in a way that children are most likely to learn it and least likely to distort it.

Gardner's MI theory provides explanation of how different intelligences influence the acquisition of different aspects of language. Musical intelligence, for example, allows for the acquisition of intonation of the FL. Bodily-kinesthetic intelligence affects the learning of phonology. And interpersonal intelligence affects learning through communication and cooperation. (Brown, 2007)

Richards and Rodgers (1986) also highlighted the importance of applying MI in language learning through indicating that:

> It certainly is fair to say that MI proposals look at the language of an individual, including one or more second languages not as an "added on" and somewhat peripheral skill but as central to the whole life of the language learner and user. In this sense, language is held to be integrated with music, bodily activity, interpersonal relationships, and so on. Language is not seen as limited to a "linguistics" perspective but encompasses all aspects of communication. (p. 117)

In spite of the usefulness of MI theory in language learning, there has been no syllabus involving teaching through multiple intelligences. The idea is rather recent and lacks some elements that could provide a direct link with language learning. Richards and Rodgers (1986) are considered the first to provide attempts in applying MI in language learning through proposing a sequence (Lazear's sequence, 1991) that could be helpful in language teaching following MI view. This sequence is made up of four stages: "awaken the intelligence—amplify the intelligence—teach with/for intelligence—and transfer the intelligence".

Similar to Gardner's view, Sternberg's triarchic theory of intelligence is also believed to affect language learning. The three proposed types of intelligence are argued to improve foreign language learning. For example, componential ability contributes in learning analytical thinking skills; experiential ability facilitates creative thinking; and contextual ability allows for adaptation to the learning environment (Brown, 2007). Sternberg and Kaufman (1998) contend that schools focus only on developing analytical skills and ignore other abilities. They claim that children with other types of intelligence, e.g. creative or practical, tend to grasp less the teaching syllabus. As a result, these researchers call attention to the importance of the application of triarchic theory in language teaching. They, further, conducted an experiment to investigate children's areas of strength and tried to apply a program that corresponds to these areas. The results showed that the program that matches all students' abilities leads to significant learning outcomes.

The prerequisite role of intelligence in learning in general and language learning in particular that is reviewed in all theories of intelligence (psychometric, cognitive, developmental, and modern) has led us to carry on investigating its impact on foreign language learning achievement. The aim is to design a test of this ability and use it as a selection basis for learners who opt to engage into a tertiary language instruction in order to enhance success. To this end, we have taken this general cognitive ability and hypothesized that it has a significant influence on foreign language learning. This hypothesis will be investigated in the practice (c.f. chapter 7).

1.2. Reasoning

1.2.1. Definition of reasoning

A clarification of the concept of reasoning requires first going through the term thinking. Thinking is considered the highest mental process involving the process of reasoning.

In everyday language, thinking is defined as the belief. For example, saying I think that water is important for life. Linguistically speaking, Merriam Webster's collignate dictionary (2014) defines the term as the act of using the mind to produce ideas, decisions or memories.

In psychology, according to Holyoak and Morrison (2005) thinking is defined as "… the systematic transformation of mental representations of knowledge to characterize actual or possible states of the world, often in service of goals" (p. 02). Thinking is a conscious process that involves a set of mental processes that function to reach desired goals that are themselves helpful in the accomplishment of cognitive activities.

Reasoning is an aspect of thinking that involves the drawing of inferences from a set of premises using logic (Holyoak & Morrison, 2005). The following figure illustrates the mental actions that appear in thinking in which reasoning is considered as an aspect.

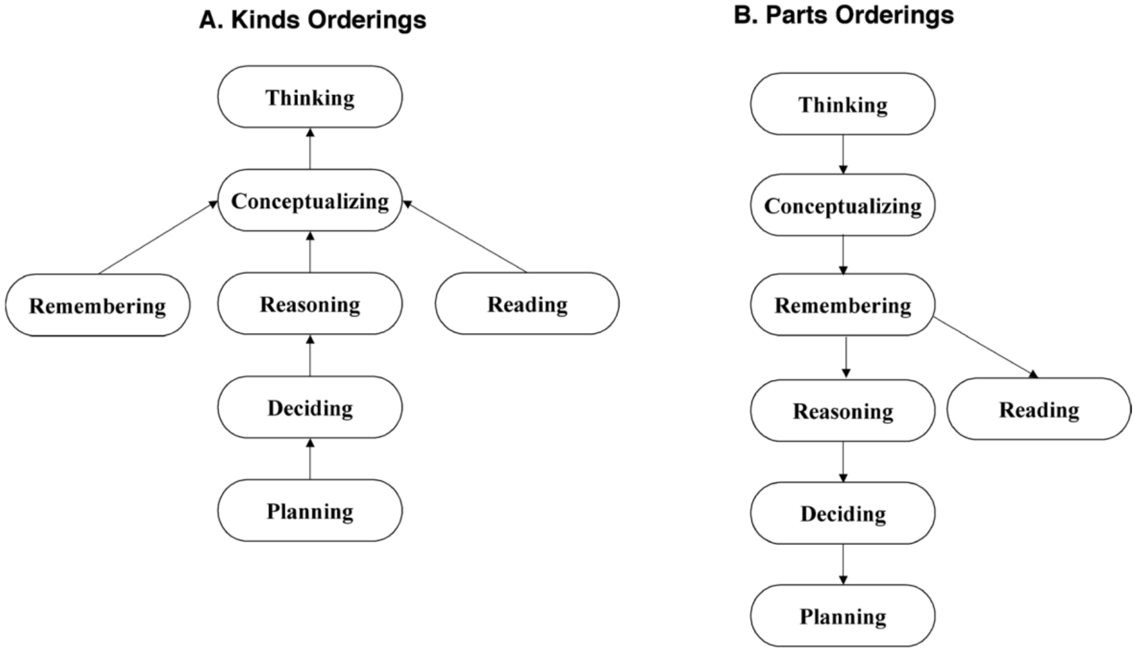

Figure 2. Mental Activities in Thinking (by Rips & Conrad, 1989, cited in Holyoak & Morrison, 2005, p. 3)

Raymond Nickerson (in Leighton & Sternberg, 2004) gives a broad definition of reasoning. He states that "(it is) an aspect of thinking that is involved not only in drawing inferences but in making decisions and solving problems as well." (p. 3)

Nickerson's definition centres the importance of reasoning in various cognitive actions like making inferences from given premises, making decisions to reach desired goals, and solving problems. For example, in problem solving goals, the process of reasoning starts to work as follows: if the process of drawing conclusions is right, then the likelihood of correct problem solving increases as the best strategies will be used (in Leighton & Sternberg, 2004). However, this definition does not explain whether the process functions inductively or deductively. These types of reasoning will be explained later in the section (c.f. section.2.3).

Evans and Over (1996, in Leighton & Sternberg, 2004) add another notion to the concept of reasoning through highlighting the explicit and sequential nature of this process.

They define reasoning as "… an explicit sequential thought process of some kind, consisting of propositional representations" (p. 51). This quotation indicates that there is an involvement of a sequence of rules to reach conclusions from given premises. More explicitly, reasoning doesn't come all at once, but through the application of different rules (Braine, 1978; Rips, 1994), or models (Johnson-Laird, 1983, 1999; Johnson-Laird & Byrne, 1991) to reach a conclusion (Leighton & Sternberg, 2004).

The examination of the aforementioned definitions of reasoning and intelligence indicates that the two concepts are interrelated. In other words, intelligence requires the ability to engage in various forms of reasoning. The aspect of reasoning has long been considered in the history of intelligence. The relationship between the two concepts will be highlighted later in this section (c.f. section 2.5).

As an operational definition, reasoning is defined as a set of "sequential thought processes", that is, the application of a sequence of general rules that are used for reaching conclusions for given premises using inductive and deductive logics (Kenneth, in Leighton & Sternberg, 2004). These rules will be stated later (c.f. section 2.2). Deductive and inductive reasoning are the main highlighted aspects of reasoning in the present study.

1.2.2. Theories (models) of reasoning

In recent years, many disciplines have placed a greater priority on how people reason, and different theories have been developed to explain the process of reasoning. Among these theories is information processing approach, mental models approach, and rule-based approach. A description of each approach is provided below.

1.2.2.1. Information processing approach

Information processing theories of reasoning (Pascual-Leone, 1970; Case, 1985; 1992, in Evans, 2004) deal with cognitive development in the explanation of the construct. These theories claim that mental power is related to age and is linked to the development of working memory capacity. In other words, the more knowledge base children develop, their working memory processes will develop and, hence, allow them to solve more complex problems. Complexity depends on the number of the processes to use and the knowledge representations to be manipulated and maintained. Therefore, the development of conditional reasoning is related with the development of age to construct, maintain, and manipulate the mental models that exist in working memory. (Markovits and Barrouillet, in Evans, 2004)

In addition to the role of cognitive development in reasoning, information processing theories argue about the existence of two separate systems in reasoning referring to them as analytic and experiential systems. While the latter depends less on working memory capacity and develops through age, the analytic system is heavily dependent on working memory processes and is more controlled. Halford and Griffith (In Evans, 2004, p. 148) discussed the difference between the two systems in reasoning through announcing that:

> Unlike experiential processing, analytic processing is directed towards breaking down problems into their component elements, examining these elements, and, from this analysis, deriving solutions, judgments, decisions, and arguments. In further contrast to experiential processing, analytic processing operates on "decontextualised" representations.

Decontextualised analytical processes are further argued to be subject to the development of metacognitive and executive control. In other words, the process of decontextualization develops when the analytic processes are used skilfully. More explicitly, these analytic processes allow for the activation of working memory 'logico-computational processing' structures that function separately from the content. (Stanovich & West, 1997, in Evans, 2004)

Halford and Griffith (in Evans, 2004) summarized the difference between the analytical and experiential processing in the following table:

Experiential Processing	**Analytic processing**
Evolved early	Evolved late
Fast	Deliberate
Automatic	Controlled and effortful
Minimally conscious	Conscious
Operates on contextualized representations	Operates on and constructs decontextualised representations
Involves activation of memories (e.g. beliefs, heuristics, stereotypes)	Involves activation of higher-order reasoning and decision-making abilities
Relies on cursory situational analyses	Relies on precision and breaking down situations into specific elements
Frees attentional resources for analytic processing	Heavy load on working memory
Operates independently from general intelligence	Operates in cooperation with general intelligence and metacognitive abilities

Table1. Characteristics of the Experiential and Analytic Processing Systems (p. 149)

Experiential and analytical processing are believed to be more developed in adolescents and adults than children. The reason behind this is that adolescents and adults have more knowledge base, more working memory capacity, and more developed metacognitive abilities. (Halford and Griffith. In Evans, 2004)

1.2.2.2. Mental models approach

Mental models are defined as structures in the mind that represent the state of affairs, either real or imaginary. (Leighton & Sternberg, 2004)

Mental models theory was introduced first by Johnson-Laird and Steedman (1978) to be later applied in the explanation of reasoning by Johnson-Laird & Byrne (1991). This theory claims that one takes meanings of words and knowledge from the world to come to conclusions. Each mental model presents a possibility. According to this model, individual differences in reasoning appear when more premises are given, which lead to the generation of more and complex mental models and decrease the truthfulness of the conclusions.

Leighton and Sternberg (2004) illustrate mental models through two possibilities in spinning a coin: the coin comes down either in head or tail. These authors argue that if the coin has more than two faces, other possibilities (models) will be considered. These models are also argued to represent visual images. For example, the statement “the author is not allowed to own a house”, presents an image for house and author but not for the negative or owning.

Johnson-Laird (1983, in Leighton & Sternberg, 2004) provides a clear explanation of this theory through stating that people go through four stages in making relationships between the given and the integrated premises to draw a conclusion. These stages are:

> Initially, a single model is formed to represent a possible state of the world in which the premises would be true. Next, the reasoned forms a putative conclusion by discovering a proposition that is true in the model and is informative (not a repetition of a premise or a trivial inference). If there are a number of possible

> ways of combining premise models then all combinations should be generated and checked against the putative conclusion until either a counter example to the putative conclusion is found. (p. 52)

Deductive syllogistic reasoning is an illustration of these different stages a person goes through in applying mental models to draw a conclusion. The first stage is *Comprehension stage*. At this stage people understand the premises through the use of language and their prior knowledge. At the second stage *Description stage* there is a description of the premise models and drawing a conclusion from them. The conclusion appears as a novel statement that was not explicitly stated in the premises. The third stage is *Validation stage* which means searching for the premises which seem false; if there is one, then the conclusion is false. The conclusion is valid if there is no premise falsifying it. (Manktelow, 1999)

Manktellow (1999, p. 32) adds another issue in his explanation of mental model approach through announcing that:

> Mental models theory proposes that reasoning is based on the derivation of a structured mental representation of the problem elements, the generation of a possible conclusion, and a search for counter-examples to this conclusion. It predicts that problems requiring multiple models will be more difficult than those requiring single models.

The examination of this quotation reveals the prominent role of working memory capacity in reasoning. The more models a person uses, the higher working memory load is used, and the more difficult the conclusion becomes. Johnson Laird and Byrne (1991, In Manktelow, 1999) illustrate these stages in the following figure:

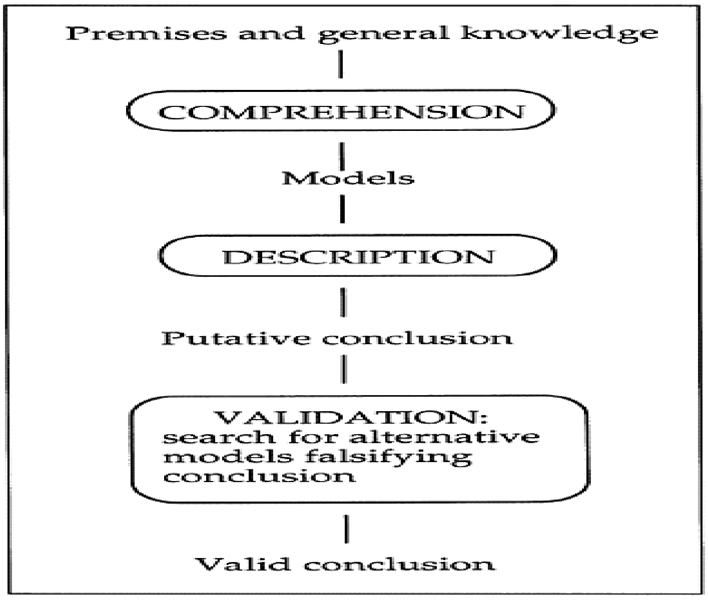

Figure 3. Laird and Byrne's Three Stages of Reasoning in Mental Models Theory (p. 18)

1.2.2.3. Rule-based model

This model is also known as mental rule approach. This approach was introduced by Braine (1978) and then by Rips (1994). Unlike mental model approach that believes in the existence of a set of mental representations, this approach claims that reasoning involves a sequence of rules before reaching a conclusion. People are argued to follow the same approach in reasoning. For example, all adults know to apply the process of ("if p then q, and p, therefore, q"). However, individual differences start to appear when more premises are given and more steps are followed to reach a conclusion, which requires high memory load and decrease the correctness of the conclusion. (Leighton & Sternberg, 2004)

Having explained the two prominent theories of reasoning (i.e. mental model approach and mental rule approach), we examine that these approaches agree on the role of working memory capacity in drawing conclusions. Both theories believe that the errors that appear in drawing a conclusion are due to the use of high working memory load. However, the two views differ in that:

> The mental models approach explains task difficulty in terms of the number of mental models that must be generated and evaluated to test possible conclusions, while the rules approaches offer explanations in terms of the number of steps in a mental logic that must be applied to move from premises to conclusion. (Kenneth, Leighton & Sternberg, 2004, p. 55)

1.2.3. Types of reasoning

People use different ways to evaluate an argument. Research in reasoning highlights two main types: deductive reasoning and inductive reasoning.

1.2.3.1. Deductive reasoning

Deductive reasoning is defined as the act of “reformulating information taken to be true and expressing it or part of it in a conclusion. Each piece of information that is taken to be true is called a *premise* (sometimes an *assumption*).” (Stenning &Monaghan, in Leighton & Sternberg, 2004). This definition highlights two main concepts: premises and conclusion. In this type of reasoning, the conclusions obtained are necessarily drawn from the given assumptions. People go through two main steps in deductive reasoning: they first test the truthfulness of premises; then they go to a conclusion from these assumptions. The conclusion in deductive reasoning is evaluated in terms of correctness. This means that regardless of whether the conclusion presents a logical statement, it should express a logical relationship with the premises. People accept or reject a conclusion according to its logical relation with the premises not according to its logical relation with reality.

Syllogistic reasoning is an example of deductive reasoning. Syllogisms are defined as formal arguments containing a major and a minor premise and a conclusion. Among these syllogisms are Aristotelian syllogisms (All C are B; No A are B; Therefore, no A are

C.). Aristotelian syllogisms contain single instances of four fundamental *quantifier expressions:* All A are B; Some A are B; No A are B; and Some A are not B. These can make up the two *premises* and the *conclusion* that form the classic patterns of a syllogistic argument, known as *moods*. (Manktelow, 1999)

The origins of deductive reasoning are found in philosophy in the early discipline of logic when this latter was considered crucial in human thinking. In the beginning of 1960s, the psychological study of deductive reasoning developed, especially with the work of Piaget and Inhelder (Evans, in Holyoak And Morrison, 2005). Piaget introduced the term logical reasoning. This type of reasoning differs from the deductive type in that while the latter refers to drawing a conclusion from given premises, logical reasoning refers to judging the validity of premises. Despite this difference, the two types work simultaneously. Logical reasoning is a baseline for deductive reasoning. More simplistically, the person has to judge whether or not what he is given is correct first before drawing a conclusion. (Leighton, in Leighton & Sternberg, 2004)

As the present work attempts to measure verbal reasoning skills in new learners of English at university, i.e. adolescents, reasoning in formal operational thinkers is worth to discuss in this section.

- **Piaget's logical reasoning in adolescents**

Piaget and Inhelder (1958) were the first to examine the development of deductive reasoning (Gallagher & Reid, 1981). Making deductive inferences was seen as an aspect of formal thinking that is the final stage in Piaget's cognitive development theory. Formal operational thinkers are claimed to be able to make logical deductions. Unlike concrete operational stage, formal operational stage is also characterized by the following:

- Formal operational thinkers do not come to a conclusion from scratch. There should be previously related information that allows them to come to this conclusion. For example one has to say that “I can conclude that P is true from the previous premises though the observation shows it is wrong”.

- The relationship between deductive inference and empirical observation should be reversed. Unlike in concrete stage where reasoning happens at the level of concrete elements, formal thinkers rely more on inferences than observation when they find a conflict between the two premises. This means that this inference is taken from previous conclusions and observations rather than taking the actual observation.

- There is a relationship between necessity and possibility at this stage. This means that formal thinkers take all possible alternatives to come to a conclusion. Concrete thinkers, on the other hand, are not able to generate all possibilities. “What Inhelder and Piaget (1958) claimed was that the underlying necessity of logical inferences was a function of the ability of a reasoner to conceive of a more or less greater range of possibilities” (quoted in Leighton, in Leighton & Sternberg, 2004). This quotation indicates that the degree of necessity relies on the number of possibilities. In other words, a conclusion is necessary if all the possible alternatives are considered.

Concerning validity, Deductive reasoning is valid if the conclusion drawn comes necessarily from the premises. This means that the conclusion reached should be true if the premises are true (Manktelow, 1999). For example, in Aristotelian syllogisms:

All A are B	e.g. All archbishops are believers
All B are C	All believers are Christians
All A are C	All archbishops are Christians

However, if one of the premises is negative the conclusion drawn will be negative:

No A are B	No Americans are Belgians
All B are C	All Belgians are Christians
Some C are not A	Some Christians are not Americans

1.2.3.2. Inductive reasoning

In the eighteenth century, inductive reasoning was defined as "an activity of the mind that takes us from the observed to the unobserved…. (it is the ability) to take us beyond the confines of our current evidence or knowledge to novel conclusions about the unknown". (Hume, 1739, cited in Holyoak & Morrison, 2005, p.95)

This type of reasoning can be illustrated through inferring that the sun will rise tomorrow from the sentence that the sun rises every day. Inductive reasoning helps in making inferences from causes to effects or vice versa. Hume assumed that the process of induction is not reflective since one doesn't need efforts to move from the observed to the unobserved; it just requires past experience of making similarities and generalizing them. For example, one generalizes that heat will cause fire from seeing heat causing fire in the past. He claimed also that even children and animals are capable of this type of reasoning.

Hume's definition gives insights to contemporary research in reasoning in that similar causes lead to similar effects. Besides, in teaching and learning contexts, associative learning is done through inductive reasoning. However, this is not always the case. The same object can cause different results in varying times. Therefore, Hume was criticized for taking one approach in his explanation of reasoning, which is known as *similarity-based approach*, and which is considered the easiest for it doesn't require efforts. (Sloman and Lagnado, in Holyoak & Morrison, 2005)

More recently, Holland, Holyoak, Nisbett, and Thagard (1986, in Manktelow, *1999*) came with a broader definition of induction through stating that induction is any inferential process that expands knowledge to the uncertainty. This means that an individual, in inductive reasoning, moves from the certain (e.g. rule) to the uncertain (example). A clearer definition of the construct is provided below in the comparison between inductive and deductive reasoning.

Unlike deductive reasoning, induction is judged in terms of strength and not in terms of validity. Inductive reasoning is strong when the conclusion is not necessarily driven from the premises, but when the premises are true. (Rips, 1990)

From the aforementioned explanations of deductive and inductive reasoning, one can distinguish between the two concepts. A clear distinction is that in deduction the process goes from general (i.e. rule) to specific (i.e. instance), while in induction it functions in a reversed manner, i.e. from instances to rules (Manktelow, 1999). Holyoak and Morrison (2005) further add that "... an inference is *deductive* if the truth of the premises guarantees the truth of the conclusion by virtue of the argument form. If the truth of the premises renders the truth of the conclusion more credible but does not bestow certainty, the inference is called *inductive*." (p. 02). Dissimilar to Hume, Carter (2005) asserts that while deductive reasoning requires an indefatigable process, inductive reasoning involves deep understanding. He adds that Solutions in the second type are not guaranteed for the various probabilities it holds.

- **Analogical reasoning**

Analogical reasoning is defined as a type of inductive reasoning that transfers information from one property to another having a similar level of specificity (Rips, 1990).

Holyoak (in Holyoak & Morrison, 2005) provides a clearer explanation of the concept through pointing out that:

> Analogy is a special kind of similarity (…). Two situations are analogous if they share a common pattern of relationships among their constituent elements even though the elements themselves differ across the two situations. Typically, one analog, termed the *source* or *base*, is more familiar or better understood than the second analog, termed the *target*. This asymmetry in initial knowledge provides the basis for analogical transfer, using the source to generate inferences about the target. (p. 117)

Similar to inductive reasoning, analogical reasoning involves a set of mental processes to draw a conclusion. These processes are illustrated in the following figure:

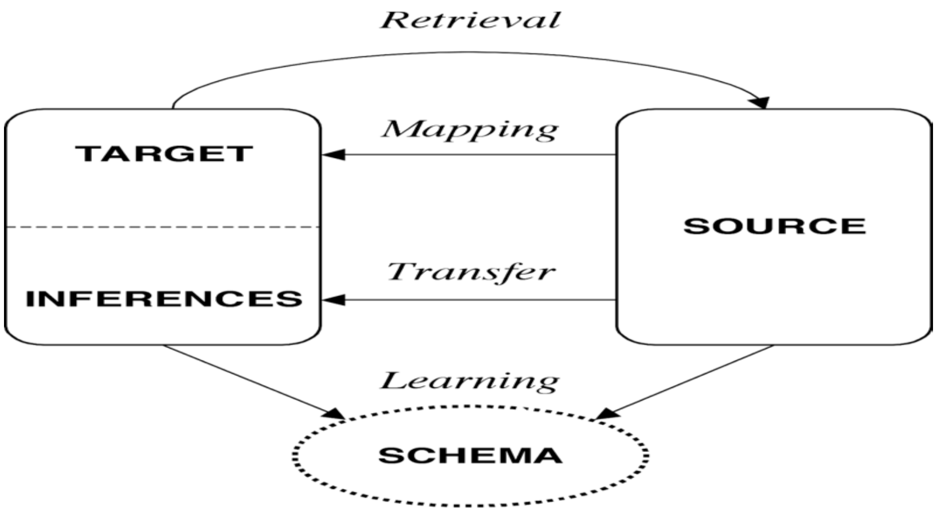

Figure 4. Major Components in Analogical Reasoning (in Holyoak & Morrison, 2005, p. 118)

Schema takes place when the source and the target are both taken as instances, and when there is a generalization of a new abstract schema. Manktelow (1999) distinguishes between three constraints in analogical reasoning:

a. Structural constraint: in this constraint mapping will occur when the target and the source have an identical or similar structure;

b. Semantic similarity constraint: mappings will appear when the source and target share similar elements;

c. And pragmatic centrality constraint: mapping will occur when the goals in the source and target are similarly expressed.

1.2.4. Tests of reasoning

Tests of reasoning vary for the variety of its types. We have seen earlier in the section that deductive reasoning is illustrated through syllogistic arguments, whereas analogical induction is a type of inductive reasoning. Therefore, syllogisms can be considered as a robust measure of deductive reasoning ability, while analogies can be taken as a prominent measure of inductive reasoning skill. An explanation of how these types are measured is provided in this section.

As a type of syllogistic reasoning, there is what is known as categorical logic (Copeland & Radvansky, 2004). This type of reasoning is presented in the form of a syllogism in which the participants are given three categorical propositions, i.e. two premises and a conclusion. These propositions should belong to the same category. This means that each part of the proposition is given twice, e.g. All <u>A</u> are <u>B</u>; some <u>B</u> are <u>C</u>; then all <u>A</u> are <u>C</u>. Copeland and Randavsky (2004) identify four forms of categorical logic: universal affirmative (All A are B), universal negative (No A are B), particular affirmative (Some A are B), and particular negative (Some A are not B).

The role of the subjects in this type of syllogism is to identify what is the major premise (P), middle premise (M) and the minor premise (S), and then they make a conclusion on the basis of these premises, e.g. All philosophers are professors (MP); All philosophers are logicians (MS); Therefore, All logicians are professors (SP). (Kemerling, 2011)

Another type of syllogistic reasoning is conditional reasoning or propositional reasoning (Manktelow, 1999). The easiest type is reasoning with one proposition (P or –P): If (P) is true, then (-P) must be wrong. Another type is with two propositions (P and Q). For these propositions, different generalizations can be made:

P (proposition 1)	**Q (proposition 2)**	**P and Q (conclusion)**
True	True	True
True	False	False
False	True	False
False	False	False
False	False	True

The ultimate two columns in the above table show that the conclusion can be either false or true if the two premises are false. If the conclusion is false, the type of reasoning is called purely conditional deduction, and if it is true it is called bi-conditional deductive reasoning. (Manktelow, 1999)

As far as analogical reasoning is concerned, one type is called proportional analogies. This type is composed of four terms (A: B::C: D). For example, hand: finger::foot:? (Toe). The first two parts are called source, and the second two parts are known as target. Spearman (in Holyoak & Morrison, 2005) identifies three mental processes one uses to draw a conclusion in this type of analogies: encoding of the terms, accessing a relation between the A and B terms, and evoking a comparable relation between the C and D terms.

An instance of proportional analogies is opposite analogies. In this type, the participants understand that the relationship between the first two elements is contradiction and induce the same relationship to the second part (e.g. fire: water:: crying: laughing). Additional examples are: object and classification analogies (e.g. knife: weapon:: red: color), object and related object analogies (e.g. cat: kitten:: dog: puppy), object and group analogies (e.g. tree: forest), degrees of a characteristic analogies (e.g. tired: exhausted:: cold: freezing), cause and effect analogies (e.g. fire: burn::read: learn), effort and result analogies (e.g. build: house:: write: letter), problem and solution analogies (e.g. unemployment: job application:: tired:sleep), tense analogies (e.g. walk: walked:: eat: ate), etc. (analogies, 2011)

Intelligence tests centre two categories of reasoning, viz. verbal and non-verbal. Our concern in the present study is verbal reasoning. This type of reasoning measures the capacity to understand and ‘play’ with words like choosing the right synonym or antonym, giving word meanings, or completing sentences. (Carter, 2005)

As mentioned earlier, more complex reasoning tasks reveal individual differences in reasoning ability as they require an effortful process, i.e. attention and high working memory load. Therefore, our verbal reasoning tasks should be chosen on this basis. This means that a pilot test will be given to assess the degree of complexity of these tasks, and those which will be found accessible to everyone not revealing individual differences will be omitted in the final reasoning measure.

1.2.5. The relationship between reasoning and intelligence

From early views of intelligence, reasoning ability has been thoroughly focused on in the explanation of human cognitive ability. While some considered it as the core factor of intelligence (e.g. Spearman, 1904), others viewed it as a mandatory aspect (e.g. Binet, 1905; Wechsler, 1975; Cattell & Horn, 1967, etc.).

We have reviewed earlier (c.f section 1.1) some definitions provided by traditional psychologists of the concept of intelligence and noticed that most of these notions addressed the skill of reasoning. Besides, the English pscyhometrician Charles Spearman (Sternberg & Grigorenko, 2002) considers the ability to deal with difficult and abstract relations as the main aspect of his g factor. Therefore, non-verbal reasoning tasks (e.g. analogies tasks) are considered measures of this factor.

The French psychologist Alfred Binet is another psychometrician who measured intelligence through tasks requiring judgment. All the items in the Binet and Simon scale of intelligence (1905) assess some aspects of reasoning irrelevant from school education. Examples of these items are vocabulary, comprehension, identifying differences between concepts, recalling numbers, drawing, following directions, etc.

Despite the fact that Thurstone (1938) disagreed with Spearman and Binet about the existence of a general factor underlying intelligence, he tackled three main aspects of reasoning in his PMA measure. For example, the items that measure the space factor are considered measures of spatial reasoning ability, as they require making judgment about whether the rotated objects in space are the same or different. Similarly, his induction factor is another appellation of inductive reasoning ability. This factor is assessed through tasks that require inference of what comes next in a series of letters, numbers, words, etc. Thurstones's deduction factor could also be named deductive reasoning skill for it requires deriving a conclusion from given data. (Pellegrino & Kail, 1985)

As our major purpose in the current work is to measure one type of intelligence, which is named linguistic intelligence, verbal reasoning ability will be assessed and will be hypothesized as an important factor. In measuring verbal reasoning skill, we will consider Thurstone's two last factors, i.e. inductive and deductive reasoning abilities. Inductive reasoning will be measured through two subtests: knowledge subtest and analogies subtest, while deductive reasoning will be assessed through three subtests: similarity subtest, understanding relations subtest, and analogies subtest. A description of these subtests is provided in the practical part (c.f. chapter 5.1.4.3).

In addition to Spearman and Binet, Vernon is another proponent of the g factor. This researcher placed general intelligence as the highest level of cognitive abilities dividing it into verbal educational (v:ed) and spatial mechanical factor (k:m). Reasoning and a variety of specific abilities like memory, speed, and attention are included under the first factor. Spatial reasoning, as another type of reasoning, is an aspect of the second factor.

Reasoning is also perceived as a crucial aspect of intelligence for Cattell and Horn (1966, in Anderson & Reid, 2005). The theory of fluid and crystallized intelligence highlights two main types of reasoning: verbal and non-verbal. Verbal reasoning is believed to be related to crystallized intelligence and is measured through a number of tasks like vocabulary, word analogies, etc., whereas non-verbal reasoning is considered an aspect of fluid intelligence and is measured through tasks such as matrices, figure classification, arithmetical reasoning, etc.

While psychometricians consider reasoning ability an important aspect of intelligence, developmental psychologists adopt measures of reasoning to explain human intelligence. Piaget's (1958) conservative problems which require the ability to reason deductively are examples of these measures (in Leighton & Sternberg, 2004).

Reasoning ability is not only considered a noticeable feature of intelligence for psychometricians and developmental scientists but also for modern psychologists. Although Gardner (1983) and Sternberg (1985) associate intelligence with a variety of abilities, they stress the importance of reasoning. Gardner (1983, in Gardner, 2011) highlights this latter in his MI theory mainly in logical mathematical intelligence. As the name indicates, logical mathematical intelligence requires the application of logical and mathematical thinking to solve problems. Gardner (1983) indicates that "… the most central and least replaceable feature of the mathematician's gift is the ability to handle skillfully long chains of reasoning." (p. 147). Besides, he illustrates another type of reasoning, i.e. spatial reasoning or abstract reasoning, in spatial intelligence type. Spatial reasoning refers to judging whether or not two objects rotated in the space are identical.

In addition to Gardner, Robert Sternberg (1985, in Grigorenko & Sternberg, 2001) identifies reasoning ability as an underlying aspect of his analytical intelligence. This type of intelligence is claimed to be identical to Spearman's g and is measured through fluid and crystallized tests. Fluid tests are abstract reasoning measures that involve items like matrices completion, whereas crystallized tests include verbal reasoning tasks like analogies, synonyms and antonyms.

1.2.6. Developing reasoning

Is it possible to improve the skill of reasoning? Reasoning ability is argued by many psychologists to be subject to development. Similar to intelligence, some experts attribute the development of reasoning to the evolution of human cognitive system (Piaget & Inhelder, 1958; Keil, 1998), while others associate it with thorough practice (Kuhn, Katz, & Jr., in Evans, 2004).

Proponents of age for the development of reasoning believe that people go through different stages of cognitive development. Reasoning, which is considered an important aspect of intelligence, is believed to develop in the development of the human mind. Piaget's conservative problems (in Pellegrino & Kail, 1985) indicate that it is only in the formal operational stage (around 11 years) individuals' thinking goes beyond concrete objects, and that more developed formal reasoning appears.

The issue of the effects of practice on developing reasoning was dealt with in the early past. John Stuart Mill (1806-1873) speculated that one aspect of deductive reasoning, which is logic, is developed through teaching. He assumed that "…the theory of names, propositions, and the syllogism, that there is no part of intellectual education which is of greater value, or whose place can so ill be supplied by anything else" (quoted in Leighton & Sternberg, 2004, p. 417). In recent years, Nickerson (1996, in Leighton & Sternberg, 2004) has advocated that reasoning can be ameliorated through a systematic instruction. Many attempts have been made to the application of practical procedures to the teaching of reasoning. For example, Sternberg (1987, in Leighton & Sternberg, 2004) conducted an experiment to test the teaching of reasoning under different conditions. He selected 81 participants and gave them a number of reasoning tasks as a pretest (e.g. the induction of word meanings). Then he divided the participants into five conditions: two control conditions and three experimental conditions. In the control conditions there was no formal instruction: in the first condition the subjects directly took the post-test without any treatment, and in the second condition they received practice on reasoning but without any formal instruction. In the first experimental condition, the subjects were taught *"knowledge-acquisition component"* processes (e.g. how to encode, compare, and combine information) that can be employed in the induction of word meanings. In the second experimental condition, they were taught to use context cues like antonyms or functional relations. In the third condition, they were taught to use mediating variables such as the position of the unknown. The results showed that the participants engaged in the three experimental conditions had better results in comparison to their peers in the control groups. Sternberg's experiment added evidence to the role of a formal instruction in improving reasoning abilities.

Another aspect of reasoning, which is creative reasoning, is also claimed to develop through teaching. Sternberg and Grigorenko (2000, in Leighton & Sternberg, 2004) designed a program for the teaching of this type of reasoning. A sample containing 86 participants (gifted and non-gifted) was selected to engage in this experiment. A pretest was given to all the participants, and then the sample was divided into two groups: the first group received regular instruction, while the second received instruction of insightful thinking. A posttest was then given to both groups. The results revealed an increase in scores for those who received knowledge acquisition components in insightful thinking.

Furthermore, practical reasoning skills can also develop through instruction. Another program was developed by Williams et al. (2002, In Leighton & Sternberg, 2004) to teach middle-school students. The students, who did homework, took notes, red and wrote about developing this type of reasoning showed better scores in comparison to those receiving no instruction.

Conclusion

Throughout this chapter we have highlighted the concepts of intelligence and reasoning. The first section that has entirely been devoted to intelligence has shown that the construct is such a complex phenomenon that cannot hold a single or definite explanation. Definitions of this term vary for the variety of its nature. For example, psychometricians have agreed that intelligence is what IQ tests measure, yet they have disagreed in determining the number of factors underlying it. For example, some psychologists have considered it as a single ability (general intelligence); others have viewed it as a binary capacity (e.g. fluid and crystallized intelligence); and still others have perceived it as a set of distinct abilities. Developmental psychologists, on the other hand, have shifted attention to the development of human cognitive system in their explanation of intelligence. Contemporary psychologists have expended intelligence to real life behaviour by proposing novel types like personal, bodily kinaesthetic, musical, and spatial for Gardner (1983); and social, practical, and creative for Sternberg (1985).

Two major tests that attempt to measure human intelligence have also been reviewed in this section: Binet's measures and Wechsler scales. The different components of these tests have been identified and various versions have been introduced. The section has also drawn attention to the important role of this ability in learning. Language learning which is considered an aspect has also been revealed to be affected by this cognitive ability.

In the second section, we have shed some light on reasoning ability. We have presented different models of how people reason. In addition, we have introduced different types of this ability with their corresponding measures. We have also provided an overview of the relationship between reasoning and intelligence. The section ends with drawing attention to the possibility of developing reasoning ability.

Chapter Two

Language Aptitude: A Literature Review

Language Aptitude: A Literature Review

Introduction

Individual differences in foreign language learning have received the lion's share of attention in the field of Second Language Acquisition (SLA). Researchers use such a concept to explain a variety of aspects that influence learning a second or a foreign language. Cognitive, affective, social, and linguistic are different concepts employed by individual differences (ID) research to explain second language acquisition. Language aptitude is believed to be an important cognitive aspect that underlies success in SLA.

In this chapter we will shed some light on the concept of language aptitude. We will clarify the term by presenting different definitions and introducing its different components. We will also review some debates concerning the nature of this construct, together with highlighting the role of this ability in language acquisition. Since one of the current research aims is to investigate whether language aptitude is an aspect of linguistic intelligence, it is necessary for us to provide a literature review on the relationship between language aptitude and intelligence. Finally, we will consider some theoretical evidence on the link between language aptitude and working memory.

2.1. Definition of language aptitude

The term aptitude, according to Merriam Webster's dictionary (2014), denotes the ability to learn. Language aptitude is, therefore, the capacity to learn a language. Although this definition is rather general, it would provide insights to the scientific explanation of the concept.

Despite the fact that all scientists agree that language aptitude is the capability to learn a language, their notions vary for the variety of the nature and components of this capacity. For example, Carroll and Sapon (1959) considered language aptitude as an "umbrella term" involving a set of cognitive capacities (i.e. phonemic ability, grammatical sensitivity, inductive language learning ability, and memory ability) that facilitate foreign language learning. (Dörnyei, 2006)

Carroll and Sapon characterization of language aptitude indicates the dynamic and multi-componential nature of this ability. Besides, these researchers claimed that this construct presents a fixed ability that predicts both the rate and the speed of language learning. (Ranta, 2008)

Dörnyei (2005), on the other hand, asserted that aptitude is a general ability that facilitates learning. He perceived this capacity as an aspect of intelligence. Another view supporting aptitude as a feature of intelligence is the one of Sternberg and his colleagues. Grigorenko, Sternberg and Ehrman (2000) defined language aptitude in terms of the ability to cope with novelty in foreign language learning.

Robinson (2000, in Robinson, 2005), in his explanation of language aptitude, introduced novel concepts such as *implicit, incidental* and *explicit learning.* Similarly, he related language aptitude with different stages of language acquisition. He (2005, p. 46) opined that language aptitude refers to " …strengths individual learners have -relative to their population- in the cognitive abilities information processing draws on during L2 learning and performance in various contexts and at different stages".

Recent research findings on language aptitude called attention to the role of working memory capacity in the explanation of language aptitude. Wen and Skehan (2011) empirical findings urged them to define language aptitude in terms of working memory capacity (c.f. 2.6).

The previously stated definitions reflect varying perceptions of the concept of language aptitude. Researchers' perceptions, as indicated above, varied according to the variety of purposes. Some focused on the components of this ability in its explanation (e.g. Carroll and Sapon, 1959); others stressed its relationship with other cognitive capacities (e.g. Dörnyei, 2005; Wen & Skehan, 2011); and again others associated the term with different contexts and stages of language acquisition (Robinson, 2005). We will highlight the different components of language aptitude, its relationship with other cognitive abilities, and its role in second language acquisition later in this chapter.

As an operational definition, language aptitude is used to refer to a set of cognitive capacities that help learning a language, and in the context of our research to learn English as a foreign language. These capacities are: phonetic ability, grammatical sensitivity, and inductive language learning ability. Phonetic ability means the capacity to perceive sounds of the foreign language, make associations with symbols, and retain these associations; grammatical sensitivity refers to the capacity to recognize different grammatical functions; and inductive language learning ability means the ability to internalize foreign language structures (Carroll, 1993). Most researchers in the field of language aptitude agree about these components (e.g. Carroll & Sapon, 1959; Pimsleur, 1966; Skehan, 1998). Although memory ability is believed to be a valuable component of language aptitude (e.g. Carroll & Sapon, 1959; Skehan, 1998), it is not considered as a component of this ability in the current study. In the present research, we hypothesize this ability, and mainly working memory capacity, as an important factor of Linguistic intelligence and, hence, a distinct variable in our investigation.

2.2. Theories of language aptitude

We have mentioned earlier that theories of language aptitude vary for the variety of purposes. One debate concerns the identification of language aptitude components. Another debate is triggered by the variety in nature of this ability. This section will present the main theories of language aptitude: those dealing with its components, and those addressing its nature.

2.2.1. Components of language aptitude

2.2.1.1. Carroll's components

In investigating the number of components underlying language aptitude, Carroll and Sapon (1959) started by trying possibly useful aptitude tests, about 30 tests (Wesche, Edwards & Wells, 1982), and made some statistical measures such as factor analysis and correlational study; then, they examined inter-correlations between different items. In1965, the first reliable aptitude measure 'Modern Language Aptitude Test' emerged and was abbreviated as the MLAT. In this measure, Carroll identified four distinct components of aptitude that facilitate foreign language learning: phonemic coding ability, associative memory, grammatical sensitivity, and inductive language learning ability. (Skehan, 1998)

a. Phonetic (phonemic) Coding Ability

This component is presented through the identification of different sounds, associating them with symbols and retaining these associations. Different mental processes are required for this component: coding, assimilation and remembering. Phonetic coding ability was extensively focused on in language aptitude measures and was claimed to be as the major component of this ability. (Dörnyei, 2010)

b. Grammatical sensitivity

The second component of language aptitude involves awareness of grammatical relationships rather than grammatical terminology (Dörnyei, 2005). This means that grammatical sensitivity is measured through the choice of similar functions from a number of alternatives without giving any grammatical terms.

c. Rote memory ability

Language aptitude third component refers to the quick learning and retention of associations between sounds and meanings. Skehan (1998) claimed that this component does not play an important role in foreign language learning since it doesn't require an effortful process.

d. Inductive language learning ability

Carroll (1973, cited in Wesche et al., 1982, p. 130) defined this component as the "ability to examine language material…and from this to notice and identify patterns of correspondences and relationships involving either meaning or grammatical form". Inductive language learning ability was considered, by Carroll, as an important component of language aptitude, even though it was weakly presented in his measure (i.e. the MLAT test, c.f. section 3.1).

Later, in 1993, Carroll added a new component to language aptitude referring to it as 'Cognitive Speed'. Cognitive speed implies "…how quickly one produces answers, both correct and incorrect, to problems of moderate difficulty" (quoted in Sparks, Javorsky, Patton, & Ganschow, 1998, p. 84). This ability is itself divided into different subcomponents: *Semantic Processing Speed*, or the speed of verbal reception; *Word Fluency*, or the speed of word retrieval; *Verbal Ability*, or general verbal knowledge; and

Semantic Fluency, or the speed of idea reception and production. Carroll’s cognitive speed focused mainly on syntax and phonology, general knowledge and general vocabulary.

2.2.1.2. Pimsleur’s components

Unlike Carroll, the applied linguist Paul Pimsleur (1966) proposed different components of language aptitude. In his test ‘The Pimsleur Language Aptitude Battery’, or the PLAB, Pimsleur highlighted three main components: linguistic intelligence, that is knowledge of words and the ability to use them to reason logically; Interest, or learners motivation to learn the foreign language; and auditory ability, which refers to the ability of receiving information through the ear. (Dörnyei, 2005)

Pimsleur’s components seem dissimilar to those of Carroll, yet two of them have just different appellations. Linguistic intelligence is identical to Carroll’s grammatical sensitivity and inductive language learning ability, and his auditory ability is the same as phonetic coding ability (Dörnyei, 2005).

It is worth mentioning that the founders of language aptitude test, Carroll and Pimsleur, have different scientific qualifications. Carroll has a background in Psychology and Learning, while Pimsleur has a career in Linguistics. Thus, the PLAB is primarily linguistic for it focuses on auditory factors (i.e. sound-symbol association), whereas the MLAT is primarily psychological as it stresses memory factors (phonetic script). In addition to the linguistic tendency, Pimsleur broadened his view by including some motivational factors like interest component. (Dörnyei, 2005)

Dörnyei (2005) pointed out that some aspects are not covered in one test but are considered in the other test. More specifically, the MLAT covers some points that the PLAB fails to, and some points are better tackled by the PLAB than the MLAT. For example, the PLAB doesn't include memory component, whereas the MLAT does. On the other hand, the MLAT doesn't target inductive language learning ability directly, but the PLAB does. Similarly, the PLAB includes motivation, whereas the MLAT doesn't (Dörnyei, 2005). A further description of the MLAT and the PLAB is provided in the coming section.

2.2.1.3. Recent views of language aptitude components

While Carroll focused on phonetic coding ability, grammatical sensitivity, inductive language learning ability, and rote memory in his MLAT, and Pimsleur centered linguistic intelligence, interest, and auditory ability in the PLAB, other studies added new other components. After conducting factor analysis study between different measures of L2 success (e.g. word decoding, reading comprehension, spelling, listening comprehension, vocabulary, phonological awareness, group achievement, L1 aptitude or IQ, and L2 aptitude or the MLAT), Ganschow, Sparks, Javorsky, and Patton (1992, as cited in Sparks et al., 1998) indentified three different components of language aptitude: phonology/ syntax, cognition/semantics, and FL aptitude. The study of Sparks et al. (1998) even highlighted somehow similar components: phonology/ orthography, syntax and semantics. In a recent study, Sparks, Patton, Ganschow & Humbach (2011) increased the number of language aptitude components into six: phonetic coding, phonological processing, language analysis, intelligence, memory, and affect (motivation).

Similar to Sparks and his colleagues view, other researchers shifted attention to new cognitive abilities, considering them as different components of language aptitude and asserting that they have an influence on SLA. For example, ten basic cognitive skills were identified: Processing Speed (PS: Anderson, 1992), Pattern Recognition (PR: Sasaki, 1996), phonological working memory capacity (PWMC) and speed (PWMS), Semantic

Priming (SP), Lexical Interference (IN), Text Working Memory Capacity (TWMC), Text Working Memory Speed (TWMS), Grammatical Sensitivity (GS), and Rote Memory (RM). (Cited in Robinson, 2005)

Skehan was another contemporary researcher working in the sphere of language aptitude. This linguist (1986, in Skehan, 1998) suggested that the MLAT would be caught into three main sub-components instead of four, reducing Carroll's two subcomponents of grammatical sensitivity and inductive language learning ability into language analytic ability, and putting focus on the role of memory ability. His view was based on the argument that both Carroll's components of grammatical sensitivity and inductive language learning ability refer to knowledge of the grammar of the foreign language, and that grammatical sensitivity is seen at the level of one word whereas inductive language learning ability relies on larger units. He (in Skehan, 1998, p. 204) defined analytic ability as "the capacity to infer rules of language and make linguistic generalizations or extrapolations" .

In focusing on the component of memory, Skehan (1998) speculated that there are individual differences in the reliance of this system. This means that some rely on it for structures (form-oriented computational approach); others rely on it for meaning (meaning-based system). Skehan shifted between these systems according to changing situations and task demands. Similarly, he highlighted two types of coding: dual-coding, which has relation to rules and which was claimed to be creative and controllable, and memory-based coding, which has relation with meaning and which was believed to be mechanical and less controllable.

In addition, Skehan's interest in information processing theory of learning led him to relate language aptitude components to different stages of SLA, creating other components which were not covered by previous aptitude tests (Dörnyei, 2006). Skehan (1998) advocated that phonemic coding ability plays a significant role at the early stage where noticing takes place, whereas grammatical sensitivity is quite relied on at later stages when patterning takes place, and memory is considered crucial at the final lexicalizing stage when fluency is achieved. The following table illustrates the role of aptitude components in the different stages of language acquisition.

SLA stages	**Corresponding aptitude constructs**
Input processing strategies (segmentation)	Attentional control Working memory
Noticing	Phonetic coding ability Working memory
Pattern identification	Phonetic coding ability Working memory Grammatical sensitivity Inductive language learning ability
Pattern reconstructuring and manipulation	Grammatical sensitivity Inductive language learning ability
Pattern control	Automatization Integrative memory
Pattern integration	Chunking Retrieval memory

Table 2. Skehan's Language Aptitude Components and SLA Stages (cited in Dörnyei, 2006, p. 50)

Furthermore, Skehan (1998) claimed that people differ in their ability of aptitude components in that some may show a good phonemic ability and less linguistic analytic ability. He added that success in language learning is influenced by different components of language aptitude. More explicitly, some learners succeed in language learning because of high phonemic ability, others because of high analytic ability, and again others because of high memory ability.

In 2011, Skehan (applied linguist) and his colleague Wen shifted attention to working memory ability as the primary component of language aptitude. They argued that this ability contributes with other aptitude subcomponents as well as the different stages of language acquisition. The relationship between language aptitude and working memory will be discussed further later in the chapter (c.f. section 6).

Another support for the role of memory as a central component of language aptitude is Miyake and Friedman view (1998, in Dörnyei, 2006, p. 48). These researchers stated that “working memory for language maybe one (if not the) central component of this language aptitude”.

A further contemporary view stressed the relationship between motivation and language aptitude in explaining success in foreign language learning. Lowe (1998, p. 15) affirmed the existence of three components of language aptitude: motivation, learning styles, and learning strategies, assuming that “ language aptitude (can be facilitated) by other factors, such as motivation, the affective filter and learning styles and strategies on the part of the learner and teaching methods and styles on the part of the teacher”. On the other hand, Dörnyei (2010) averred that language aptitude and motivation are not separable and that they work interchangeably for achieving success. He reviewed Schumann’s view (2004) on the relationship between the two constructs stating that “motivation is not independent of cognition… but instead it is part of cognition, and therefore, there can be no "cognitive" approaches to SLA that do not include motivation”. (Quoted in Dörnyei, 2010, p. 254)

2.2.2. The nature of language aptitude

We have reviewed in the previous part of the section some of the debates regarding the components of language aptitude. This part presents other theories concerning the nature of this ability. While research witnessed a debate over whether language aptitude is a unitary or componential issue, other studies raised another debate over whether language aptitude is a fixed or developed ability.

2.2.2.1. Aptitude as a general/specific ability: unitary view vs. componential view

Concerning the view of language aptitude as a general ability, Sasaki (1993, in Ehrman, 1998) discovered a general cognitive factor, which she claimed to be similar to Spearman's g in more than 42% Japanese college students studying English as a foreign language. Other research evidence is Ehrman's study. Ehrman (1998) made an investigation for predicting success in language of US students from different fields (e.g. Information Agency students, Defense students, Commerce students) using the MLAT test. The results showed a significantly strong correlation with primary mental abilities test (.67), which confirmed the existence of a general ability, or general intelligence functioning in the MLAT. Dörnyei (2005, p. 47) is another proponent of aptitude as a general ability who announced that:

> The complex of general intelligence and the complex of language aptitude share definite commonalities but do not coincide completely. The more precisely we identify the various independent components of language aptitude, the more clearly we can establish which cognitive components have direct, indirect, zero, or even negative bearing on one's language learning capacity…treating L2 aptitude in a monolithic way obscures the nature of the relationship between general cognitive abilities and specific linguistic ones.

According to Dörnyei (2006) language aptitude is part of a more general factor that is known as intelligence. In the beginning of ID research, intelligence was associated with learning success, but recently, it has involved the ability to learn a foreign language.

As far as the componential nature of language aptitude is concerned, some researchers conducted factor analysis to examine the relationship between the components of aptitude with the components of general intelligence. For example, Wesche et al. (1982, in Skehan, 1998) used factor analysis study between Thurstone's primary mental abilities and Carroll's MLAT subcomponents. The results revealed three separate factors: verbal knowledge, general intelligence and memory ability. Besides, Bley- Vroman (1988, in Bain, McCallum, Bell, Cochran & Sawyer 2010), in his Fundamental Difference Hypothesis, claimed that children depend on specific mechanisms that are specific in language learning, whereas adults depend on general abilities like verbal analytic ability.

Skehan (1998) is another proponent of the componential nature of language aptitude. He advocated that individuals have a specific talent for learning a foreign language. He criticized the view of the existence of general language ability stating that if a general ability exists, it exists in all domains (the 'g factor'), but the question remained about those who are more able in some areas than others. Skehan concluded that there is no specific language talent, but a set of abilities (auditory ability, memory ability, and language analytic ability) that facilitate language learning.

Further evidence on language aptitude as a set of abilities is Segalowitz's neuropsychological findings (1997, in Dörnyei, 2005). This latter asserted that "what we perceive as language learning ability is not a fixed characteristic of a person but rather a complex reflection of the whole learning situation" (quoted in p. 60). For him, learners differ in learning capacity because their cognitive abilities differ according to the demands of learning situations.

Moreover, Lehmann, Juling, and Knopf (2002, as cited in Bain et al., 2010) made an investigation on what underlies both language and mathematical achievements. They hypothesized that general cognitive abilities are essential for performance in areas like mathematics and language learning; and specific abilities are essential for achievements. The results revealed the existence of specific factors for mathematical ability as well as for language learning ability.

2.2.2.2. Aptitude as a developed/fixed ability

Proponents of language aptitude as a fixed ability claimed that aptitude for second language is similar to aptitude for first language. Carroll (1973, in Carroll, 1993) acknowledged that this ability is fixed at birth or develops in the early years of the child's life, through mother-child interaction. He further advocated that this ability is relatively stable over the life span, which allows individuals to acquire additional languages.

Harley and Hart (1997, in Gass & Selinker, 2008) are other advocates of language aptitude as a fixed ability. They opined that learners from different group levels achieve similar proficiency for second language. Their study indicated that there was no difference in learning in the same population of learners in grade 11, where one group started learning the second language in grade 01 and the other group did not start until grade 07.

A further supporter of aptitude as a fixed ability is Skehan (1998). This linguist contended that language learning aptitude is a cognitive ability that individuals are endowed with, and on which the environment has no influence. He (1998, p. 226) added that language learning is also possible after puberty, yet it is less effective and individual differences are more apparent than in first language acquisition. in focusing on the idea that aptitude is a fixed ability, he (1998, p. 195) averred that:

> Whatever seems to be implicated in foreign language aptitude does not appear to be simply the product of experience, but instead connects with underlying capacities. (…) one can take now the initial variation and simply propose a constant value for fading to account for individual differences which are a reflection of original variation and a lower level of capacity to that which prevailed early in life.

Ellis (1998, as cited in Skehan, 1998, pp. 195-196) confirmed that language aptitude is a fixed ability through acknowledging that it is not simply a product of experience, and that individual differences start to appear early in life.

When many researchers believed that aptitude is an unchangeable ability, others insisted upon the view that the concept is relative to development. McLaughlin (1986; 1990, as cited in Sáfár & Kormos, 2008) asserted that previous language learning experiences have positive effects on language success. He (in Sáfár & Kormos, 2008, p. 5) indicated that “aptitude should not be viewed as a static personality trait; novices can become experts with experience”. Eisenstein (1980, in Sáfár & Kormos, 2008) as well illustrated that students with previous experience in FL training have a higher aptitude than their peers. Similarly, Grigorenko (2000, in Sáfár & Kormos, 2008, p. 5) added that “language aptitude is a form of developing expertise rather than an entity fixed at birth”. A further study was conducted by Sparks, Ganshow, Fluharty, and Little (1995, in Sáfár & Kormos, 2008) on learners of Latin to investigate the effects of previous experience. The results confirmed the developmental nature of aptitude. Sáfár and Kormos findings (2008) added evidence to the influence of language experience on aptitude.

One view assembling between aptitude as a fixed and developed ability is the one of Gass and Selinker (2008) who contended that aptitude is not totally biological, and that social contact has a positive impact on it. In other words, people who possess the ability to learn a second language were already exposed to it in their childhood. Another assumption was that people with a high language aptitude also master musical skills. Gass and Selinker added that recalling prose in L1 is another aspect of language aptitude as a developed construct.

The variety of the theories concerning the nature and the components of language aptitude indicated the controversy about the issue. Similar to intelligence, it is impossible to decide whether aptitude is a general ability or a set of specific capacities. Similarly, one cannot determine if this capacity is stable or develops through social or teaching experience.

2.3. Language aptitude testing

While intelligence testing triggered the curiosity of many researchers, there was a need to develop a test of language aptitude, especially when deficiencies in learning a foreign language became quite obvious. Early attempts started in the 1920s (e.g. prognosis tests that were based on Linguistic intelligence in L1), yet it is not until the 1950s that aptitude testing started to flourish, mainly by the emergence of the two popular measures: the Modern Language Aptitude Test (or MLAT: Carroll & Sapon, 1959) and the Pimsleur Language Aptitude Battery (or PLAB: Pimsleur, 1966).

Despite the wide popularity these measures received, they were developed without any theoretical basis. In other words, these tests followed the process of trial and error learning through selecting the tasks that seemed to discriminate between more and less able language learners (Dörnyei, 2005). In addition, aptitude tests do not predict success; they only predict differences in the rate of learning (Skehan, 1998, p. 194). A further description of these tests is provided below in the section.

2.3.1. The Modern Language Aptitude Test

The abbreviated form of this measure is the MLAT. This test was developed by Carroll and Sapon in 1959 to be the first reliable aptitude measure. This measure includes five subtests that assess mainly phonetic ability, grammatical sensitivity, and memory ability:

- **Subtest 1. Number learning**

This subtest measures the component of memory. It includes forty three numbers with their translation into the foreign language- an artificial language in this case (e.g. 'ba' is 'one'). The participants' task is to remember the translations of the given numbers in the original language. (Sasaki, 2012)

- **Subtest 2. Phonetic script**

This subtest is also called 'phonetic transcription' (Sparks et al., 2011). The task measures primarily phonetic coding ability. It can be administered in two different ways. The subjects are either instructed to listen to produced sounds (e.g. the sound 'bot') and select the right symbols (/bɒt/) (Sasaki, 2012), or they are asked to read a set of nonsense syllables and choose the right transcription. (Sparks et al., 2011)

- **Subtest 3. Spelling clues**

This task measures two components: vocabulary knowledge and phonetic coding ability. Fifty words containing some deleted letters are given, and the subjects are asked to choose from the list of options the right synonym, e.g. “ernst”: A. shelter B. slanted
C. impatient D. sincere E. free. (Sasaki, 2012)

- **Subtest 4. Words in sentences**

This subtest intends to measure grammatical sensitivity component. The subjects, in this task, are given a list of pairs of sentences with some underlined elements in the first sentence and are asked to induce the same function in the second sentence from a number of options, e.g.1. <u>MARY</u> is happy.

2. From the <u>look</u> on your <u>face</u> <u>I</u> can tell that you <u>must</u> have had a bad <u>day</u>.
A B C D E

(Sasaki, 2012). The subjects are not required to give any grammatical terminology; rather they just induce the same function from a list of choices. (Stern, 1983)

- **Subtest 5. Paired associates**

This subtest assesses Carroll’s rote memory component. The subjects in this task are given a short period of time to retain a list of nonsense words and their translation into English (e.g. ‘kab’ for ‘juice’ in English), then they are asked to find out the right translation from a list of choices (‘kab’: A. juice, B. cart, C. corn, D. tool, E., run).

Carroll (1981) acknowledged that he didn’t test the component of inductive language learning ability thoroughly as he did with the other components (Sasaki, 2012). As has been previously indicated, this component is better assessed by the PLAB. We will show how the PLAB measures this ability later in the section.

The MLAT test of aptitude did not receive a major change since its emergence. For example, Skehan (1989, in Skehan, 1998) assembled the components of grammatical sensitivity and inductive language learning ability under the component of 'language analytic ability', claiming that both of these components tend to identify and generalize different language patterns. Similarly, memory was another component added by Stern (1983) to refer to recalling associations between L1 and L2 and hence replaced the task of paired associates.

It is worth noting that the MLAT test is more psychological than linguistic. In other words, it measures a set of cognitive abilities rather than language capacity (Sasaki, 2012). This test was subject to many criticisms for being associated with the audio-lingual method of language teaching that put focus on developing structures. However, Carroll (1990) pointed out that "one promising direction is to develop tests that would exemplify language learning tasks that are not covered in existing batteries." (Quoted in Robinson, 2005, p. 50)

2.3.2. The Pimsleur Language Aptitude Battery

The abbreviated version of this measure is the PLAB. This test is another paper-and-pencil measure that was developed seven years (1966) after the administration of the MLAT to assess learners' aptitude to learn a foreign language. Similar to the MLAT, this measure contains six parts that gauge Pimsleur's hypothesized aptitude components: linguistic intelligence, interest, and auditory ability:

- **Part 1. Grade Point Average:** this part indicates the reported marks Students receive in English, history, mathematics, and science;
- **Part 2. Interest in Foreign Language Learning:** learners mention their degree of interest in learning the foreign language on a five-point scale;

- **Part 3. Vocabulary:** the students choose the words that best correspond to the target word in a multiple choice test (e.g. prolonged: A. prompt ; B. Difficult; C. decreased D. Extended);
- **Part 4. Language Analysis:** the participants are presented with different words or phrases in the foreign language, i.e. an artificial language, with their equivalents in the original language; then, they are asked to deduce the right structure to the given sentence from a list of choices (e.g. 'Gade' is used for 'father, a father'; 'Shi' for 'horse, a horse'; 'Gade shir le' for 'Father sees a horse'; 'Gade shir la' for 'Father sees a horse'; 'be' for 'carries'. So 'A horse carried Father' would be expressed as: A. 'gade shir be'; B. 'gade shir ba'; C. 'shi gader be'; D. 'shi gader ba'?).
- **Part 5. Sound Discrimination:** the subjects listen to different sounds of words in a recorder; then they listen to a number of sentences that contain these words, and then they are asked to find where each word is presented.
- **Part 6. Sound-Symbol Association:** in this part, the learners listen to two- or three-syllabic nonsense words and are asked to identify the right word from a list of alternatives. (Dörnyei, 2005)

The MLAT and the PLAB measures were not the sole outcome of aptitude testing. Many additional tests emerged in an attempt to determine learners' aptitude for learning foreign languages. Examples of these measures are: the Artificial Language Aptitude Test (ALAT), The Defense Language Aptitude Battery (DLAB), The Elementary Modern Language Aptitude Test (EMLAT), and the VORD. However, some tests were removed for governmental purposes. For example, the Pimsleur Language Aptitude Battery was neglected for requiring small group tests which does not fit the testing of groups of government workers. Similarly, the ALAT was discarded for its weak design and was subsequently replaced by the DLAB in the 1970s. (Lowe, 1998)

During the 1970s and 1980s, language aptitude tests did not receive any change until the coming of current psychologists who gave new insights to the concept (Dörnyei, 2005). Petersen and Al-Haik (1973), for instance, designed the Defense Language Aptitude Battery, or the DLAB, to measure the likelihood of learning languages which are structurally close to English. On the other hand, James Child came with the VORD (1973) to predict success in languages which are far in structure from English. (Child, 1998)

In recent years, Grigorenko, Sternberg, and Ehrman (2000) designed a new aptitude test on the basis of Sternberg's view of adaptation, novelty and ambiguity. The 'Cognitive Ability for Novelty in Acquisition of Language as applied to Foreign Language Test' (or CANAL-FT in short) stemmed from Sternberg's triarchic theory (1985) that deals with language skills which expand to real life situations (i.e. natural settings) rather than just academic or psychometric settings. Therefore, it tackles novelty and ambiguity in the process of learning. (Dörnyei, 2005)

Sáfár and Kormos (2008), in their measurement of aptitude (HUNLAT test), used four subtests that are similar to the MLAT. These subtests are hidden sounds, language analysis, words in sentences, and vocabulary learning.

2.4. Language aptitude and second language acquisition

In the middle of the twentieth century, when learning foreign languages was a crucial issue, observable deficiency from the part of learners called attention to develop a test to identify individuals who seem more adept to engage in a language instruction. From that time, aptitude tests have gained a wide popularity all over the world to be the "raison d'être" for selection in foreign language learning. However, two major questions were raised drawing the attention of most SLA experts: Are language aptitude measures good predictors of success in foreign language learning? To what extent language aptitude has an influence on foreign language learning? A couple of issues concerning language aptitude and second language acquisition are worth to be discussed in this section. We will highlight the impact of language aptitude in different contexts of SLA. We will also deal with language aptitude in language pedagogy.

2.4.1. The influence of language aptitude in SLA

Although the MLAT test of language aptitude was found successful in predicting success in foreign language learning for almost five decades (Kormos & Sáfár, 2008), it has long been challenged for being associated with the audio-lingual method of teaching that centers the learning of structures through rote memorization (Anastasy, 1988; Bruhn, 1992, in Ehrman, 1998; Bowden, Sanz & Stafford, 2005; Sáfár & Kormos, 2008). However, other criticisms were directed to these criticisms in that language aptitude maintains to play a role in communicative language teaching classrooms. Skehan (1986, in Sparks & Ganschow, 2001) asserted that aptitude tests are good predictors of language learning success for tackling both linguistic skills and knowledge. Likewise, Ehrman (1998) indicated that the correlation between aptitude tests and learning success is still the same with the communicative approach to language teaching (.42; .62). In an earlier study, Ehrman and Oxford (1995, in Ranta, 2008) conducted a Foreign Service Institute (FSI) context to investigate the predictor of reading and speaking proficiency. They examined the relationship between these skills and a variety of factors: language aptitude, learning styles, learning strategies, anxiety, motivation, and personality. The results showed that the highest correlation was between language aptitude and reading and speaking proficiency (.50).

The British linguist Stephen Krashen (1981) was the first to discuss the relationship between aptitude and communicative language settings. He highlighted two types of instruction: formal and informal. The former is controlled and requires more attention and is the place for explicit learning, while the latter is less controlled and takes place in natural settings and allows for implicit learning to take place. Language aptitude was believed to function in the first type but fails in the second type. Conversely, Skehan (1989, as cited in Skehan, 1998) insisted on the fact that aptitude is more required in natural settings than under formal instruction. Reves (1982, in Skehan, 1998) assembled between both views through stating that aptitude, in addition to motivation, appears to be highly correlated with both formal and informal settings.

The linguist Robinson (1996; 1997, in Robinson, 2005) made another investigation on the functioning of aptitude under four conditions of learning: '*implicit'* in which learners acquired the rule implicitly through meaningful practice; '*incidental'* in which they looked for meaningful tasks giving no interest to form; '*rule-search'* in which learners were asked to look for rules; and '*instructed*' in which they were explicitly exposed to the rule. The results showed a significant relationship between aptitude and these conditions except for incidental learning. He (Robinson, 2002, in Hummel, 2009) indicated that this latter is influenced by working memory. Besides, Robinson (2005) claimed that learning L2 complex structures is strongly linked with the MLAT grammatical sensitivity sub-component.

In addition to Robinson, other researchers were interested in the relationship between language aptitude components and the development of different skills of the foreign language. Skehan (1998) and Ellis (1998, in Skehan, 1998) speculated that each component of the MLAT plays an important role in developing different aspects of the FL. These researchers claimed that phonemic coding ability affects the auditory processing of input; grammatical sensitivity and inductive language learning ability influence the processing of linguistic material; and memory has an impact on the acquisition of new vocabulary. In addition, Skehan (1988) identified three stages of information processing linking each component of aptitude to a stage, e.g. phonetic ability component to input processing stage, language analytic ability to central processing stage, and memory ability to output stage. The following table summarizes the relationship between language aptitude and these stages:

Aptitude factor	**Stage**	**Operations**
Phonemic coding ability	**Input**	Noticing
Language analytic ability	**Central processing**	Pattern identification Generalization Restructuring Dual-coding organization
Memory	**Output**	Retrieval -Computed performance -Exemplar-based performance

Table 3. Aptitude and Language Learning Stages (Skehan, 1998, p. 203)

Likewise, Sternberg, Ehrman, and Grigorenko (2000) claimed that aptitude components predict different types of learning. For them, language-analytic ability (i.e. the MLAT grammatical sensitivity and inductive language learning ability) can predict formal explicit language learning, while phonemic coding ability and memory ability predict implicit language learning.

Another worthwhile issue of aptitude is addressing its impact on first language acquisition. Skehan (1986, in Skehan, 1998) started by investigating the relationship between first language acquisition, foreign language learning and language aptitude in secondary school students for several years. He found a significant correlation between first language ability and the ability to learn an L2. After Skehan came Sparks and Ganschow (1990, in Sparks & Ganschow, 2001) with their Linguistic Coding Deficit Hypothesis (or LCDH). These researchers opined that difficulties in acquiring phonological and orthographic aspects in the foreign language are due to difficulties in acquiring these aspects in the first language. They conducted studies with other researchers (Ganschow et al., 1991; 1994; Sparks et al., 1992a, b, 1996; Sparks, Ganschow, Artzer, Siebenhar, & Plageman, 1997; 1998, in Sparks & Ganschow, 2001) to evaluate their hypothesis. The results confirmed that those who are successful in L2 are also successful in the phonology, orthography and syntax of their native language.

2.4.2. Language aptitude and language pedagogy

One of the main objectives of aptitude measures in language pedagogy is curriculum evaluation. Language aptitude scores aid in deciding which instruction to use with language learners with regard to their cognitive abilities. Ehrman (1996), Sawyer and Ranta, (2001) as well as Skehan (1989) affirmed that aptitude tests are used to uncover cognitive strengths of individuals and their learning styles and subsequently aid in determining the quantity and the quality of corresponding language instruction. (Dörnyei, 2005)

Wesche (1981, as cited in Dörnyei, 2005) proposed three language instructions according to language aptitude scores: an *audio-visual method* that corresponds to high scores in the MLAT phonetic ability; an *analytical approach* which is directed to high scores in the MLAT 'words in sentences and spelling clues'; and a *functional approach* that goes with high scores in auditory or memory ability. He made an experiment through matching the students with these three approaches. The results indicated that analytic learners who were matched with the analytic approach did better that those matched with the audio-lingual approach. Wesche concluded that adopting the differentiated approach while teaching leads to better results as it makes the learners comfortable in the lessons.

Skehan (1986, in Dörnyei, 2005), at first, supported Wesche's matching individualized approach in that a teaching instruction that matches different learning profiles (in his case two different learning profiles: *analytic and memory-oriented*) could be a successful instruction. However, recently, Skehan (1998, in Ranta, 2008) admitted that a *compensatory teaching instruction* is more beneficial in increasing learner's language aptitude. The reason is that the development of the different components of language aptitude is linked to different stages of the process of acquisition. For example, the phonological component is linked to early stages of acquisition. Skehan, further, suggested a useful technique to develop this component in teaching vocabulary. Learners with phonological disability might learn better if they are presented with new words, cutting them into syllables and phonemes, and giving sound drills. Similarly, language analytic ability could be developed following group work technique (e.g. through giving a passage with missing elements to fill in and making the learners work in groups to find the answers and give justifications) that allows learners to share different aptitudes. (Ranta, 2008)

As indicated above, language aptitude factor gained a wide popularity in SLA research. Many SLA experts stressed this ability in explaining different aspects of second language acquisition, e.g. learning stages (e.g. Skehan, 1998), learning contexts (Krashen, 1981; Skehan, 1989; Ellis, 1989; Robinson, 1996; 1997; 2002; 2005; Sternberg, Ehrman & Grigorenko, 2000), teaching methods (Carroll, 1990; Skehan, 1998; Ehrman & Oxford, 1995; Ehrman, 1998), and teaching techniques (Wesche, 1981; Skehan, 1986; 1998). However, one should confess that aptitude is not the sole factor that is believed to affect second language acquisition. Alternative theories of SLA shiftED attention to affective factors rather than cognitive. For example, Gardner (1985, 1990) and Gardner & Lambert (1972) shifted attention to motivation and attitude. Horwitz, Horwitz, & Cope (1986) and MacIntyre & Gardner (1991, 1994) stressed the issue of anxiety. And again others directed attention to learning styles and learning strategies (Oxford, 1990). (Cited in Ehrman, 1998)

2.5. The relationship between language aptitude and intelligence

Language aptitude and intelligence have been thoroughly considered under the cognitive aspect of individual differences research. These cognitive abilities were also revealed to have a significant relationship with second language acquisition (c.f. chapter 1.1.4 and chapter 2.4). The issue of the relationship between intelligence and language aptitude was raised in the emergence of aptitude tests, mainly in the late 1950s and the beginning of the 1960s. Research findings varied in determining the degree of association between these constructs. While some claimed about existing significant relationship, others believeed that language aptitude and intelligence are independent constructs.

Carroll and Sapon (1959) demonstrated a significant correlation between the MLAT test and IQ scores (.34, .52). However, later, Carroll (1960) advocated that aptitude is a talent or a number of talents independent from intelligence. He asserted that intelligence tests fail to identify those who are more able in foreign language learning. Through the use of factor analysis, Carroll (1960, in Sparks & Ganschow, 2001) proved the existence of four abilities which were considered the main aspects of language aptitude and that affect foreign language learning: phonetic coding ability, or the ability to code and remember auditory information; grammatical sensitivity, or the ability to handle grammar; inductive language learning ability, or the ability to infer linguistic, rules; and rote memory ability, or the capacity to learn phonetic and grammatical associations.

Two decades later, Carroll (1981, in Reed & Stansfield, 2002) added that language aptitude and verbal intelligence are independent constructs. He emphasized that the patterns of correlation between intelligence and academic achievement are not similar to the ones of aptitude. Carroll (in Reed & Stansfield, 2002, quoted in p.3) stated that "aptitude should be defined in terms of prediction of the rate of learning".

However, in another study, Carroll (1993, in Sparks et al., 1998) contradicted his earlier view by speculating that the MLAT components (phonetic coding, verbal memory, grammatical sensitivity and spelling) are grouped under crystallized intelligence factor. This latter is included under the second level of his theory of cognitive abilities (i.e. stratum II) with seven additional factors (fluid intelligence, cognitive speed, etc.). Language aptitude and language proficiency are incorporated under the lowest level (i.e. stratum I) with various other low abilities.

Another view supporting the relationship between intelligence and language aptitude is Gardner and Lambert's (1965). These SLA researchers (Gardner & Lambert, 1965, in Wesche et al., 1982) argued about existing correlations between some aspects of aptitude and general intelligence scores. They used the MLAT test to measure language aptitude, and adolescent PMA test to measure intelligence. They relied on factor analysis to find out common variables between the two measures. Although the results of factor analysis showed the emergence of two different factors: one for PMA and one for the MLAT components, there was a correlation of .43 between words in sentences and reasoning.

In addition, Wesche et al. (1982) conducted various correlations and factor analysis studies between the MLAT measure and Thurstone's Primary Mental Abilities (PMA) test in order to examine the relationship between aptitude components and the components of general intelligence. These researchers claimed that language aptitude is perceived in relation to intelligence. They (1982, p. 128) stated that "In attempting to understand the nature of language aptitude through the relationships among language aptitude and intelligence test scores, it is important to note that one's conception of intelligence will affect the interpretation of one's findings". The results of their factor analysis showed that language aptitude sub-tests are second-order intelligence factors. Likewise, Sasaki (1991, in Skehan, 1998) conducted factor analysis to investigate the degree of association between different constructs: aptitude, intelligence and second language proficiency. The results substantiated a strong correlation between the obtained three first-order factors: aptitude, verbal intelligence and reasoning. Other evidence is provided by Niwa (2000, in Robinson, 2005) who indicated a strong relationship between intelligence scores (using Wechsler Adult test), working memory scores (using reading span tasks) and L2 aptitude (using Sasaki's Language aptitude Battery).

Furthermore, Dörnyei (2005) advocated that aptitude is an important aspect of intelligence and, that this latter is considered an umbrella term. This psycholinguist reviewed past research on the relationship between the two cognitive abilities. Dörnyei opined that some intelligence and language aptitude components are interrelated, assuming that the relationship between intelligence and language aptitude is perceived as the relationship between the scores in both tests (the MLAT and the PLAB tests), and that this latter includes L1 vocabulary test, which is essential subpart of general intelligence test. He added that non-linguistic tests of intelligence are also correlated with language aptitude test scores. In addition, Dörnyei claimed that intelligence tests involve many areas like: linguistic ability, memory ability, reasoning ability, etc.

Skehan (1998), on the other hand, pointed out that despite the fact that intelligence tests tackle verbal ability through items like vocabulary and memory for words, they do not share a strong association with language aptitude scores. He illustrated that there are individuals with a very high language aptitude score but average or above average IQ score. Skehan went on to note that it is aptitude which correlates more with language proficiency. Similarly, Sparks, Ganschow, and Pohlman (1989, in Sparks & Ganschow, 1993) speculated that although 63% of college students showed difficulties in language learning (in phonology, syntax and semantics), they revealed between average and high IQ scores.

2.6. The relationship between language aptitude and working memory

Working memory is a further cognitive ability that draws the attention of many researchers in the area of individual differences. Similar to its relationship with intelligence, extensive experimental investigations were devoted to the link between aptitude and working memory capacity since the emergence of aptitude measures. Carroll and Sapon (1959) considered memory ability as a factor of language aptitude and provided a measure to this construct through the subtest of paired associates. (Sasaki, 2012)

Later, in 1993 in the book of *Human Cognitive Abilities*, Carroll's factor analysis findings revealed that many aspects of memory are highly correlated with language aptitude. This led him to add different measures of immediate memory to the new version of the MLAT: “Memory Span, Associative Memory, Free Recall, Meaningful Memory, and Visual Memory”. (Cited in Beiera & Ackerman, 2004)

Skehan (1998) criticized the component of immediate memory that was assessed in the MLAT test of language aptitude, claiming that this component focuses on just encoding ability (i.e. the ability to assimilate new items). He claimed that this component would be more important if it involves retrieval aspect. Skehan (1998, p. 203) stated that:

> In the longer term, though, it is desirable that aptitude research explores the separate potential of more retrieval-based sub-tests. Provisionally, then, we have a reinterpretation of the role of memory within language aptitude. It is now not simply the capacity to assimilate and encode new material, it also implicates the capacity to retrieve exemplars (chunks) quite rapidly to support fluent speech production.

In a recent study, Skehan and his colleague Wen (2011) introduced working memory as language aptitude hypothesis. They argued that working memory ability which is an active process might be incorporated with language aptitude. They (2011, pp. 34-35) pointed out that “the prospect of incorporating WM as a key component in foreign language aptitude is possible, feasible and promising indeed”. The arguments behind their claim is that the two abilities have an influence on developing different skills of the foreign language; differences in these abilities affect differences in learning achievement; and that working memory, like language aptitude, plays a vital role in various stages of second language acquisition. In another work, Skehan and his colleagues (Chan, Skehan & Gong, 2011) centered on the importance of the phonological loop that is a component of working memory in the acquisition of vocabulary and in developing structures of the foreign language. They (2011, p. 60) acknowledged that:

> Given the centrality of working memory as a component of foreign language aptitude, it is, of course, possible to develop phonological memory aptitude tests which are based on non-words in the L1. But it is intriguing to consider what would happen if non-words were developed which are based on the language to be learned.

Similarly, Miyake and Friedman (1998) stress the active process of working memory in their explanation of language aptitude. They indicate that it is more than a passive storage of information that precedes long term memory, and that it is an active process used for language comprehension and language production.

The idea of working memory as language aptitude is not very recent, Miyake and Friedman (1998) preceded Skehan in hypothesizing working memory as language aptitude (Kormos & Sáfár, 2008). They supported their hypothesis by the following arguments:

- Working memory can have the same sub-abilities as aptitude has;
- Individual differences in L1 working memory are closely related to individual differences in L2 working memory, language comprehension, and the speed of L2 acquisition. (cited in Dornyei, 2006)

Furthermore, Sawyer and Ranta (2001) were also interested in the link between memory and aptitude. These researchers called attention to the consideration of working memory as a central component of language aptitude as well as its crucial role in the process of second language acquisition. (Dörnyei, 2005) In stressing the importance of working memory in foreign language proficiency and language aptitude, Sawyer and Ranta (2001, in Dörnyei, 2005, p. 58) noted that:

> (…) noticing is crucial to learning, and attention is required for noticing, and attention at any moment is limited by WM capacity, then there must logically be a close relationship between amount of learning and size of WM. It is also likely that WM serves as an arena in which the effects of other components of aptitude are integrated.

Robinson (2002) was the first to provide empirical evidence on the relationship between working memory and language aptitude. Robinson's findings revealed a significantly strong correlation between reading span tasks, which are considered a measure of working memory capacity, and aptitude scores. He further advocated that language aptitude is an active component in language learning, and that working memory is just a subcomponent of this construct (Robinson, 2005). Kormos and Sàfàr (2008) reported similar findings on the link between working memory and aptitude using digit span, instead, for measuring working memory capacity. In another study, Robinson (2003, in Dörnyei, 2005) highlighted the importance of one component of working memory, which is the phonological loop, in the acquisition of new vocabulary emphasizing that attention is a prerequisite process.

Hummel (2009) is another researcher interested in the link between working memory, language aptitude and language proficiency. In his work of "Aptitude, phonological memory, and second language proficiency in non-novice adult learners", he reported significant correlations between phonological memory, which is an aspect of working memory; and second language proficiency (.35), as well as the different components of L2 proficiency (e.g. phonological memory and vocabulary: .36; phonological memory and grammar: .33), and between aptitude and second language proficiency (.25), including different proficiency components (e.g. aptitude and reading: .29; and aptitude and grammar: .25), yet a weak correlation between phonological memory and language aptitude (.08). Hummel further demonstrated that the effect of phonological memory on L2 proficiency is more in children than in adults. He concludes that phonological memory plays an important role in activating attention, in processing auditory information, and in storing and recalling novel phonetic material. He added that this ability predicts success in children, adolescents and non-novice adult learners at primary levels but not advanced levels.

Conclusion

Language aptitude, which is another cognitive aspect of individual differences, has received thorough attention in the field of SLA as it involves different components (i.e. phonetic or auditory ability; grammatical or analytic ability; and memory ability) that play a significant role in foreign language learning. Research on language aptitude was limited until the emergence of the MLAT measure- the first measure of language aptitude. Despite the fact that this test gained an extensive popularity for being proved successful in predicting success in foreign language learning, a variety of measures emerged attempting to make adaptations, e.g. the DLAB; ALAT; EMLAT; VORD, CANAL-FT; HUNLAT, etc.. Far from the heated debate concerning the nature and the components of this ability, many SLA experts attempt to provide an explanation of the contribution of this ability in different learning contexts (formal and informal: Robinson, 2005) and learning stages (early and late: Skehan, 1998).

Since the emergence of the first language aptitude measure, extensive research has been devoted to the link between this cognitive ability and a number of other capacities. Concerning its relationship with intelligence, views varied from the consideration of aptitude as a crucial aspect **(**Dörnyei, 2005) to emphasizing its separation **(**Sparks &

Ganschow, 1993; Skehan, 1998). As for its relationship with working memory, most research evidence revealed a strong interrelationship making of this concept a key component of language aptitude. The next chapter is devoted to the explanation of working memory ability that is the third cognitive factor of individual differences research.

Chapter Three

Working Memory and Working Memory Capacity

Introduction

3.1. Information processing and memory stages

3.1.1. Models of information processing

3.1.2. Memory stages

3.1.2.1. Sensory register

3.1.2.2. Short term store

3.1.2.3. Long term store

3.2. Working memory

3.2.1. Definition of working memory

3.2.2. Theories of working memory

3.2.2.1. Models of working memory

a. Baddeley and Hitch model

- **the phonological loop**
- **the visuospatial sketchpad**
- **the central executive**
- **the episodic buffer**

3.2.2.2. The nature of working memory and working memory capacity

3.2.2.2.1. The nature of working memory

a. Working memory as a unitary ability

b. Working memory as a set of abilities

3.2.2.2.2. Working memory capacity

a. Miller's view

Working Memory and Working Memory Capacity

Introduction

Memory is a magical, rather a natural ability, that allows individuals to access their past. This cognitive ability has triggered the attention of research since the emergence of psychology as a scientific discipline (in the 19^{th} century). Many decades later, the concept of working memory emerged (in 1974) to receive the lion's share of attention in cognitive psychology as well as a variety of other disciplines: psycholinguistics and SLA, to name but a few. Extensive research was devoted to the study of this construct from different perspectives: the nature of working memory, its structure, its capacity, its measurement, and its role in performing higher cognitive behaviour.

In this chapter we will introduce the concept of information processing through elucidating different memory stages. A whole section will be devoted to an explanation of working memory construct through presenting some theories concerning its structure, its nature and its capacity. Since we aim at providing an appropriate measure of working memory capacity, we will review different short-term and working memory span tasks. Working memory is elected as a hypothesized component of Linguistic intelligence for the current research which necessitates providing theoretical evidence on the relationship between the two constructs and which will be provided in this chapter.

3.1. Information processing and memory stages

The term information processing emerged in the emergence of cognitive psychology to explain the mental processes that function in the human mind, and which cause behaviour that interacts with the external environment. Massaro and Cowan (1993) advocated that information processing theory aims at explaining the mental processes that occur between stimulus and response. Cognitive scientists perceive the human mind as the processor of information comparing it with a computer in processing digits. In his definition of cognition, Neisser (1967, in Lutz & Huitt, 2003), identified a number of information processing stages. He (in Lutz & Huitt, 2003, p. 8) noted that cognition is "the encoding, structuring, storing, retrieving, using, or otherwise learning knowledge".

Heidjen and Stebbins (1990, in Massaro & Cowan, 1993) speculated that information processing (IP) approach implements some features of the behaviourist theory. The difference between behaviourism and IP approach is that while the former aims at understanding behaviour, the latter explains how mental processes cause behaviour. This means that IP theory tackles specific information processing rather than general behaviour. IP approach, hence, aims at understanding complex behaviour through an explanation of simple mental processes.

3.1.1. Models of information processing

Models of information processing vary in terms of purposes. Some models put focus on the structural processing of information (e.g. Atkinson and Shiffrin model, 1968), whereas others stressed the nature of processing itself (e.g. Craik and Lockhart, 1972). This section is devoted to the structural view of information processing. The nature of processing will be highlighted later in the chapter (c.f. section 2.2.2.3).

The first *prototypical* model of information processing was Atkinson and Shiffrin Two-store Model (1968). This model was composed of two basic stores: short term store (STS) and long term store (LTS). Atkinson and Shiffrin claimed that information enters STS via consciousness through the recognition of sensory patterns; then certain strategies and control processes are applied from the LTS for storage and retrieval. These psychologists highlighted three major processes that appear between the STS and LTS: encoding, storage, and retrieval. These mental processes involve a variety of other processes. Encoding is the first information processing step that refers to putting in information in the STS. After encoding, rehearsal takes place. Rehearsal refers to the process of maintaining information in the STS until it moves to the LTS. This process is illustrated through repetition strategy. Decoding is another step in information processing that represents the transformation of information into other codes in the STS. Retrieval is another step in information processing that takes place in the LTS. Tulving (1972, in MacLeod, 1979) provided a distinction between two different stores in the LTS: semantic store and episodic store. The former refers to event-free knowledge, while the latter refers to event-related information. The word "transfer" is basic for Atkinson and Shiffrin model (1968). This term refers to the process of moving information from one store to the other with keeping it in the original component.

3.1.2. Memory stages

Atkinson and Shiffrin model of information processing (1968) highlighted three memory components: sensory register, short term store (STS) and long term store (LTS). Here is an explanation of each component.

3.1.2.1. Sensory register

It is also referred to as 'sensory memory' (Atkinson & Shiffrin, 1968). This store is the primary stage for perceiving a stimulus and a crucial step in information processing. Stimuli cannot move to other stages of information processing if they are not perceived in sensory memory. Information in this store is exposed to rapid decay if it is not transferred to the next stage. The stimulus is instantly registered by "sensory dimensions" when it is presented. For example, when individuals are presented with letters or words, a visual image is formed in this store and is transferred to auditory verbal linguistic STS (avl STS) and not a visual STS. As a characteristic of this store, 'avl STS' retains information better than the visual short term store. The reason behind this is that visual STS lacks rehearsal strategy. The role of control processes in this system is to select the information that should transfer to STS. Two main processes characterize this stage: attention and automaticity.

- **Attention**

Shiffrin (1988, in Massaro & Cowan, 1993, p. 404) defined attention as "(…) all those aspects of human cognition that the subject can control… or aspects of cognition having to do with limited resources or capacity, and methods of dealing with such constraints". For Lutz & Huitt (2003), attention is the focus on the perception of one stimulus and the neglect of others. This process facilitates the transformation of information to other stores, yet it is exposed to meaningfulness and complexity of new information.

The component of attention presents the very initial stage of perceiving the stimulus. This stage is related to the human senses, i.e. each sense is related to perception in a separate way. Non-perceived stimuli are argued not to transfer to any memory store, while the perceived information is either exposed to decay and hence be forgotten, or is directly transferred to other memory components. The period of information in this component takes ½ of a second for visual stimuli and 3 seconds for auditory stimuli. (Lutz & Huitt, 2003)

- **Automaticity**

The second process functioning in the STS is automaticity. Automaticity is argued to be the opposite of attention. In other words, attention is the conscious transfer of information to other memory stores, whereas automaticity is the unconscious processing of information. Driscoll (2001, in Lutz & Huitt, 2003, p. 4) averred that "When tasks are over-learned or sources of information become habitual, to the extent that their attention requirements are minimal, automaticity has occurred". Automaticity permits attention to be 'redirected' to other information and, hence, allows for multitasking.

In order to recognize the stimulus in sensory memory, one has to relate it with existing memory structures so that it becomes meaningful: without meaningful perception, information cannot move to the other storing systems. Information becomes meaningful and, hence, easily recognized if one understands the different patterns through which it is represented. Driscoll (2001, as cited in Lutz & Huitt, 2003, p. 4) defined pattern recognition as "the process whereby environmental stimuli are recognized as exemplars of concepts and principles already in memory."

3.1.2.2. Short term store (STS)

It is also called 'short term memory' (STM). This component was presented the second in Atkinson and Shiffrin model of information processing. Short term store receives input from both sensory register and LTS. However, information is rapidly lost within 30 seconds maximum (it takes somehow a longer time in comparison with the sensory register). Information in the auditory verbal linguistic (avl) store is thought to reside from15 to 30 seconds in this store.

Atkinson and Shiffrin (1968) claimed that information in this store is exposed to a complete decay. What can transfer it and prevent it from decay is the control process ‘rehearsal’. However, this latter can just transfer a limited amount of input into LTS. Storage, search and retrieval strategies like grouping, organizing and chunking are examples of the control processes used in this store. In order for information to be transferred to LTS, it has to stay in STS. The amount of information depends on the control processes used in STS. One example of the control processes is rehearsal strategy, i.e. repeating a stimulus until it forms traces in LTS. A trace is then defined as “(an item containing) a number of pieces of information and this information is assembled in a ‘multi-constructed manner” (Bower, 1967, in Atkinson & Shiffrin, 1968, p. 25). Search strategies can appear in processing letters or words in short term memory. Letters and numbers cannot transfer to auditory verbal linguistic STS until search from LTS takes place to make relations between visual images and verbal presentations.

Although Atkinson and Shiffrin model was considered successful in explaining different memory stages and opens the way to extensive research in the field of memory, it lacks many explanations of the different proposed components. STS was perceived as a simple store that receives information from sensory register and transfers it to LTS. Recent research has highlighted the complex nature of short term memory suggesting a new label ‘working memory’ (Baddeley & Hitch, 1974) with a focus on its multi-componential nature. A whole section is devoted to the explanation of this concept (c.f. section 2).

3.1.2.3. Long term store (LTS)

It is also referred to as long term memory (LTM). This component is considered as a permanent store that holds information coming from the STS for approximately indefinite amount of time. Information in this component is not exposed to decay. This store is either linked to the sensory systems like memory of smell or taste, or independent from these systems (e.g. memory of words or semantic memory).

Information is retrieved from this store to STS. Atkinson & Shiffrin (1968) contended that in order to retrieve information, one has to search for the correct trace. If this trace is similar but not correct, the search remains until finding the correct trace. Tips of the tongue are considered an illustration of finding a similar trace. In this case, the individual is able to recall the stimulus but not at the moment. Atkinson and Shiffrin announced that if individuals are given the right answer in a set of alternatives, they can easily recognize the right answer.

Long term memory was the most studied component by psychologists. Psychological research developed several tests to measure it. Examples of LTM measures are free and serial recall as well as paired associates. The variety of LTM measures reflects the non unitary nature of this system. Tests vary from those that measure the non-declarative memory, which is also known as 'procedural' by Tulving (1985), and 'implicit' by Schacter (1987), and the declarative, episodic or explicit memory. Mitchell, Brown, and Murphy (1990) conducted experiments to confirm or disconfirm Tulving's hypothesis of the dissociation between episodic and procedural memory. Their results supported the separation of the two systems. Here is a comprehensible distinction between long-term memory systems as proposed by Tulving and Schacter.

Tulving (1985, in Tulving, 2002) claimed about the existence of three different, yet, related systems, namely episodic, procedural and semantic. In his definition of episodic memory, he stated that it is "a neurocognitive (brain/mind) system, uniquely different from other memory systems, that enables human beings to remember past experiences" (Tulving, 2002, p. 1). This experimental psychologist announced that procedural memory reflects behaviour, i.e. it repeats stimuli without conscious recollection, whereas semantic and episodic memory systems rely thoroughly on this conscious recollection. Besides, he distinguished between semantic and episodic memory systems through indicating that the former is a general knowledge of the world, whereas the latter is a personal knowledge of specific events or ‘episodes’. The difference between Tulving’s procedural, episodic and semantic memory systems can be illustrated through the example of driving a car. The skill of driving derives from procedural memory; the meaning of the word "car" relies on semantic memory; and remembering the first time one has driven a car requires episodic memory. Tulving (2002) further advocated that these systems relate to each other in the sense that procedural memory is the basis of semantic memory, and that this latter supports episodic memory. However, procedural memory can function with neither semantic, nor episodic; and semantic can function without episodic. Mitchell et al. (1990) study illustrated that episodic memory is affected by age, while semantic and procedural memories remain relatively intact. Squire (2004) argued that it is only declarative memory (Tulving’s episodic and semantic) that is affected by amnesia.

After Tulving came Schacter (1987) with another distinction between LTM systems. This psychologist differentiated between implicit and explicit types of LTM. He assumed that the latter requires a conscious recollection of events, while the former is accessed without a conscious process. In addition, Schacter explained how implicit memory can result in facilitating performance of a task without a conscious awareness and demonstrated this through the example of relearning, since in this type of learning the already existing information facilitates the process.

Moreover, Schacter highlighted the concept of priming as an aspect of non-declarative memory, defining it as “facilitation in the processes of a stimulus as a function of a recent encounter with the same stimulus” (Schacter, 1987, p. 506). Priming functions in being exposed to a stimulus influencing the decision making of a person. The process of priming is illustrated through word identification, word stem, and fragment completion activities. In these activities, individuals indirectly make use of the process of priming to recognize or identify the previously exposed stimuli.

a. Neurological Evidence of the different areas of memory systems

Nyberg, Forkstam, Petersson, Cabeza & Ingvar (2002) conducted a number of neurological studies to explain different memory systems and their position in the brain. According to Position Emission Tomography (PET) studies, they found that WM, which involves active maintenance, is relative to activity[4] in premotor and parietal regions of the brain as well as in the right inferior and polar frontal cortex, and lateral and medial parietal cortex. In episodic memory, on the other hand, and mainly in cued recall or recognition tasks, there is an increasing activity in right inferior and polar frontal cortex, and lateral and medial parietal cortex. Semantic memory requires an activity in left inferior, frontal, and middle temporal regions and right cerebellum, which are the same regions for autobiographical tasks.

Further evidence is provided by Squire (2004). This neuropsychologist demonstrated that the frontal lobes are regions of episodic memory system. He conducted Functional Magnetic Resonance Imaging (FMRI) studies and discovered that in primary steps of learning, there was an increase of activity in the medial temporal lobe, yet in advanced levels, this activity decreased, while an activity in neostriatum increased. Squire added that declarative memory, unlike other memory systems rely very much on the forebrain. Concerning the role of the hypocampus, it is hypothesized (Schunk, 2012) that this latter plays an important role in consolidating the synaptic connections, i.e. it is not, actually, where our memories are stored, but as a kind of relay station, it definitely helps

[4] Activity is used in neuroscience to refer to the increase of the flow of blood in brain regions.

consolidating memory. The following figure illustrates the different memory systems and their regions in the brain:

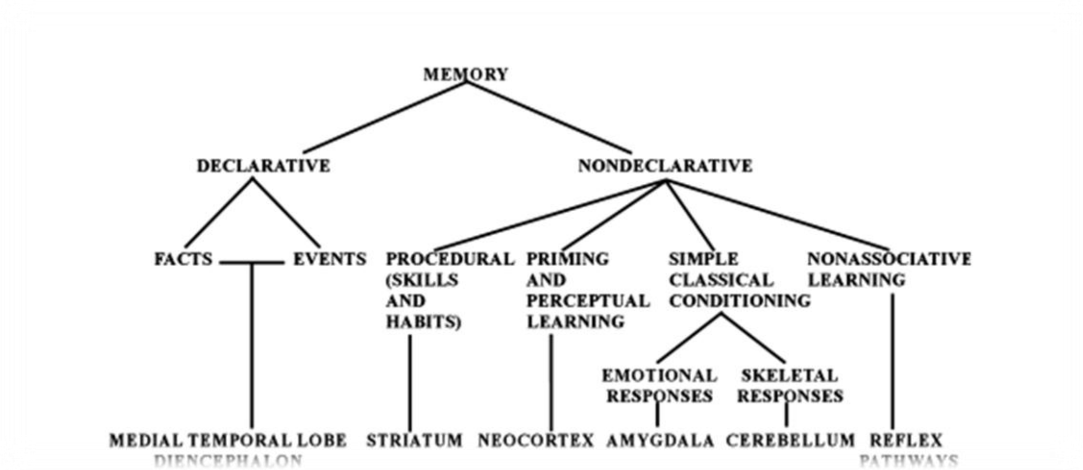

Figure 5. Memory Systems and Brain Mechanisms (Squire, 2004, p. 173)

Atkinson and Shiffrin model of information processing was claimed to be the most used model. This model considered both learning and memory as multi-staged. Atkinson and Shiffrin (1968) pointed out that in encoding there is a manipulation of information before its storage. However, as previously stated, these psychologists did not clarify the control processing; they just considered rote rehearsal until Craik and Lokhart (1974, in Craik & Lokhart, 1990) came with the idea of surface and deep processing. Craik and Lokhart model will be discussed in the coming section (c.f. section 3.2.2.2.3). Atkinson and Shiffrin (1968) model is illustrated in figure 6 and 7.

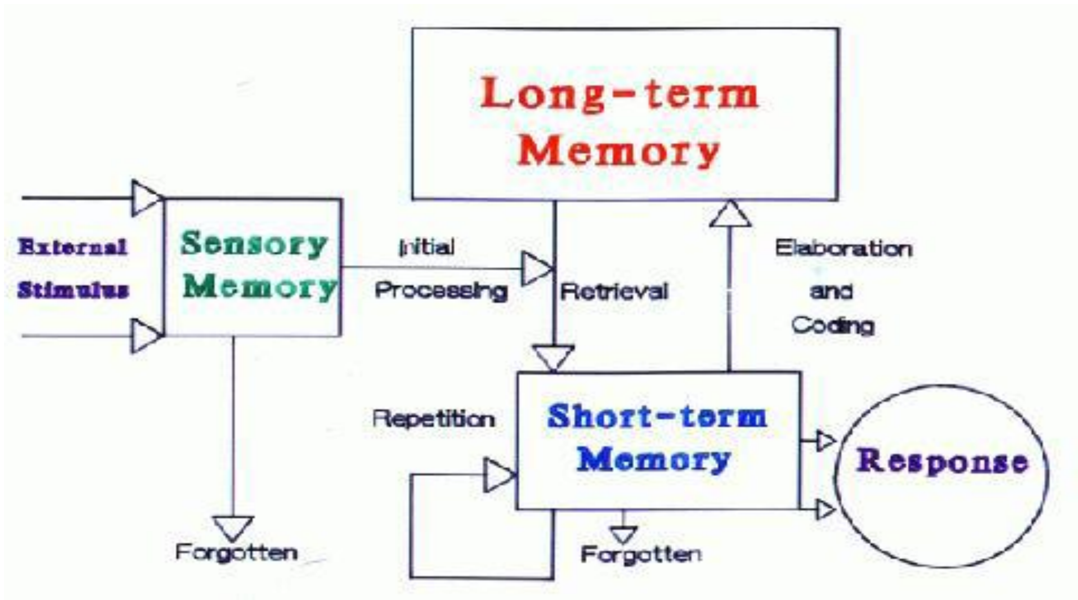

Figure 6. A Stage Model Proposed by Atkinson and Shiffrin (1968, cited in Lutz & Huitt, 2003, p.3)

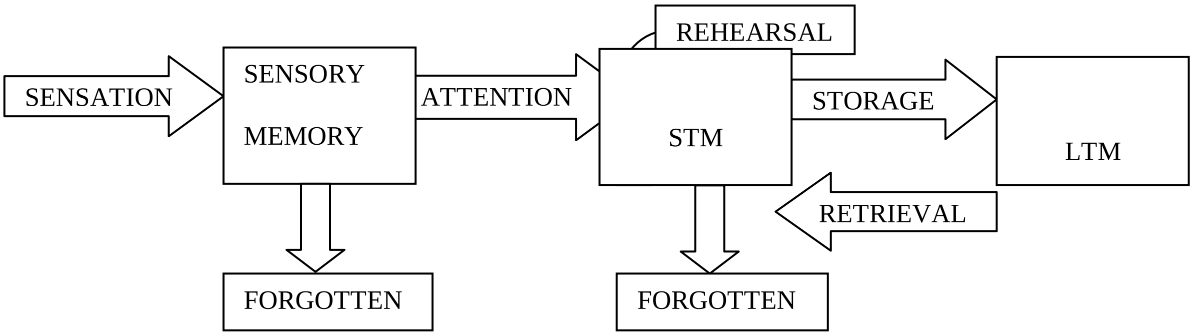

Figure7. The Traditional Model of Memory by Atkinson & Shiffrin (1968, p. 37)

Despite the fact that the Two-store Model was considered the most influential in the explanation of information processing, other models emerged to provide detailed explanations of what was neglected in it. Nearly three decades later, Massaro and Cowan (1993) introduced two alternative models of information processing with a distinction between them: discrete model and continuous model. Discrete model claimed that information is not transferred to the next stage unless it is completely processed in the previous stage. The continuous model, on the other hand, predicted that information is transferred and transmitted simultaneously. Massaro and Cowan (1993) further announced that all models of information processing highlight four main processes either in a discrete or continuous way: input, transformation, transmission, and output.

Moreover, Lutz & Huitt (2003) identified three basic stages of information processing: encoding stage, structuring and organizing stage, and deep processing stage:

- **Encoding stage:** it appears at the beginning when a stimulus is processed. Lutz & Huitt (2003) emphasized the importance of maturation in encoding. They further illustrated that adults can process 5+/- 2 chunks of information, while children of 5 years can process 3 chunks, and children of 9 years can process 4 chunks. Besides, they proclaimed that experience as well has an important role in encoding. This means that experienced people can better encode a stimulus than those who are exposed to it for the first time.
- **Structuring and organizing stage:** this step occurs after the encoding and storage of information.
- **Deep processing stage:** the more relation there is between new and old information, the more information is processed. Lutz and Huit (2003) assume that successful learning takes place if instruction links new materials to past experience.

3.2. Working memory

Atkinson and Shiffrin Two-store Model of information processing received a wide popularity for highlighting two separate stores in the memory system. Past empirical findings showed that LTM patients (e.g. amnesic patients) have a deficit in their long term store and STM patients have an impaired short term store (Milner 1966; Shallice &Warrington, 1970, in Baddeley, 2004), whereas Atkinson and Shiffrin study drew attention back to the importance of STM in long term learning. In the 1970s a new model was introduced by Baddeley and Hitch (1974) to switch attention to the interaction between the two memory systems and highlight the active nature of short term memory, replacing this latter by the concept of working memory. So what is working memory?

3.2.1. Definition of working memory

Baddeley (2000, p. 418) defined working memory (WM) as “a limited capacity system allowing the temporary storage and manipulation of information necessary for such complex tasks as comprehension, learning and reasoning”.

Baddeley’s notion of working memory highlighted two main issues: the limited capacity of the system, and the active nature of the process. Working memory, according to Baddeley, can be illustrated in higher cognitive actions like learning, problem solving and reasoning where there is an interaction between storage process and manipulation of information process. Baddeley (1986) employed the concept of working memory as an umbrella term that involves the interaction between the traditional short-term and long-term stores in an active manner so to perform higher mental actions. In other words, the concept of working memory was used to refer to a whole active process than a mere storage component. The importance of working memory in higher cognitive behaviour like intelligence and learning will be considered in a separate section (c.f. section 4). We will deal with the limited capacity of this system later in the section (c.f. section 2.2.2.2).

As can be observed from Baddeley’s definition, the concept of WM is dissimilar to Atkinson and Shiffrin STM. In distinguishing between the two concepts, Jarrold and Towse (2006, p. 39) pointed out that:

> (…) short-term memory refers to an individual's ability to store or maintain information over a limited time period, while (WM) refers to the ability to hold information in mind while manipulating, and integrating other information in the service of some cognitive goal (…). Although there is clearly some degree of overlap between these definitions, as working memory does involve the storage of information for limited time periods, working memory is, importantly, the broader concept.

This quotation indicates that short term memory is a single ability that is a temporary storage of information, whereas working memory is more than a storing mechanism but also a process of manipulating information necessary for accomplishing cognitive tasks. Jarrold and Towse (2006), hence, supported Baddeley's view of the multi-componential nature of working memory.

- **Operational definition**

Working memory is used in this study synonymously with cognitive psychologists' notions, that is, it refers to the temporary storage and manipulation of information (Baddeley, 2000). This construct can be illustrated through tasks that involve simultaneous storage and processing components. Examples of these tasks are reading a set of sentences and remembering the last word of each in parallel, calculating a set of mathematical operations and retaining the results, or listening to a long passage and filling in the gaps with previously perceived words. These tasks are also considered good measures of an individual's working memory capacity. We will refer back to these tasks in a separate section (c.f. section 3.2).

3.2.2. Theories of working memory

Similar to the constructs of intelligence and aptitude, theories of working memory vary for the diversity of its scope. Some psychologists put focus on its structure (e.g. Atkinson & Shiffrin, 1968; Baddeley & Hitch, 1974). Others emphasized the nature of the system (e.g. Miller, 1956; Cowan, 2000). And again other researchers considered the function of this capacity in higher cognitive actions (e.g. intelligence and language learning). All these issues will be discussed in this section.

3.2.2.1. Models of working memory

Models of working memory provide a structural view of the system through explaining the variety of components it contains, and the mental processes these components involve. Research in cognitive psychology introduced two prominent models that account for the structure of STM: Atkinson and Shiffrin model (1968) and Baddeley and Hitch model (1974). In the previous section, we have shed some light on the former model considering it helpful in explaining the processing of information through different stages. The Two-store Model, although it lacks many details about the proposed components, is considered the basis of Baddeley and Hitch model. This part of the section is mainly concerned with an explanation of Baddeley and Hitch view of working memory. It presents the different components of this ability with a description of each.

a. Baddeley and Hitch model

Before the emergence of Baddeley and Hitch model of WM, cognitive psychologists were interested on the relationship between stimulus and response focusing attention on the different components involved in information processing (Atkinson & Shiffrin, 1968).

However, by the coming of Baddeley and Hitch (1974), attention shifted to the dynamic nature of the component of STM considering Atkinson and Shiffrin STM as a mere storing process. Baddeley (1986) criticised these researchers in that not every item in STS can move to LTS, asserting that information is confronted to interference and decay. He further affirmed that learning cannot be guaranteed by the longer period information resides in STS (Baddeley, 2004). Baddeley and Hitch (1974) replaced the concept of STM by WM perceiving this latter as a central process functioning in complex cognitive behaviour such as learning, reasoning and comprehension. This process involves storing, manipulation of information and attention. (Baddeley, 2003a)

In an early attempt, Baddeley and Hitch (1974, in Baddeley, 1986) divided the construct of working memory into three subcomponents: the phonological loop, the visuospatial sketchpad and the central executive. An explanation of each component is provided below.

1. The phonological loop

It is also referred to as the articulatory loop (Baddeley, 2012). This subsidiary component is the first, the simplest, and the most studied in Baddeley and Hitch model (1974). The phonological loop is also divided into two subsystems: phonological store and articulatory rehearsal. The former is responsible for holding memory traces in order to maintain information for few seconds, while the latter refreshes these traces and makes visual representations of information in the store. For example, in immediate letter recall tasks, although articulatory rehearsal makes visual representations for the perceived letters, subvocal representations are still required, and the retention of these letters relies heavily on phonological characteristics. This is why individuals find it difficult to retain a series of letters like (T, C, V, D, B, G) because these letters have similar sounds. (Baddeley, 2003b)

Neurological evidence (Vallar, Corno, & Basso, 1992, in Baddeley, 2003b) revealed that the phonological loop resides in the left hemisphere. Baddeley, (2003b, p. 192) added that the two sub-systems of this component, .e. phonological store and articulatory rehearsal, have different areas in the brain through reviewing that:

> (…) studies support the hypothesis of separable storage and rehearsal systems, with Brodmann area 44 being the cortical area associated with storage, while subvocal rehearsal appears to be associated with Broca's area (Brodmann areas 6 and 40). In both cases, activation is principally in the left hemisphere.

Two basic issues were extensively dealt with in the explanation of the phonological loop: similarity effect and word length effect. Within similarity effect, Studies (Conrad & Hull, 1964) showed that non-similar letters, e.g. B, W, Y, K, R, X, are better recalled than similar ones, e.g. T, C, V, D, B, G. Further studies conducted by Baddeley (1966) revealed that individuals recall non-similar words (e.g. *pit, day, cow, sup, pen*) better than similar ones (e.g. *man, cat, map, cab, can*) and that words which have semantic associations, e.g. *long, huge, big, tall, large*, are better recalled than those which have different meanings, e.g. wet, thin, soft, dark. (Baddeley, 2003b)

As far as word length effect is concerned, evidence (Baddeley, Thomson, & Buchanan, 1975) showed that long words are more difficult to store, take longer time to recall, and are more exposed to decay than short words. In a five-words immediate serial recall task, Baddeley, Thomson, & Buchanan experiment (in Baddeley, 2003b) indicated that monosyllabic words (e.g. cat, fast, dark, etc.) are best recalled (showing 90% of recall) if compared with five-syllabic words (e.g. university, international, opportunity, auditorium, etc) which showed only 50% of recall. (Baddeley, 2003b)

Another worthwhile issue in the examination of the phonological loop is time-based decay. This latter is also shown to have an effect on recall. The study conducted by Baddeley, Thomson, and Buchanan (1975, in Baddeley, 2003a) revealed that disyllabic words have differing recall ability, i.e. short disyllabic words (e.g. bishop, Tipple) were recalled better than long dissyllabic words (e.g. Friday, harpoon). Saito and Miyake (2004, in Maehara & Saito, 2007) added that the nature of forgetting depends not only on the time spent but also on the amount of information to be recalled, referring to it as 'representation-based interference' instead of 'time-based interference'.

Interference is another concept necessary for the explanation of the phonological loop. It refers to disruptions in the recall of information. Individuals forget either by the influence of past learning, i.e. proactive interference, or recent learning, i.e. retroactive interference (Cowan., 2000). Proactive interference can be illustrated by facing difficulties to recall some English words for a non-native speaker because of the influence of the mother tongue. An example of retroactive interference is having a trouble to remember the place where the car is parked because of exhaustive shopping.

In addition to similarity effect, word length effect, decay, and interference, primacy and recency effects are also considered crucial in the study of the phonological loop. Primacy effect refers to a better recall of the first items, whereas recency effect is the recall of the last items. The former appears in situations when the recall is immediately after the presentation of a series of items, or when it is after a distraction task[5], whereas the latter appears only when the recall is immediately after the presentation of the series. (Altarriba & Isurin, 2012)

[5] A distraction task is given for measuring working memory capacity. In this task the subjects are presented with a recall task, then their attention is directed elsewhere by giving other things that prevent their memorization of the previous task

Regarding the measurement of the articulatory loop, serial recall tasks, and mainly immediate serial recall, are quite opted for to fit the limited capacity of this component. Non-word serial recall is considered an example. In this task, the subjects are given a list of pseudowords in varying length to recall (a pseudoword is defined as a word not existing in a language but having the same phonotactic rules of real words). The backward digit span is another task used in Wechsler intelligence test for children to measure their STM, and particularly the phonological loop. Daneman and Carpenter Reading span tasks (1980) which are considered complex measures of working memory capacity are also good measures of the articulatory loop. (Kormos & Sàfàr, 2008)

The phonological loop was believed to be a useful aid for sentence comprehension and language acquisition. Baddeley (2003b) reviewed research findings on the role this component in facilitating learning new vocabulary and syntactic structures. Besides, it is perceived as the most responsible system of phonological short term memory (PSTM) and the storage of phonological sounds. The phonological loop, or phonological memory (PM: Hummel, 2009), was shown essential for individual differences in both first language acquisition (Baddeley, 1986; Gathercole & Baddeley, 1993) and second language acquisition (Baddeley, Gathercole, & Papagno, 1998; Gathercole & Thorn, 1998; Harrington & Sawyer, 1992; Papagno, Valentine, & Baddeley, 1991). (Hummel, 2009)

2. The visuospatial sketchpad (or Scratchpad)

While the phonological loop is responsible for processing verbal information, this component stores and manipulates visual and spatial data. Studies (Baddeley, 1996; Logie, 1986; Logie et al., 1990; Baddeley et al., 1991b; De Renzi & Nichelli, 1975; Shallice & Warrington, 1970; Della Sala et al., 1999) revealed that this system involves two independent subcomponents, each with different representations, storage and manipulation: one holing visual information and the other for spatial information. The visuospatial sketchpad is less related to language disorders in comparison to the phonological loop. However, it is claimed to interact with reading ability. This component functions mainly when one reads a descriptive passage or describes any familiar object. (Baddeley, 2003b)

As the subcomponent of visuospatial sketchpad differs, the visual representations are assumed to differ as well. In other words, this component holds specific features in objects such as colour, shape, orientation, etc.., which increases its capacity to store information. The capacity of this loop is believed to be four different features in four objects, so the overall capacity of this loop increases to sixteen individual features in four objects (Baddeley & Repovš, 2006). An illustration of the multiple functions of this subsystem in the temporary storage and manipulation of spatial, visual and kinesthetic information under one representation is performing a set of actions simultaneously such as driving a car, listening to a football game and imagining the match simultaneously. (Baddeley, 2003b)

In addition, visual WM was argued to be related to perception more than other components. Experimental findings (in Baddeley & Repovš, 2006) illustrated that individuals recall items better if these items are preceded by a visual cue. Information is transferred to WM by either *top-down perceptual experience*, that is, the influence of past experience in encoding, or *bottom-up process*, by using visual cues or groupings in encoding.

Concerning interference in the visuo-spatial sketchpad, evidence (Baddeley, 1986; Smyth & Scholey, 1994; Smyth, 1996) showed that deliberate eye movement leads to interference in spatial WM. On the other hand, Baddeley (1986) claimed that unintentional eye movement aids in active rehearsal which leads to the activation of attention. (Cited in Baddeley & Repovš, 2006)

As far as the location of this component in the brain is concerned, neurological studies (e.g. Della Sala & Logie, 2002; Smith & Jonides, 1997) illustrated that the two subcomponents of the visuospatial sketchpad appear principally in the right hemisphere. (Cited in Baddeley, 2003b)

3. The central executive

Unlike the phonological loop which is the most discussed and the simplest subcomponent, the central executive is the most important but the least empirically studied and explained subsystem. The central executive is defined as "the ability to focus, to divide and to switch attention and the ability to relate the content of working memory to long-term-memory" (Baddeley & Repovš, 2006, p. 13). This quote indicates that the central executive has a double role: internal and external. External role involves the activation of attention when subjects engage in novel tasks, whereas internal role implies the control of attention in the two slave subsystems, i.e. phonological loop and visuospatial sketchpad (Baddeley, 2004). The double role of the central executive appears also in the control of attention and the link of information with LTM. However, attention was more attributed to this component rather than its relationship with LTM. This latter was later linked to another sub-component namely the episodic buffer.

Concerning the measurement of the capacity of this subcomponent, tasks assembling the processes of storage and attention are given. Reading span tasks (Daneman & Carpter,

1980) and operational span tasks (Turner & Engle, 1989) are examples of these tasks. We will refer back to these tasks in the coming section (c.f. section 3).

While the phonological loop is believed to locate in the left hemisphere and the visuospatial sketchpad in the right hemisphere, the central executive is claimed to reside in the frontal lobes. Neuropsychological evidence (Shallice, 1982; 1988, in Baddeley, 1996) proved that difficulties in attention are attributed to impairments in the frontal areas of the brain. The following figure exhibits the initial model of working memory.

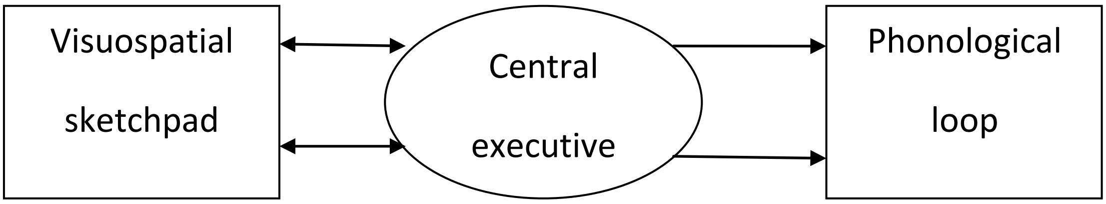

Figure 8. The Initial Model of WM Proposed by Baddeley & Hitch (1974) (in Baddeley, 2000, p. 418)

4. The episodic buffer

Before the appearance of the episodic buffer in working memory model, the central executive was argued to be responsible for both attention and storage. However, three decades later, Baddeley (2000) introduced a recent model when he has integrated the component of the ‘episodic buffer’ and made it principally concerned with the storage of information and devoting the component of the central executive to the control of attention. The episodic buffer, thus, refers to the limited capacity of relating information between the two subsystems and LTM. This subcomponent relates information between the two subcomponents through the use of *multi-dimensional codes*; likewise, it retrieves it from LTS via conscious awareness and modifies it when necessary. Forming chunks of information can be a feasible demonstration. The buffer integrates information from various sources and works under the control of the central executive to perform complex tasks. It is called episodic for its job; that is, it takes episodes of information and extends them over time, and transfers information from/to episodic LTM and relates it to WM. (Baddeley, 2000)

This subcomponent was also revealed important in the representation and storage of visual information (Baddeley & Repovš, 2006). The buffer is not only able to represent the original world, but rather, it also aids in creating a new world that is required in problem solving tasks. For instance, experiments were conducted by Baddeley and Andrade (2000, in Baddeley & Repovš, 2006) in which participants were asked to form novel images for known objects, e.g. imagining an ice hockey playing elephant while doing another working memory task. The results revealed that high WM and LTM were used. Neurological studies (e.g. FMRI) showed that frontal areas in the brain are also crucial for this buffer (Baddeley, 2000). The following figure represents the new working memory model.

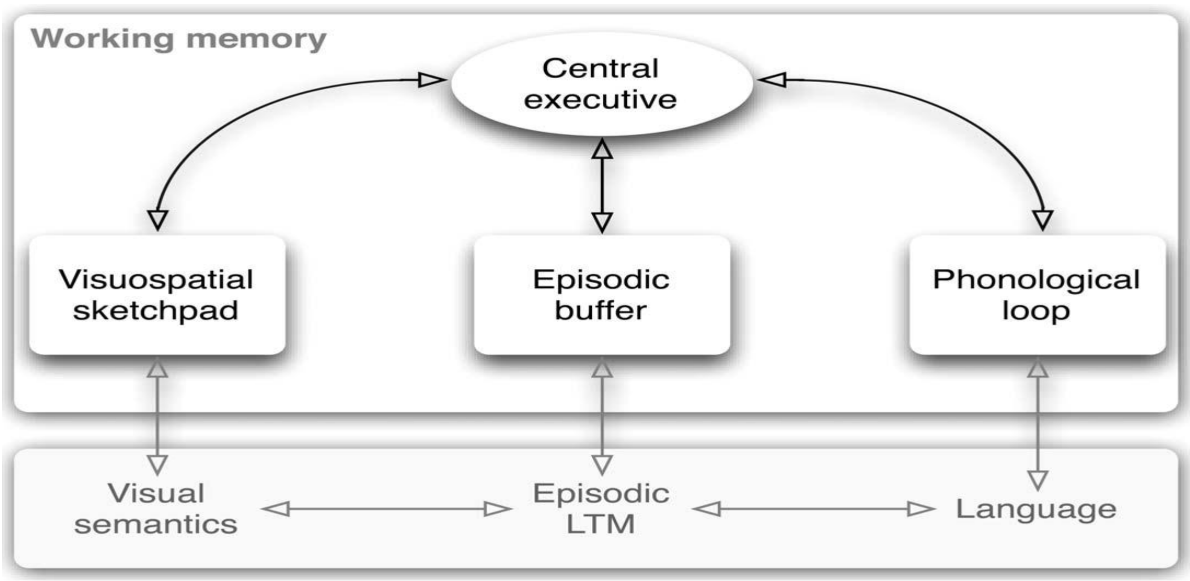

Figure 9. The Current Model of Working Memory (Baddeley, 2000, p. 418)

Baddeley and Hitch model is considered more explicit in the explanation of working memory. Unlike Atkinson and Shiffrin model, this model focused attention on the role of WM in higher cognitive actions like reasoning, language comprehension, and problem solving as these actions require information to be processed and manipulated for a short period of time. Besides, this model dealt with an interaction between old and new information. The active nature of this model (i.e. the multiple roles that WM occupies like controlling, focusing attention, transferring information into LTM) made it influential in neuropsychology, cognitive science, neuroimaging, developmental psychology, and computational modelling (Baddeley, 2000). However, the model was criticised for lack of clarification of some subcomponents such as the central executive. In addition, experimental evidence proved that amnesic patients with a deficit in LTM perform well in STM span tasks and acquire musical skills in a normal way. (Baddeley & Hitch, 2000)

3.2.2.2. The nature of working memory and working memory capacity

Contemporary theories of working memory went beyond the description of its structure, and shifted attention to other issues such as the nature of working memory, its capacity, and its contribution in higher cognitive behaviour. This part of the section is mainly concerned with reviewing the debate of the nature of working memory as well as its capacity.

3.2.2.2.1. The nature of working memory

a. WM as a unitary capacity

Proponents of this view claimed that working memory is a unitary capacity system functioning in higher cognitive actions. Daneman and Carpenter (1980) illustrated this unitary capacity in comprehension tasks where there is a simultaneous activation of storage and processing systems. In their experiment of reading span, the participants who were observed with more storage ability showed better comprehension than their peers.

Cowan (2000) supported the view of working memory as a unitary system considering the focus of attention as central to it. He averred that encoding, retrieval, and other higher cognitive behaviours require focus of attention. In addition, Kane, Hambrick, and Conway (2005, p. 67) asserted that working memory is a 'general-domain construct' through noting that:

> Direct support for our attention hypothesis comes from findings that extreme groups of high and low WMC span scorers differ in the performance of prototypical ―attention-control‖ tasks (…). In short, people with lower WMC show poorer control over thought and action than do those with higher WMC (…) and by showing slower and less flexible allocation of visual attention to objects in space.

b. Working memory as a set of abilities

The pioneering view of WM as a set of separate abilities is the one of Baddeley and Hitch (1974, in Baddeley & Hitch, 2000) who claimed about the existence of two separate subsystems and one executive system. However, their model was criticized in that it didn't fully support the nature of WM as a set of separate abilities, considering the component of the central executive that is the central component of WM system as unitary. (Jarrold & Towse, 2006)

Other exponents of the componential nature of working memory attempted to link its components with specific abilities. For instance, Jurden (1995, in Dang, Braeken, Ferrer

&Liu, 2012) speculated that some memory abilities are related to intelligence, while others are not. His study showed that verbal memory is not correlated with non-verbal intelligence, and that non-verbal memory is not related with verbal intelligence as well as academic achievement scores. Similarly, Shah and Miyake (1996, in Dang et al., 2012) study revealed that spatial WM capacity is related with spatial general intelligence rather than verbal intelligence. Haavisto and Lehto (2004, in Dang et al., 2012), as well, indicated that verbal WM correlates with verbal ability and school achievement, whereas visuo-spatial WM is related to nonverbal reasoning and spatial visualization. Further evidence is provided by Dang and his colleagues (Dang et al. 2012) who conducted an experiment to examine the number of WM components. Different tests were administered (WM tests, general fluid intelligence measure and general crystallized intelligence measure), and the results revealed a significant correlation between general fluid intelligence and visuo-spatial WM ability, and between crystallized intelligence and verbal numerical WM. Dang et al. concluded that WM contains two separate subsystems, namely visuo-spatial WM and verbal numerical WM. Even more, Jarrold and Towse (2006) provided another view that WMC relies on three main abilities, viz. processing efficiency, storage capacity, and controlled attention.

3.2.2.2.2. working memory capacity (WMC)

Extensive attention has been directed to the explanation of working memory capacity from early theories to modern views. In the early past, the American psychologist Wiliam James (1890) divided memory into two types: primary memory (similar to STM) and secondary memory (similar to LTM). He advocated that the former is a limited capacity system, whereas the latter is relatively indefinite. James thought gave insights to Miller's view of memory capacity and the notion of chunking. (Bowden et al., 2005)

a. Miller's view

In 1956, Miller published a paper "The magical number seven, plus or minus two: Some limits on our capacity for processing information", introducing the limited capacity of human memory. Miller's theory started by observing individuals encode information in familiar separate patterns in LTM and recall these patterns in the same way as encoding them, whereas other independent items with no associations were noticed to be recalled separately in STM. Miller, then, conducted a set of immediate serial recall tasks to measure memory and discovered that individuals' memory capacity is approximately seven chunks. Miller's magical number seven was not statistically proved; rather, it was just a coincidence. Miller concluded that number seven reflects the compound capacity of memory system. Miller was the first to introduce the concept of chunking. A chunk is defined "a collection of concepts that have strong associations to one another and much weaker associations to other chunks concurrently in use" (Cowan., 2000, p. 89). It is also synonymous with "a meaningful unit". A chunk can be illustrated by forming a number of meaningful units from the following independent letters: "f, b, i, c, b, s, i, b, m, i, r, s" like making the famous acronyms: FBI, CBS, IBM, IRS. In order to increase one's memory capacity, Miller called upon intelligent forming of chunks of information like making four chunks from the whole previous twelve letters to facilitate their recall. In stressing the importance of chunking, Miller (1956, p. 94) pointed out that:

> (…) the span of absolute judgment and the span of immediate memory impose severe limitations on the amount of information that we are able to receive, process, and remember. By organizing the stimulus input simultaneously into

several dimensions and successively into a sequence of chunks, we manage to break (or at least stretch) this informational bottleneck.

b. Cowan's view

Four decades after Miller came Cowan with a different standpoint. In his article "The magical number 4 in short-term memory: A reconsideration of mental storage capacity", Cowan (2000) advocated that adults can recall four clusters of information naming these clusters *"memory storage capacity"*. Thus, he replaced Miller's magical number 7 by another magical number 4($\pm$1). Best memory performance, according to Cowan, occurs when chunks are not more than 4. If the number of recalled items exceeds his proposed magical number, interference occurs and affects this effectiveness. Cowan (2010, p. 52), further, noted that "we believe that there truly is a central working memory faculty limited to 3 to 5 chunks for adults, which can predict mistakes in thinking and reasoning". In addition, this psychologist assumed that working memory capacity remains four whether in one or both hemispheres. Cowan (2010, p. 56) supported his viewpoint by a number of arguments:

> The capacity-limit-as-weakness camp suggests reasons why it would be biologically expensive for the brain to have a larger working memory capacity. One way this could be the case is if there is a cycle of processing in which the patterns of neural firing representing, say, four items or concepts must fire in turn within, say, every consecutive 100-millisecond period, else not all concepts will stay active in working memory.

3.2.2.2.3. Levels of processing theory

While past theories of information processing (e.g. Atkinson & Shiffrin model, 1968; Baddeley & Hitch model, 1974) put strong emphasis on the different components information goes through, other views emerged as a reaction to highlight the processes concerned with learning and memory. Among these views is the Craik and Lockhart Levels of Processing Theory (1972). These prominent researchers claimed about the existence of two types of processing: shallow processing and deep processing. They believed that the former goes with maintenance rehearsal, while the latter is related to elaborative rehearsal. Craik and Lockhart (1972) opined that it is only in the second type of processing that memory traces can be formed, which improves the storage of information.

Craik and Tulving (1975, p. 268) define the term ‘depth’ as “the greater degrees of semantic involvement”. Semantic processing can be illustrated by associating the concept to be encoded with its category, like associating the word “dog” with the category of animals. In addition to semantic processing, deep processing involves also associations between a word and other words having the same rhyme, making meaningful use of the word in personal examples, or linking information with previous knowledge. (Baddeley, 2004)

Furthermore, Craik and Tulving (1975) announced that questions requiring positive responses lead to better retrieval than those requiring negative responses. However, these latter ones can be recalled in the same way as the former questions if they involve elaborative processing (e.g. thinking and explaining). These psychologists highlighted the importance of semantic processing through stating that “retention depends critically on the qualitative nature of the encoding operations performed; a minimal semantic analysis is more beneficial than an extensive structural analysis” (p.268). Craik and Tulving (1975) conducted experiments in which subjects were asked different questions about words with regard to their structures and meanings. The results revealed that better recall is associated with semantic questions rather than other questions.

In a recent work, Craik and Lockhart (1990) provided a retrospective announcement of their work of 1972. They emphasized the role of perception and comprehension in forming more durable memory traces. These two cognitive processes were claimed not to act without the process of attention. These researchers, further, reacted to the criticisms given to their theory; as one claim is that depth of processing is not determined by memory outcomes, and that amnesic patients can process information deeply (i.e. they can understand information); yet their memory fails to retrieve. Another criticism was the one of Baddeley (1978, cited in Craik & Lokhart, 1990) who questioned the idea of making *functional principles* insisting on specifying structures for the process of information. Craik and Lockhart reaction to the first criticism pointed to the emphasis of more effort and time. They themselves criticized Baddeley's model of WM for its intensive consideration of structures, and indicated that rehearsal is not a mechanism that carries information from STM to LTM but just a principle. An example of this principle is associating the word "dog" with an image.

3.3. Tests of memory

Early attempts in measuring human memory were done more than a century ago. By the emergence of Experimental Psychology, Galton (1883) measured this capacity through the recall of complex poetry. Similarly, Ebbinghaus (1885) exposed subjects to nonsense syllables to assess their recall. In recent years, there was adherence to these tests from the belief that everyday memory cannot be informative of the individual's ability to recall. (Urbina, 2004)

However, another contradictory view emerged to assert that human memory measures are not valid unless they go beyond laboratory tests to real life situations. This reaction provided evidence that amnesic patients forget appointments, yet their performance in STM tests remains intact (cited in Baddeley, 2004). This view has directed us to choose real English words rather than nonsense words to measure the participants' actual working memory capacity in the current study. The reason is that the current WM measure aims at assessing working memory capacity in the foreign language, i.e. it aims to identify those who are more able in remembering words in the foreign language.

Provided that working memory testing is crucial for the current investigation, a review of the literature of short term memory and working memory measures is considered mandatory. We have distinguished earlier between the two concepts in that while short term memory refers to holding information for a short period of time for immediate recall, working memory refers to holding information for a short time while performing other tasks simultaneously.

Two concepts are quite important for the measurement of both short term and working memory abilities: recognition and recall. These concepts refer to the degree of retrieval from short term memory. They differ from each other in that while the former requires more cues that aid for retrieval, the latter does not require any cues. Recognition is easier than recall in that it requires a context which itself helps in retrieval, whereas recall does not. Recognition is illustrated through giving a series of items to the subjects to remember for a short period of time, then exposing them to a list of items, and they answer 'yes' if the item is previously perceived and 'no' if it is not. Recall is illustrated by giving a series of items to remember for a short period of time, and the participants are required to give the items in their order or in a reversed order.

3.3.1.Short-Term Memory Span Tasks

STM measures are those measures that assess the temporary storage capacity. Christal's (1959, in Beiera & Ackerman, 2004) distinguished between five factors underlying short term memory measures: *visual imagery,* in which the participants retain visual images; *incidental memory,* which is the memory of unintentionally stored information; *delayed recall*, which is the retention of information after certain amount of time; *memory for content,* which refers to memory for words or numerals; and *memory for temporal position,* which is memory for order.

Kelley (1964, in Beiera & Ackerman, 2004) added four different factors for short term memory assessment: *rote memory*, in which the participants are tested in the ability to recall or recognize a number of verbal, spatial and numerical information; *meaningful memory*, which refers to making associations; *span memory*, which is synonymous to memory for order; and *visual memory*, in which the participants are asked to remember either by recall or recognition of visual representations.

In measuring short term memory capacity, Conway, Cowan, Bunting, Therriaul, and Minkoff (2002) proposed simple tasks like *word span* and *digit span*. Yuan, Steedle, Shavelson, Alonzo and Oppezzo (2006) added extra tasks like *letter tasks, shape tasks,* and *position tasks.* In these tasks, individuals are required to recall stimuli in their order or in a reversed order. An experiment made by Masson and Miller (1983, cited in Yuan et al., 2006) is giving individuals a series of consonants in an increasing number and asking them to write them back in their order. STM tasks are also used to test the visuo-spatial capacity. Puzzles are an instance whereby the participants use the bottom up approach to make a whole picture of the many pieces they have been given.

3.3.2. Working Memory Span Tasks

In cognitive psychology and second language acquisition research, complex span tests are opted for in the measurement of working memory capacity. Complex working memory measures require the activation of multiple processes like controlling attention, focusing attention and avoiding interference (Sanchez, Wiley, Miura, Colflesh, Ricks, Jensen & Conway, 2010). Conway et al. (2002) advocated that these tasks require executive attention and other processes like *chunking* and *rehearsal*. Bowden et al. (2005) measured this active capacity by tasks that require reading or listening to a set of sentences and judging their grammaticality or semantic truthfulness on the one hand, and remembering the last word of each sentence on the other hand.

In the history of memory testing, three main tests received the attention of cognitive psychologists to be recognized as fairly reliable and valid means that provide knowledge about someone's working memory capacity (Conway et al., 2002). These tests are known as Reading Span Tasks (RSPAN), Operation Span Tasks (OSPAN), Listening Span tasks (LSPAN) and Counting Span Tasks (CSPAN). The word 'span' is used to refer to WMC. For example, someone is told to have a span of 4 or 5, etc. (Daneman & Carpenter, 1980). For the reliability of OSPAN measure, Kane and Engle (2003, p. 50) averred that:

> Prior research has established the OSPAN task to be a reliable and valid marker of WM capacity. With respect to reliability, OSPAN demonstrates adequate internal reliability as indexed by Cronbach's alpha (approximately .65–.75; Conway et al., 2002; Engle, Cantor, & Carullo, 1992; Engle, Tuholski et al., 1999; La Pointe & Engle, 1990). OSPAN scores also remain stable over test–retest intervals of a few minutes (r .77–.79; Turley-Ames & Whitfield, 2002), to 3 weeks (stability coefficient .82; Klein & Fiss, 1999), to 3 months (stability coefficient .76; Klein & Fiss, 1999). Moreover, in studies comparing versions of OSPAN that differ in arithmetic difficulty, Conway and Engle (1996) and Lehto (1996) found correlations among them to be in the range of .70–.80.

The reliability of these tasks made them widely used in other disciplines like clinical psychology, educational psychology, neuropsychology, developmental psychology, and some other fields. These tasks were designed from the perspective of Baddeley and Hitch model of WM (1974) which highlighted this active process that is responsible for storage and manipulation of information necessary in solving complex cognitive tasks such as reasoning.

RSPAN is the initial adopted task by Daneman and Carpenter (1980) in order to assess both processes of WM: storing process and manipulation of information process. This task is also referred to as verbal span task (Bailey, 2012). Daneman and Carpenter employed RSPAN as a WM measure to investigate whether there is a correlation with reading comprehension. As a procedure, they gave an increasingly long series of sentences (from 3 to 7) to a number of subjects and instructed them to read or examine the semantic accuracy of these sentences and to remember the last word or a separate word that appeared at the end of each sentence. For example:

READ ALOUD

1.When at last his eyes opened, there was no gleam of triumph, no shade of anger.

2.The taxi turned up Michigan Avenue where they had a clear view of the lake.

RECALL (*anger, lake*)

At the end of each span, the subjects recalled these words, and their memory capacity was determined by the maximum number of words they could recall accurately after a short interval. Exposure time should have been as long as it took to read the sentences at a normal pace (i.e. about 5 seconds). Daneman and Carpenter found that the average working memory capacity is between 2 to 5 words. It is noteworthy that Daneman and Carpenter test took into account working memory capacity in relation to language. This has urged us to include this task in the current WM measure.

The second measure of WMC is operation span tasks (OSPAN). Similar to the previous task, OSPAN involves the activation of two WM processes: evaluating the semantic accuracy of sentences or the results of mathematical operations, and the recall of separate items (e.g. letters, digits or words). This test was first developed by Turner and Engle in 1989. These researchers took the subjects to solve some mathematical calculations and remember independent items in each series (e.g. 1. Is (8/2)+8= 5? **P;** 2. Is (1*4)-4=0? **J)**. The number of operations ranged from 2 to 6. The final OSPAN score is the sum of the number of correctly recalled items, i.e. it ranges between 0 and 6. (Kane & Engle, 2003)

Some researchers claimed that OSPAN is more predictive of working memory capacity than RSPAN. Kane and his colleagues (Kane et al., 2004, in Jarrold & Towse, 2006) experiment showed that OSPAN, unlike RSPAN, is a valid measure of WMC in non-natives. Sanchez, Wiley, Miura, Colflesh, Ricks, Jensen and Conway (2010) supported this view and added that OSPAN tasks are found as good measures for both WMC and the prediction of fluid intelligence (Gf), whereas RSPAN tasks are not.

Listening span (or LSPAN) is the third adopted measure for the assessment of verbal working memory capacity. This task was first adopted by Daneman and Carpenter in 1980. While RSPAN involves the perception of visual stimuli like letters, numbers, words, and sentences; LSPAN requires the perception of auditory (i.e. oral) sentences. Two aspects of working memory are also considered in this measure, viz. recall capacity and manipulation of information ability. The individuals, in this task, listen to a set of sentences; then they are asked to recall the last word of each. Sometimes, the task can be even more complex by adding some questions to the perceived sentences. For example, the sentence ‘a cat barked at a dog’ is given and the participants judge whether it is meaningful or not, with the recall of the last word. (Dehn, 2008)

Case and other researchers (Case et al., 1982, in Kane et al., 2005) adopted an additional measure of WMC, referring to it as counting span tasks (CSPAN). Like the previous tasks, this task also assesses recall ability and manipulation of information capacity. The subjects in CSPAN are given a number of different colours of dots to count; then they are asked to recall the obtained numbers. Evidence (e.g. Kurland & Daneman, 1979, in Sanchez et al., 2010) showed that adults perform better than children in these tasks.

As far as scoring is concerned, two scores should be given to the previous tasks: one for processing component, and the other for storage component. For example, in OSPAN, the judging of the accuracy of sentences or calculations is given a score, and the recall of words is given another score (Kane et al., 2005). We should note that in the current WM measure, we will give a unique score that reflects working memory capacity. This score will be devoted to storage ability. We believe that reading, listening or judging the accuracy that are given to measure process ability are just distraction tasks[6] that disrupt the attention of individuals and, hence, reveal real working memory capacity.

- **Assessing attention**

Attention is a fundamental aspect in working memory. For this reason, it is required from us to review some studies that focus on its measurement. Kane, Bleckley, Conway, and Engle (2001, in Kane & Engle, 2003) used Antisaccade tasks to measure one aspect of attention which is visual attention. In their study, the participants were disturbed by a light in one side and were required to avoid it and concentrate on the other side to recognize the given stimuli. These researchers observed the eye-movement of the participants towards the light and noticed that those with high WM ability made less eye movement errors, i.e. looking at the light.

Stroop task is another task used by Kane and others (2001) to measure working memory capacity, selective attention, and internal and external control of behaviour. The participants, in this task, were exposed to confusing stimuli, e.g. the red colour written in blue, and were asked to remember these colours. The researchers found that memory capacity was less when the participants were given incongruent stimuli, i.e. when the colours were written with different colours (i.e. writing red with blue) than congruent stimuli, i.e. when the given colours were written using original colours. Incongruent stimuli were referred to as the Stroop effect or Stroop interference. These researchers concluded that WM is necessary for attentional control in these tasks. (Kane & Engle, 2003)

[6] C.f. p. 108

3.4. The role of working memory in higher cognitive behaviour

We have seen earlier that all definitions of working memory highlight its role in higher mental actions. Among these actions are learning and intelligence. As our current work aims at establishing relationships between a set of cognitive abilities, namely working memory, reasoning, and language aptitude, in addition to examining the role of these abilities in foreign language learning achievement, it is necessary for us to provide a literature review of the relationship between working memory and intelligence and working memory and language aptitude, as well as the role of WM in language learning. The theoretical overview of the relationship between working memory and language aptitude is dealt with in the previous chapter (c.f. chapter 2.6). This section is devoted to the role of working memory in language learning as well as its association with intelligence.

3.4.1. Working memory and language learning

Working memory is required whenever learning takes place. Any type of learning requires the manipulation of information, interaction with LTM, and simultaneous storage and processing of information. (Kyllonen, in Dehn, 2008)

Regarding the relationship between working memory and language learning, educational and psychological research on working memory has long affirmed its impact. In psychology, Baddeley and Hitch (1974) stressed this system as the primary component that maintains and manipulates the vocabulary and the grammar of both L1 and L2. In 1990, Baddeley and Gathercole (in Altarriba & Isurin, 2012) conducted a study to examine the role of working memory in learning vocabulary. They asked children of 5 and 6 years old to give new names for known toys (mapping a new word form to already known objects), and found that those with low scores in non-word repetition tasks didn't succeed in giving new names. In another study, Baddeley and his colleagues (Baddeley et al., 1998, in Altarriba & Isurin, 2012) considered WM as a *"language learning device"* after proving a positive correlation between this ability and native vocabulary learning for children. In 1999, Baddeley (as cited in Juffs, 2006) assumed that language proficiency depends on working memory capacity from his observation of individuals with higher WMC remembering nonsense words better than those with less WMC.

Two components of working memory were quite focused on in the study of language acquisition: attention and the phonological loop. Attention is believed to be a mandatory aspect for the acquisition of the vocabulary and grammar of the foreign language. Kormos and Sàfàr (2008, p. 269) stressed the importance of this component through stating that:

> (…) working memory affects the acquisition of syntactic and vocabulary knowledge also through its attention regulating function. (…) attention is at the core of noticing and encoding both new pieces of information as well as regularities in long-term memory, which constitutes the basic mechanism responsible for learning words and rules of grammar in L2.

A further view is provided by Wen and Skehan (2011) who opined that more fluent speakers rely more on their attentional processes when they retrieve words from their lexical knowledge to find the correct structure of L2. These researchers pointed out that it is L2 that is affected by attentional control and not L1, associating this latter with automatic processing. In addition to attention, Wen and skehan stressed the role of the phonological loop component in developing lexical knowledge. They concluded that both components have great effects in SLA and particularly in the acquisition of grammar and vocabulary.

Attention has been indicated previously to have a crucial role mainly in second language acquisition. The phonological loop, on the other hand, is a basic component required in processing L1 as well as L2. In stressing the importance of this component in L1 acquisition, Baddeley (2003b, pp203-204) advocated that:

> (…) disorders in working memory may impact on language processes. While a huge amount of such language processing is relatively automatic, deficits within the phonological loop, and to a lesser extent, within other aspects of working memory, may seriously impair language processing. It seems likely that the interface between working memory and language will continue to be a fruitful one.

Further evidence on the role of the phonological loop in L1 acquisition is provided by Kormos and Sàfàr (2008). Their experiment revealed a strong correlation between this component and the acquisition of L1 vocabulary for children. Concerning the role of the phonological loop in second language acquisition, a number of studies (Berquist, 1997; Ellis, 1996, in Juffs, 2006) showed that it is a good predictor of L2 proficiency. Further views on the impact of phonological memory in developing language proficiency are reviewed in the previous chapter (c.f. chapter 2.6).

As far as the role of working memory in different stages of second language acquisition is concerned, Schneider and Detweiler (1987, as cited in Miyake & Shah, 1999) presented a model of WM through highlighting a variety of components: auditory, lexical, semantic, syntactic and motor. They speculated that in initial levels of learning, i.e. beginning and intermediate levels, information processing is quite controlled and effortful and depends more on WM processes; while in advanced levels this process becomes less controlled and mechanical.

Another worthwhile issue with regard to the role of working memory in second language acquisition is the use of some memory techniques in learning the vocabulary and grammar of the foreign language. As for vocabulary learning, the technique of "paired associates" can be used through which learners associate a foreign word either with their native language or with a picture. Another technique is "security word" or "mediator", whereby a foreign item is associated with another foreign item which does not hold the same meaning, yet it goes with the learner's native language, such as taking advantage, for a Spanish learner of English, of the word "blank", that is associated with the Spanish word "blanco" in order to learn the word "white", by imagining blank sheets as white. Similarly, learning grammatical rules can be done through using some memory techniques. Learners can use the principle of "meaningful relationships", such as learning grammatical rules in meaningful contexts. (Stevick, 1976)

3.4.2. Working memory and intelligence

The relationship between working memory and intelligence has long been a compelling issue in cognitive psychology. Major empirical works were directed to the relationship between WMC and Cattell's types of intelligence, viz. fluid and crystallized. This part of the section is concerned with reviewing some research findings on the relationship between these constructs.

The idea of the association between memory and intelligence commenced with Jacobs' work (1887). This psychologist believed that owning good memory abilities is attached with being more intelligent. Jacob's study informed him that older and more intelligent children can remember long lists of digits in comparison to young and less intelligent ones. Jacob's view stimulated the founders of the first practical intelligence test. Binet and Simon (1905) started to observe children's memory capacity. They noticed that three-year-olds were able to remember two digits; four-year-olds could recall three digits; and seven-year-olds recalled five digits. This observable difference of memory capacity between different ages led Binet and Simon to include tasks of immediate memory in the first test of intelligence. From that time until now, short term memory has been an important aspect in Binet's tests of intelligence. Memory subtest was shown to correlate with Binet's other subtests like arithmetic ability, similarity, etc (Altarriba & Isurin, 2012). Memory capacity was also measured in Wechsler's Adult Intelligence Scales (WAIS). The subtest of digit span measure, for example assesses numerical memory. (Beiera & Ackerman, 2004)

The link between memory and intelligence was not only restricted to psychometric theories of intelligence but also extends to developmental views. In their book of *The Psychology of the Child*, Piaget and Inhelder (1969, in Gallagher & Reid, 1981) provide two definitions of the concept of memory, considering one as broad and the other a narrow definition. The broad definition is that memory is an aspect of intelligence because it allows the individual to adapt to the environment through the use of past experience. Piaget and Inhelder narrow definition is similar to traditional notions of memory since it indicates that this ability is a collection of information, perception and imitation.

By the beginning of the 1970s, the idea of memory as a simple system of processing information was criticized, and the need for more active capacity became rudimentary. As a result, Baddeley and Hitch (1974) came up with a new model of information processing putting emphasis on the active and componential nature of memory and referring to it as working memory. Working memory was defined by Baddeley (2000) as an active system that temporarily stores and manipulates information that is necessary for higher cognitive abilities such as intelligence. Baddeley (1996) stressed the importance of the central executive, which is a component of working memory, in intelligent behaviour. De Jong and Das-Smaal study (1995, in Schweizer & Moosbrugger, 2004) added evidence to the relationship between the central executive and intelligence. These researchers pointed out that this component is more associated with intelligence than the other two slave systems (phonological loop and visuo-spatial sketchpad) although they also show a link. They (in Schweizer & Moosbrugger, 2004, p. 334) noted that "(...) it is reasonable to assume that attention is only linked to working memory, while working memory is the only predictor of intelligence".

Concerning the link between working memory and fluid intelligence, various findings revealed strong interrelationships. Kyllonen and Christal (1990) study of the association between working memory and a set of cognitive abilities like reasoning, general knowledge and processing speed, demonstrated the highest correlation between reasoning ability and working memory capacity (.80 to .88). These psychologists concluded that both constructs are similar and that reasoning ability is just "little more than working memory".

Similar findings were obtained by Conway and his colleagues (Conway et al., 2002). The psychologists conducted experiments to measure both types of memory, i.e. STM (by simple recall tasks) and WM (by OSPAN, RSPAN, and CSPAN tasks), in addition to other cognitive abilities like processing speed[7] (by Digit-Symbol substitution, and Digit and

[7] Speed of processing is defined by Conway et al. (2002) as the capacity to rapidly encode, transform and retrieve information in WM

Letter comparison) and general fluid intelligence for undergraduate students aging between 18 and 22. The results showed a very strong correlation between WMC and Gf (.98), a weak correlation between STM and Gf (.29) and between processing speed and Gf (.11). They concluded that working memory capacity is "the primary determinant of Spearman's g". In another study, Kane et al. (2005) demonstrated a correlation of (.72) between WM and Gf.

Engle (2002) is another psychologist who illustrated a strong association between working memory and Gf. This psychologist used attention tasks, i.e. Antisaccade Task, Stroop Task, and Dichotic Listening Task, to measure WMC. The results revealed that the subjects with high WMC were faster in identifying letters, made fewer errors in identifying congruent and incongruent colours, and were more able in ignoring unrelated information. Engle came up to say that WMC is much more related and "maybe isomorphic" to Gf.

In 2008, a further study was conducted to investigate the effects of training on WM tasks in increasing fluid intelligence. Jaeggi and other colleagues (Jaeggi, Buschkuehl, Jonides & Perrig, 2008) carried out four experiments with a varying number of training sessions, i.e. from eight to nineteen sessions, on working memory tasks. The participants were given a pre-test on Gf before their training and then a post test after the training sessions. The results showed a *dramatic* improvement in Gf. These researchers attributed this improvement to the increase of the function of the central executive, i.e. attention control.

Neurological evidence as well revealed the connection between WM and Gf. Kane and Engle (2002) experiment demonstrated the involvement of the prefrontal cortex in a variety of cognitive actions such as the control of attention, WMC and Gf. Besides, Gray, Chabris & Braver (2003) Functional Magnetic Resonance Imaging (FMRI) findings showed that both reasoning and working memory performance involve activity in the lateral prefrontal and parietal regions in the brain.

In addition to its relationship with fluid intelligence, working memory is also argued to correlate with crystallized intelligence. Alloway and Alloway (2009) conducted an experiment with learners with learning disabilities through training them with working memory tasks. Two groups were involved: a control group that had no training session, and an experimental group that was engaged in a WM training program. Before the program, a pre-test was given to both groups including Gc measure (vocabulary subtest of Wechsler intelligence scale), WM measure (letter recall), and academic achievement measure (numerical operation test in Wechsler intelligence scale). In the training program, the participants were given three games; each game contained 30 tasks with increasing difficulty, and then they were asked to process and recall information. A post test was administered later to examine the effects of training. The results showed dramatic improvement in the scores of Gc. Alloway and Alloway (2009, p. 05) pointed out that "…this increase in working memory capacity was not restricted to improvements in fluid skills but transferred to acquired skills as demonstrated by gains in *Gc* and academic attainment."

While previously mentioned findings confirmed the link between working memory capacity and one type of intelligence, i.e. fluid or crystallized, Dang et al. (2012) work found that working memory is linked to both types. These researchers attempted to investigate the nature of WM as a unitary or componential system through studying its relationship with fluid and crystallized intelligence measures. 348 Chinese college students aged between 18 and 22 years old were selected for this study. The participants were given six tasks to measure their working memory capacity: RSPAN, OSPAN, CSPAN, distance estimation span, letter rotation span, and dot matrix span. WM measures varied in storage components: the three first tests relied on verbal-numerical storage component, whereas the three last ones required visual-spatial storage ability. Measures of fluid intelligence were taken from Raven's Advanced Progressive Matrices Test and Cattell's Culture Fair Intelligence Test, and measures of crystallized intelligence were taken from Verbal Wechsler Adult Intelligence Scale (Verbal-WAIS). The results indicated the separation of WM components with varying degrees of correlation with the two types of intelligence. More clearly, visual-spatial WM was found to correlate strongly with fluid intelligence and both abilities were noticed to rely on executive attention. Verbal-numerical WM, on the other hand, showed a significant correlation with crystallized intelligence, and these abilities were also argued to have an important role in language learning and language comprehension.

Conclusion

Working memory is an active process of information that is always required in every simple and complex human behaviour. Throughout the chapter, we have highlighted the construct of WM from different perspectives. We have shed some light on information processing theory that has stimulated the emergence of the concept and have introduced different memory stages. A number of theories discussing the structure of WM (Atkinson and Shiffrin model, 1968; Baddeley & Hitch model, 1974), its capacity (unitary and componential: Miller, 1956; and Cowan, 2000), and its function (e.g. levels of processing theory by Craik and Lockhart, 1972) have also been reviewed. For the assessment purpose of the current study, we have introduced some reliable and valid measures of WM (e.g. RSPAN, OSPAN, and CSPAN).

The chapter has also highlighted the role of working memory in learning and particularly language learning. We have dealt with the interaction of working memory components with different stages of language acquisition and reviewed some findings of its relationship with language proficiency. As we hypothesize working memory capacity as a component of general linguistic intelligence, we have reviewed some theoretical evidence on the relationship between working memory and intelligence. The next chapter deals with language learning, achievement, and psychological testing that are considered important concepts in the present investigation.

Chapter Four

Foreign Language Learning/ Psychological Testing

Introduction

4.1.Second language acquisition

4.1.1 Definition of language

4.1.2 Components of language

4.1.3 Definition of learning

4.1.4 Learning vs. Acquisition

4.1.5 Second language vs. foreign language acquisition

4.1.6 Theories of second language acquisition

4.1.6.1. Early psychological views

4.1.6.2. Applied linguistics and SLA theories

a. Structural linguistics and behavioural psychology

b. Generative linguistics and cognitive psychology

c. Constructivism: a multidisciplinary approach

4.1.6.3. Psycholinguistic theories

4.1.7. Factors influencing Second Language Acquisition

4.1.8. Learning stages

4.1.8.1. Preproduction stage

4.1.8.2. Early production stage

4.1.8.3. Speech emergence stage

4.1.8.4. Intermediate fluency

4.2. Language learning achievement

Foreign Language Learning/ Psychological Testing

Introduction

Second language acquisition (SLA) is a recent field emerging in the second half of the twentieth century, notably when interest in learning a foreign language was prevalent. It sheds light on various issues germane to learning any additional language. The following chapter provides an explanation of the two basic concepts: language and acquisition, and reviews major theories with regard to this latter. It sketches out some factors that influence SLA. Stages of language acquisition are also worth to be highlighted in this chapter.

The concept of language learning achievement is another worthwhile issue in the study of second language acquisition. It deals with the outcome of learning/acquiring a language. This chapter will also deal with this concept, in some detail, through providing a comparison with language proficiency and reviewing some recognized measures.

For the measurement purpose of the current research, it is required from us to deal with some basic issues regarding psychological testing. The chapter will also provide an explanation of this latter concept and discern its main conditions.

4.1. Second language acquisition

The field of SLA involves a variety of issues like learning and acquisition, second language and foreign language, theories and stages of SLA, to name but a few. All these issues will be highlighted in this section.

4.1.1. Definition of language

Language, according to Merriam Webster's online dictionary, refers to a system of words or signs that are used to express thoughts and feelings. In linguistics, the term is so more complex and includes a variety of aspects. Brown (2007, p. 6) provided a comprehensive definition through including eight main aspects that underline the concept:

> Language is systematic; it is a set of arbitrary symbols; those symbols are primarily vocal, but may also be visual; those symbols have conventionalized meanings to which they refer; language is used for communication; language operates in a speech community or culture; language is essentially human, although possibly not related to humans; language is acquired by all people in much the same way: language and language learning both have universal characteristics."

4.1.2. Components of language

In their study of language, linguists identified five universal components: phonology, syntax, morphology, semantics and pragmatics. A description of each component is provided below.

Phonology is the study of speech sounds. Linguists highlighted a set of rules for the interaction of sounds, referring to them as phonological rules. One rule is that some sounds must not be put together. For instance, in English, the sound "b" and "n" cannot appear next to each other in a word. Another rule concerning the English language is that words cannot start with the sound /ɪŋ/. In addition to rules, the study of speech sounds entails some aspects in rapid speech such as assimilation and elision (Brown, 2007). Assimilation is defined as the change that appears to a sound as a result of the influence of a nearby sound. For example, in the expression 'ten minutes', the sound /n/ that appears in the word 'ten' is influenced by the sound /m/ that appears in the word 'minutes and becomes /m/, so the expression becomes the following /temmınıts |. Elision, on the other hand, is defined as the omission of a sound because of the influence of a following sound. This can be illustrated by omitting the sound /t/ in the expression 'must be' and writing /məsbi/ instead. (Carter & Nunan, 2001)

Syntax is concerned with the structures of sentences. To know the syntax of the foreign language involves knowledge of how the different parts of a sentence are arranged. Linguists provided descriptions of how language works. For example, they pointed out that adverbs can change their position in a sentence without affecting the meaning, while nouns cannot. The sentence "<u>Yesterday</u>, Sally saw Jane" is the same as "Sally Saw Jane <u>yesterday</u>"; however, the sentence "<u>Jane</u> saw <u>Sally</u>" is different from "<u>Sally</u> saw <u>Jane</u>". (Brown, 2007)

When syntax deals with the structure of sentences, morphology involves different word formations. A morpheme is defined as the smallest meaningful unit. There are two types of morphemes: bound morphemes and free morphemes. The former cannot stand alone, while the latter can. For example, the word 'unforeseen' includes both types of morphemes: 'un' and 'for' are bound morphemes and 'see' is a free morpheme. (Brown, 2007)

Semantics and pragmatics are concerned with the study of meaning. Semantics differs from pragmatics in that the former involves the study of literal meaning, while pragmatics is the study of contextual meaning. In other words, semantics examines the constant meaning of expressions, whereas pragmatics examines what speakers mean by using these expressions. (Brown, 2007)

Brown (2007) added that learning a language involves learning its different sounds, words and their combinations, as well as the meaning of these combinations, and the speakers' intention to use them.

As an operational definition, the term Linguistic intelligence is derived from the concepts: intelligence and language. Language, or more specifically linguistic, is used to involve three main components: phonology, grammar and vocabulary. Phonology implies understanding and remembering foreign language sounds. Grammar involves the internalization of the different syntactic structures and word functions. Vocabulary is knowledge of foreign language words. These three components were also argued to be components of language aptitude (c.f. chapter 2.2.1), and language proficiency (c.f. chapter 4.2.2). A more detailed definition of Linguistic intelligence is provided in chapter one (c.f. chapter 1.1.2.5).

4.1.3. Definition of learning

According to Merriam Webster's online dictionary, learning means the activity or process of gaining knowledge or skill by studying, practicing, being taught, or experiencing something. Although this definition provides a general knowledge of the concept, it lacks some specific details, like how learning takes place, i.e. mental processes involved, and where it occurs, i.e. in natural or academic settings.

In educational psychology, learning refers to the "change in an individual caused by experience" (Slavin, 2006, p. 134). Learning and development are closely linked constructs. In other words, individuals start to learn from the day they are born. However, physical development is excluded from learning. Besides, learning takes place either intentionally or unintentionally. Intentional learning is a brain activity that is controlled. It can be illustrated through acquiring knowledge in academic settings. Unintentional learning, on the other hand, is a non-controlled process that appears in natural settings. This type can be demonstrated by learning to walk for a baby (Slavin, 2006). Sitting, crawling, standing up then walking are the results of maturation, they are triggered up by biological processes which are innate (in the genotype). So these processes have nothing to do with learning which involves the interaction of a complex organism with the environment. This interaction produces learning.

In the field of SLA, Brown (2007) identified seven main aspects of learning. He averred that learning is the act of acquiring or getting information or skills and their retention. Retention is a memory activity that implies storage and other cognitive organizations. He also announced that it is a conscious process that is relatively permanent. However, it is also somehow exposed to forgetting. In order for information or skills to be permanently stored, they have to be practiced (i.e. rehearsal, c.f. chapter 3). He added that learning is a change in behaviour due to experience (something that most psychologists and linguists agree with). All these aspects are put into action in second language learning.

4.1.4. Learning vs. acquisition

A number of SLA experts use the terms acquisition and learning interchangeably when they explain the process of learning any additional language to one’s mother tongue inside or outside the classroom (Ellis, 2003). However, a thorough analysis of the two concepts indicates that they are quite different. The American linguist Stephen Krashen

(1981) summarized the difference between these terms through stating that learning, or as he refers to as *formal learning*, takes place in formal settings within the individual's control system. The individual, in this type of learning, usually receives a formal instruction and is presented with rules and feedback. Acquisition, or *informal learning,* on the other hand, takes place naturally in natural settings not requiring any conscious process. An example of the former type is learning English in the classroom and of the latter is learning English in its natural environment in the United Kingdom or the United States. Krashen presumed also that it is the second type, i.e. acquisition, that leads to better learning outcomes.

4.1.5. Second language vs. foreign language acquisition

Similar to the terms learning and acquisition, linguists use the term 'second language' or 'L2' to refer to any language beyond one's mother tongue, regardless of the environment where this language is learnt whether in academic settings or in natural contexts. Ellis (2003, p. 03) speculated that "L2 acquisition, then, can be defined as the way in which people learn a language other than their mother tongue, inside and outside the classroom, and 'Second Language Acquisition' (SLA) as the study of this."

This quotation states that Second Language Acquisition (SLA) is the study of how second/foreign languages are learnt in a natural environment or formal settings. The discipline emerged as a separate subfield in the 1950s as a result of the interaction between the disciplines of linguistics and psychology. (Troike, 2006)

4.1.6. Theories of second language acquisition

Views of second language acquisition varied for the variety of the domains that attempt to explain it. Psychologists, for example, distinguished between cognitive, affective and developmental factors in the explanation of SLA. Psycholinguists, on the other hand, focused on the different mental processes required in acquiring an L2. Linguists centred their focus on the nature of language in their explanation of SLA. SLA experts assembled between linguists and psychologists views instead.

The following section provides an overview on early psychological views of SLA. Then it presents major schools of thought in the field of SLA: Structural linguistics and behavioural psychology, Generative linguistics and cognitive psychology, and constructivism, and concludes with providing a psycholinguistic explanation of SLA.

4.1.6.1. Early psychological views

We have stated earlier that Second Language Acquisition did not emerge as an independent discipline until the mid twentieth century. However, the study of language was incorporated in psychology in the nineteenth century. Memory experiments (Galton, 1883) are examples when the testing of language was dealt with in psychology. Memory ability was measured through making associations between none-sense words and meaningful words that were given as stimuli. From this experiment emerged the idea of remembering foreign language words through making meaningful associations (Craik & Lokhart, 1972). Another example of early studies of language in psychology is the work of Freud with slips of the tongue or the pen. Freud attributed the errors made by speakers and writers to internal emotional conflicts. (Stern 1983)

4.1.6.2. Applied linguistics and SLA theories

The different views of second language acquisition among various scholars in Applied Linguistics and SLA research led to the emergence of three different schools for the study of second language acquisition mainly by linguists and psychologists:

a. Structural linguistics and behavioural psychology

The structural linguistic school of thought emerged in the 1940s and 1950s by a number of structural linguists like Leaonard Bloomfield, Edward Sapir, Charles Hockett, Charles Fries, to include but a few (Brown, 2007). These linguists sought to provide a scientific observation and description of human languages from studying the structural characteristics of these languages. They claimed that language can be caught into pieces, and these pieces can be studied scientifically in isolation. A basic assumption was that languages are different and that the role of a linguist is only to describe what is observed in these languages, and it is not acceptable to make any prescription among languages.

In psychology, two main schools of behaviourism emerged to the study of learning in general and language learning in particular, namely Classical Conditioning and Operant Conditioning. Classical conditioning theory was introduced by the Russian psychologist Evan Pavlov who conducted an experiment with a dog to examine how learning takes place. Pavlov (in Brown, 2007) noticed that the dog learns to make associations with the ringing of the bell after a short period of time, i.e. it learns to salivate. Pavlov's experiment gave rise to Stimulus-Response Learning. This type of learning involves an automatic relationship between stimuli and responses; that is, whenever the stimulus is conditioned (ringing the bell), the response is conditioned as well (salivation).

After Pavlov came Skinner (1938, in Brown, 2007) with the notion of operant conditioning. Skinner viewed Pavlov's classical conditioning as a type of learning that is associated with animals rather than human beings. This psychologist neglected the importance of stimulus and put focus on response instead. He argued that one cannot examine the stimulus that leads the baby to touch a near object or ring the bell it finds besides, and that it is the repeated, but unconditioned, ringing of the bell that teaches the baby the source of the sound. The ringing of the bell is called an operant. Operants are defined by Skinner as a set of consequences and not responses, associating these latter ones with stimuli. The repeatedly occurring sound, for skinner, is named a reinforcer. Skinner, further, pointed out that operants are either reinforced or punished, and in both cases learning takes place. In the book of *The Technology of Teaching* (1968, in Brown, 2007), Skinner stressed the importance of a reinforcer in language learning through proposing a program that includes a "step-by-step reinforcement" for successful teaching. The theory of operant conditioning was associated with the audiolingual method of language teaching that was prevalent mainly between the 1960s and 1970s and that focused on reinforcement through the application of language drills.

b. Generative linguistics and cognitive psychology

The Transformational Generative School of Linguistics was introduced by the American linguist Noam Chomsky in the 1960s (Brown, 2007). This researcher claimed about the existence of generative grammar for all languages. Chomsky's influence by Dessaussure's notion of langue and parole led him to introduce the concepts of competence and performance. He criticized transformational linguists for focusing only on what is observed and shifted attention to the hidden levels of meaning. From that time, the idea of 'deep structure' and 'surface structure' flourished.

Cognitive psychologists, at that time, were influenced by Chomsky's theory which urged them to direct attention to the study of human behaviour through the employment of deeper structure like the application of logic, reason, extrapolation, and inference. Ausubel's Cognitive Theory is an example. Ausubel (1963, in Brown, 2007) distinguished between two types of learning: rote learning and meaningful learning. The former type is not related to existing cognitive structures and does not make any meaningful relations. An example is remembering a new phone number without making any associations. Meaningful learning, on the other hand, involves the acquisition of skills and information through making a meaningful relation with existing cognitive structures. Ausubel further associated successful learning with meaningful information processing, i.e. adding new information to the already existing information, and claimed that rote learning leads to interference because of the so many rote materials that the organism receives. He, further, criticized the audiolingual method of language teaching that encouraged rote learning, calling upon the teaching of linguistic communication in meaningful contexts to avoid forgetting. (Brown, 2007)

Brown (2007) supported Ausubel's idea of distinguishing between rote and meaningful learning as well as between primary and peripheral attention, and highlighted the role of automatic forgetting. He advocated that in language teaching, one should pay attention to automatic forgetting. In the primary stages of teaching, learning can be meaningful through the application of meaningful illustrations, pictures, definitions, etc.. However, in later stages, learning becomes automatic and so forgetting is. So to reduce this forgetting, other techniques can be used like paraphrasing and mnemonics.

Another investigation of second language acquisition in cognitive psychology is McLaughlin's attention processing model (1987). This model highlighted two types of processing, viz. controlled and automatic processing, with corresponding types of attention: focal and peripheral attention. McLaughlin claimed that the first type of processing is limited and short term, i.e. only small amounts of information is processed, and appears in initial stages of learning. The second type is permanent and is characterised by processing a large amount of information and appears in advanced stages. He further opined that focal attention is central, whereas peripheral attention is secondary. For example, in beginning levels of language learning, adults, unlike children, give focal attention to language forms (e.g. grammar, vocabulary and pronunciation). However, in advanced levels, they give peripheral attention to these forms and give focal attention to meaning instead. (Brown, 2007)

Anderson's ACT*[8] and PUPS[9] model (1989, in Kempen, 1992) is another widespread theory of second language acquisition. In his model, Anderson distinguished between three levels of analysis in cognitive mechanisms: knowledge level, algorithm level and implementation level. The first level describes what an individual can do and is similar to Chomsky's competence. The second level explains the application of knowledge; it can be illustrated through speaking or understanding the language. This level reveals the capacity of the cognitive mechanism. In the third level, the observable behaviour of the cognitive mechanism depends on ways of implementing procedures in a computational environment. An example of implementation level is the study of speech errors. While Chomsky's competence was related to knowledge level, his performance was linked to both algorithm and implementation levels. Anderson believed that learning takes place in the three levels. This means that at knowledge level, learners process utterances spoken by people in their working memory to store them in LTM. At the algorithm level, Children,

[8] Adaptive Control of thought

[9] PenUltimate Production System

for instance, are able to induce the grammar of their native language by comparing their speech with those of adults and induce the results using their *Linguistic Processor*. At the implementation level, learning is automatized. In other words, at this stage, unlike the previous stages, there is a reduction of the effort used in *executive cognitive procedures*, which leads to easiness in the use of these cognitive mechanisms.

Current researchers in cognitive psychology shifted attention to the role of some components of working memory in second language acquisition, like the role of attention and phonological short term memory (PSTM). As for attention, there was a controversy regarding its influence on learning a foreign language. While some research findings (e.g. Leow, 1997; 2000; 2001; Rosa & Leow, 2004; Rosa & O'Neill, 1999) confirmed its effective role in L2 learning, other empirical results (e.g. Williams, 2004) revealed that learning can take place without awareness. Yet, another study (Gass, Svetics & Lemelin, 2003) showed that attention is necessary for learning syntax but not lexicon. Concerning PSTM, many researchers centred its role in the acquisition of different aspects of L2. Papagno and Vallar (1992) and Service and Craik (1993) associated the role of PSTM with the acquisition of vocabulary, and Schmidt (1997) and Williams and Lovatt (2003) confirmed its relationship with the acquisition of L2 grammar (in Gass & Selinker, 2008). The role of attention and short term memory in second language acquisition are discussed further in the previous chapter (c.f. chapter 3.2 and 3.4).

c. Constructivism: a multidisciplinary approach

Constructivism assembles between psychology, sociology and linguistics in the explanation of second language acquisition. This school emerged in the last part of the twentieth century and was named after the two constructivists Piaget and Vygotsky. Two major branches were involved in constructivism: cognitive and social. Cognitive constructivism proposed that individuals cannot immediately understand the information they are given, but they have to construct their own representation of the world through the use of their experience. Piaget (1950s) is the pioneer of this paradigm. According to him, learning is a developmental process involving *change*, *self generation*, and *construction*. These aspects are linked to previous learning experience. This developmental psychologist believed that children do not immediately develop their thinking but go through a number of stages. He generated four universal stages of cognitive development, namely sensory motor stages, preoperational stage, concrete operational stage, and formal operational stage. A description of each stage is provided in chapter one (c.f. chapter 1.1.2.4).

Social constructivism, on the other hand, stressed the role of interaction and cooperative learning to construct images for reality. The Russian psychologist Vygotsky introduced this theory. Vygotsky (as cited in Brown, 2007) opined that learning and thinking are socially constructed and developed through the interaction with the environment. He employed the term Zone of Proximal development (ZPD) to mean the difference between existing knowledge and potential knowledge. This term indicates that every child cannot learn in isolation but through the communication with more able people.

Although constructivism centred the role of the active process of constructing knowledge for its acquisition, there was a paradox within its paradigms. While Piaget considered the individual him/herself as a source of constructivism, emphasizing the role of cognitive development in learning, Vygotsky stressed the impact of the environment in learning and ignored the *predetermined stages*. (Brown, 2007)

4.1.6.3. Psycholinguistic theories

Psycholinguistic theories of SLA consider the mind in their explanation of language acquisition. They focused on a set of mental processes that are involved when individuals acquire language. Information processing (IP) approach is considered an example of these theories. This approach claimed that language learning is a complex skill. The complex skill is simplified into simple skills through the process of attention. Language learning, like any other skill, starts in a controlled manner; then it becomes automatic through practice. (Troike, 2006)

Troike (2006) reviewed Skehan's three stages of information processing: input, central processing, and output (c.f. p. 89). Input is the first stage; it is responsible for the perception of information. It requires attention and noticing to become intake. Troike advocated that successful intake depends on the degree of attention students pay. Central processing is the second stage and is considered the heart of information processing. In this process, learning takes place through moving from controlled to automatic processing. Restructuring takes place in this stage and can be illustrated by writing or saying the word 'foots' as the plural of foot, i.e. adding the 's' of the plural to an irregular noun, then correcting this plural and saying 'feet'. Output is the third stage that refers to the production of information. Learners produce language orally or in writing. In order for the output to be successful, it has to be practiced. Practice allows for enhancing fluency and, hence, the automatization of processing. Troike (2006), further, pointed out that the process of second language acquisition starts with focusing attention on practicing vocabulary and syntactic structures, and that it is until this process becomes automatized, one can move to more complex processes like creating long productions.

4.1.7. Factors influencing Second Language Acquisition

Second language acquisition is influenced by a variety of factors. SLA research identified five major ones, viz. age factor, cognitive factors, affective factors, anthropological factors, and linguistic factors. This section sheds light on two of them: age and cognition; the factors that will be dealt with in the current investigation.

- **Age and second language acquisition**

Within age factor, SLA experts claim about the existence of a critical period for language acquisition, i.e. critical period hypothesis (CPH). Brown (2007) defines the term critical period as a biologically predetermined period when language can be acquired more easily and beyond which time language is increasingly more difficult to acquire. He reviewed that the study of the effects of the critical period was first implied to L1 acquisition (e.g. Lenneberg, 1967; Bickerton, 1981), then it was expanded to include L2 acquisition in recent years (e.g. Ioup, 2005; Singleton & Ryan, 2004; Moyer, 2004; Hyltenstam & Abrahamson, 2003; Scovel, 2000; Berdsong, 1999).

SLA researchers presumed that this period appears around puberty (from 11 to 13), associating it with brain lateralization. This means that in this period the brain becomes mature and its two hemispheres take independent functions: the left hemisphere becomes specialized for logical and analytical skills, whereas the right hemisphere is directed to social and emotional skills. Language is argued to reside in the left hemisphere. Evidence (in Brown, 2007) showed that people with good language skills, when having accidents affecting their left brain area, start to have impairment in their language. Brain lateralization was claimed (Lenneberg , 1967) to start around two and to complete in puberty. This means that children having accidents affecting their left hemisphere transfer linguistic skills to the right hemisphere. An example is the study of Adams (1997) which found that a child not speaking at eight years old, when having a left hemisphericτomy, he starts to speak at nine years old. Another study (Thomas Scovel, 1969) revealed the plasticity of the brain in childhood that enables the acquisition of first and second language in native-like fluency, and that this plasticity stops in brain lateralization. (Brown, 2007)

- **Cognitive factors**

Cognitive research on SLA centers focus on the role of some cognitive abilities in L2 acquisition, on the one hand, and associates this latter with different stages of cognitive development on the other hand. Concerning the effects of cognitive development on SLA, four universal stages were highlighted by the developmental psychologist Jean Piaget (1930s): sensorimotor stage, preoperational stage, concrete operational stage, and formal operational stage. A description of each stage is provided in chapter one (c.f. chapter 1.1.2.4).

Some SLA researchers (e.g. Singleton & Rayn, 2004, in Brown, 2007) associated the critical period with concrete stage of development. Conversely, other experts (e.g. Ausubel, 1964, in Brown, 2007) asserted that formal operational thinkers, i.e. adolescents and adults, acquire L2 grammar better than children, thanks to their developed reasoning skills which they apply for analyzing grammatical rules.

As far as the influence of cognition on SLA is concerned, thorough research cast light on the role of a number of cognitive capacities. Intelligence, working memory, and language aptitude received the lion’s share of attention in explaining success in SLA. Each of the so mentioned abilities are explained in separate chapters, and their influence is also highlighted (c.f. chapter 1.1.4 for the influence of intelligence on SLA, chapter 2.4 for the influence of aptitude on SLA, and chapter 3.4.1. for the role of working memory on SLA).

4.1.8. Learning stages

Research in Psychology and SLA showed that people go through the same stages when they acquire their L1 or any additional language. In psychology, Piaget (1959, in Slavin, 2006) claimed that language develops with the development of the child's cognitive system, generating four universal stages of cognitive development. He opined that L1 acquisition starts to develop when the child moves from sensorimotor stage to preoperational stage (i.e. at about age two), when he starts to use words or concepts that help him understand the environment. For example, at this stage, the enfant can use one word like 'bye-bye' or 'Mommy' or two-word sentences like 'more milk'. At about age three, the child develops his language and starts to be a skilful talker. For example, he starts to use simple sentences and some interrogatives like 'where doggie go?'. Although children can express complex thought at this stage, their language is still simple and lucks some grammatical aspects, like the use of articles ('a' and 'the') and auxiliaries (e.g. did). At the age of four, the child develops some rules of the spoken language. He learns the plural and some morphological rules like 'ed' and 'ing' before he starts his kindergarten. However, he generalizes these rules to irregular words. For example he utilizes 'goed' instead of 'went' to express the past and 'mouses' instead of 'mice' to express the plural. It is worthwhile that language development quite depends on parents talk with their children. (Slavin, 2006)

In SLA research, a variety of models emerged to explain the process of language acquisition. One simple model is the Natural approach proposed by Krashen and Terrell

(1983). This model assembled between acquisition stages and classroom activities. Krashen and Terrell generalized four universal stages of acquisition and discuss the role of learners and teachers in each stage. These stages are: preproduction stage, early production stage, speech emergence stage, and intermediate fluency stage.

4.1.8.1. Preproduction stage

This stage begins in early hours of exposure with the foreign language and lasts to six months. Learners, at this stage, listen to the teacher without making any verbal communication. They may answer the teacher's questions with non-verbal or 'yes' or 'no' responses. The teacher has to keep in mind the students' non-readiness to speak. So he has to produce clear, slow and simple speech and use facilitating techniques such as gestures, facial expressions and objects. The students may acquire up to 500 words at this stage. They also develop what is referred by Cummins (1979) as basic interpersonal communications skills (BICS, c.f. section 2).

4.1.8.2. Early production stage

The second stage starts in three months and may last up to one year. Learners, at this stage, develop more receptive vocabulary (about 1000 words); however, they use only 10% of it, i.e. only words that are used regularly. They become capable of answering 'wh' questions that require short responses (e.g. who, what, when, and where). Since it is the first stage when learners start to use language, the teacher should give opportunities to discuss lessons in a pair or group work so to decrease anxiety, make learners feel at ease with language, and give an opportunity for everyone to speak. Learners start to use formulaic language at this stage (e.g. how ya doing) without knowing what is the function of each word. The teacher should avoid the use of idiomatic expressions and unfamiliar vocabulary. Here also, there is an observable increase in the students' independence in developing vocabulary.

4.1.8.3. Speech emergence stage

After one year of exposure with the foreign language, this stage appears and continues until three years. Learners start to build somehow a rich repertoire, i.e. up to 7000 words. They also become able of using long sentences and answering 'how' and 'why' questions that require long responses and complex sentences. The use of some idioms and unusual vocabulary also appears at this stage as with the increase of the use of non-verbal cues.

4.1.8.4. Intermediate fluency

This stage appears after three or four years of exposure with the foreign language. Learners develop immense vocabulary (around 12000 words). They also develop Cummins' Cognitive Academic Language Proficiency (CALP, c.f. section 2). Instead of producing simple sentences, they turn to extend discourse and engage in topics that require analysis, synthesis and evaluation such as problem solving, essay writing, literary critics, etc.. In addition, their analysis of the previous issues becomes similar to native speakers. However, mistakes can appear at this stage as well, since learners are still in the process of academic learning. In this case, the teacher can interfere through giving a support.

Psychological and educational research has long considered the role of some cognitive abilities in different stages of language acquisition. The results have revealed a strong interrelationship between some working memory components and different stages of second language acquisition as well as language aptitude components and second language acquisition stages. Concerning the role of working memory, evidence (Schneider & Detweiler, 1987, in Miyake & Shah, 1999) showed that at initial levels of acquisition, mainly beginning and intermediate levels, the process of information is quite controlled and effortful and depends more on WM processes, while in advanced levels, this process becomes less controlled and mechanical (c.f. chapter 3.4.1). As for the role of language aptitude, Skehan (1998) associated the component of phonetic ability with early stages of language acquisition, grammatical sensitivity component with later stages, and memory component with more advanced levels (c.f. chapter 2.2.1.3).

4.2. Language learning achievement

The concepts of language learning achievement, language proficiency and language learning success are commonly used in the realm of second language acquisition to explain learning outcomes. These concepts are germane to the sphere of language assessment. The section provides a clarification of language learning achievement through comparing it with language proficiency. It further reviews some standardized language assessment scales.

4.2.1. Definition

The concept of language learning achievement is used to describe language learning outcomes after a specific period of time. At the surface level, this definition seems so clear in that it considers assessment of language skills. However, other concepts might also be used to refer to the same ability. Baecher (1982, p. 01) noted that:

> (…) Confusion is apparent in the plethora of terms that are used to identify some aspects of the language assessment process over a specific period of time. For instance, there are the terms, "language proficiency", "language dominance", "bilingual proficiency"; another set includes "language aptitude", "language ability", "language attainment", "linguistic academic achievement", and" global language proficiency" with emphasis upon the bilingual individual".

Stern (1983) as well advocated that providing an accurate definition or measurement of language proficiency is problematic. We would apply Stern's point of view regarding proficiency to achievement as well and say that it is impossible to provide a specific definition of language achievement.

Sometimes, researchers in linguistics and language teaching and learning (e.g. Baecher, 1982; Stern, 1983) use the concepts of language achievement and language proficiency interchangeably to refer to language learning ability over a specific period of time. However, DeAvila and Duncan (1980, in Baecher, 1982) distinguished between the two terms through stating that language achievement is just an aspect of language proficiency. Language proficiency, for them, refers to the acquired language skills in both schools and natural settings not necessarily related to any specific instruction or content, while language achievement takes place in academic settings and is based on instruction and content. They (in Baecher, 1982, p. 14) averred that "… language achievement is more likely to be dependent upon proficiency than vice-versa". Another supporting view of the consideration of language achievement as an aspect of language proficiency is Cummins distinction between BICS and CALP (1979). Cummins proclaimed that language proficiency involves two main aspects: Basic Interpersonal Communication Skills (CALP) and Cognitive Academic Language Proficiency (CALP). He further indicated that the BICS is conversational and is related to everyday communication skills, while the CALP is related to academic settings. Achievement, regarding Cummins' view, might then be viewed as a synonym of the CALP.

Again, another concept was introduced and was claimed to be similar to language achievement and language proficiency. Competence [10] was viewed by Avery and his colleagues (Avery et al., 2001) as the synonym of language proficiency. Conversely, Taylor (1988, in Llurda, 2000) argued that competence is just a pure knowledge of language and that proficiency is both knowledge and the application of this knowledge.

- **Operational definition**

The concept of language achievement is used in this study to refer to the students' acquired language skills after a specific period of time, in relation to instruction and content (Cummins, 1979; DeAvila & Duncan, 1980). In other words, we will consider the students foreign language learning outcome with regard to the content, i.e. all the modules, they have been taught for a period of one year.

4.2.2. Components of language achievement

As language achievement and language proficiency are perceived synonymously by some researchers in the field of applied linguistics and language learning and teaching, the components that are identified for language proficiency will be similar to those of language

[10] Competence and performance are two basic concepts used respectively by Chomsky to mean language ability and the application of this ability

achievement. Researchers (e.g. Valdés & Figueroa, 1994; Canales, 1994, in Del Vecchio & Guerrero, 1995) claimed that knowing the language is not limited to knowing the discrete elements such as grammar, pronunciation and vocabulary; rather, proficiency involves knowledge of these elements as well as possessing what is known as communicative competence.

Communicative competence, as well, was believed to involve different subcomponents. Duran (1988, in Lynch, 2003) highlighted four main components for communicative competence: grammatical competence, which includes mastery of vocabulary, word formation, sentence formation, and spelling; sociolinguistic competence, which involves mastery of the appropriate use of language in different contexts; discourse competence, which includes mastery of the cohesion and coherence devices employed to achieve unity in a text; and strategic competence, which includes some metacognitive strategies employed to warrant effective communication.

4.2.3. Standardized language proficiency (achievement) tests

From the time foreign language learning became prevalent, there was a need to develop tests that measure learners' proficiency. Language proficiency measures purport to place learners with similar proficiency levels in homogeneous groups before they engage in a language program. These measures vary for the variety of experts' notions of the term. Despite this variety, some standardized tests have been recognized as famous measures of language proficiency. In their Handbook of *English Language Proficiency Tests*, Del Vecchio & Guerrero (1995) identified five common standardized tests: Basic Inventory for Natural Language (BINL), Bilingual Syntax Measure (BSM), IDEA Proficiency Tests (IPT), Language Assessment Scales (LAS), and Woodcock-Muñoz Language Survey

(WMLS). The three last measures (IPT, LAS, and WMLS) assess the four skills, viz. listening, speaking, reading and writing, in addition to grammar and vocabulary, while the first two first ones focus on the assessment of oral skills. A description of these tests is provided below.

- **Basic Inventory of Natural Language (BINL)**

This test is a criterion referenced instrument[11] that was developed in 1979 by Herbert (in Del Vecchio & Guerrero, 1995). It perceives language proficiency in terms of vocabulary, morphology and syntax. It measures these components in addition to oral skills (i.e. listening and speaking), considering fluency as an important component. Four levels of proficiency are classified in a scale: non-English speaking (NES), limited English speaking (LES), fluent English speaking (FES), and proficient English speaking (PES). As a procedure, ten minutes are given to complete the test. The participants are exposed to a number of coloured posters and are instructed to describe some pictures. The answers are recorded in a tape, and the experimenter examines three elements: average number of words (i.e. fluency), grammatical competence, and sentence length. Concerning the scoring procedure, fluency is scored according to the number of given words, and grammatical competence is scored in terms of the use of different word functions.

- **Bilingual Syntax Measure (BSM)**

This test was developed four years before the previous test (Burt, Dulay & Hernández-Chávez, 1975, in Del Vecchio & Guerrero, 1995). It is based on two assumptions: one is that language is acquired through the process of creative constructions; and the other is that there is a universal hierarchical order in the acquisition of syntactic

[11] Criterion referenced tests are measures that assess the students performance according to some standards.

structures. This test focuses also on the assessment of oral skills. Five levels of proficiency are classified as follows: no English, receptive English, survival English, intermediate English, and proficient English. The time administrated for this measure ranges between 10 and 15 minutes depending on the speed of the individual to answer. Similar to the previous measure, a number of multi-coloured pictures are given and learners are asked to produce a speech about them. As for scoring, only 18 from 22 are scored, and the scores are distributed on the correct answers.

- **Idea Proficiency Test (IPT)**

This test was developed in 1978 by Dalton (in Del Vecchio & Guerrero, 1995). It perceives language proficiency as developmental, incremental, systematic, symbolic, social, and involves receptive and productive skills. This test measures language four skills in addition to vocabulary, syntax, comprehension and verbal expression. It classifies learners in three levels of proficiency: non-English, limited English; and fluent English (for speaking, and competent English for reading and writing). The mean administrated time for the oral test is 15 minutes, i.e. it ranges from 5 minutes for Non-English speakers to 20 minutes for fluent English speakers. For reading test, it ranges from 45 to 70 minutes, and for writing from 25 to 45 minutes. In assessing vocabulary, syntax, comprehension and verbal expression, a multiple choice test is given, whereas for writing a series of consecutive events is given and the student is required to construct a story. The oral test is scored through summing the wrong answers after classifying them in one of the two boxes: correct or wrong. As for reading and writing, the number of correct answers is considered.

- **Language Assessment Scale (LAS)**

Language assessment scale was developed by De Avila & Duncan in 1982 (in Del Vecchio & Guerrero, 1995). These experts argued that language is composed of four elements: phonology, lexicon, syntax and pragmatics, and measure proficiency with the consideration of these components in addition to the four skills. Three levels of proficiency are also identified for this scale; in oral skills: non speaker, limited speaker, and fluent speaker; and in writing skills: non literate, limited literate, and competent literate. Concerning time procedure, there is no specific administered time for this measure, i.e. the length of time depends on the proficiency of the participants. For example, in grade two the time administrated ranges from 45 to 55 minutes. The oral test has two forms: a short form including vocabulary, listening and story retelling, and a long form containing these tasks in addition to minimal pair sounds and phoneme tasks. As for scoring, the number of incorrect answers is summed and then a decision between the three levels is made.

- **Woodcock-Muñoz Language Survey (WMLS)**

This measure was developed in 1993 (Del Vecchio & Guerrero, 1995). It stems from Commins' view (1979) that highlights two different types of proficiency: BICS and CALP. It measures basically the latter type (i.e. the cognitive aspect of language proficiency). WMLS is used in advanced settings and aims to aid teachers understand students' language abilities for program evaluation and the degree of readiness for a language instruction. The four language skills are assessed in addition to vocabulary, memory and comprehension. It classifies learners according to five levels of proficiency: negligible English, very limited English, limited English, fluent English, and advanced English. The time allocated for this test ranges between 15 and 20 minutes.

Seven subtests are used in this measure: picture vocabulary subtest, verbal analogies subtest, letter-word identification subtest, dictation subtest, understanding directions subtest, story recall subtest, and passage comprehension subtest. In the first subtest, the learners are instructed to name the given objects in order to measure their lexical knowledge. The second subtest measures reasoning in addition to lexical knowledge. The participants listen to three words of an analogy and then deduce an appropriate fourth word. The third subtest measures fluent reading of words with a missing letter, yet it does not require knowledge of meaning. Dictation subtest assesses pre-writing skills like spelling, punctuation, capitalization and word usage. The fifth and the sixth subtests assess aspects of oral language. In the fifth subtest, the learners listen to a record in the form of instructions and are asked to answer them; and in the sixth subtest they listen to a passage, and then they are asked to recall as many details of the story as possible. The last subtest measures reading skills as it requires the examinees to read short paragraphs and induce the missing words or to match pictures with written sentences. (Alvarado, Ruef & Schrank, 2005)

In spite of the fact that standardized language proficiency (achievement) tests are quite opted for when engaging learners in a foreign language instruction, they were criticized for lacking reliability and validity[12]. For example, the study of Ulibarri and his colleagues (Ulibary et al., 1981, in Del Vecchio & Guerrero, 1995) demonstrated a lack of consistency between three measures of language proficiency, viz. Language Assessment Scale, Bilingual Syntax Measure, and Basic Inventory of Natural Language. In addition, standardized proficiency (achievement) tests that do not require productive answers, e.g. multiple choice or matching tests, are criticised for lacking authentic environment while testing proficiency. As a result, performed-based tests emerged and turned to be more informative about learners' proficiency. Yet, these tests were themselves subject to criticism for:

- Lacking inter-rater reliability or the difficulty of providing accurate interpretations which might be caused by the inability to produce valid scores.

[12] See section 3 for definition of reliability and validity

- ➢ Inadequacy of the chosen materials that assess proficiency as there is no specific definition of the concept.
- ➢ Problems that might be caused by making generalizations, since these authentic measures might not lead to the same results in different learning contexts. (Michaelle, 1993, in Lynch, 2003)

Concerning the assessment of language learning achievement in the current study, we should note that we did not adopt any standardized measure. Having followed the operational definition of this concept, the students point average in the modules they have been taught during a whole year in learning EFL will be taken as a means to measure their achievement. In other words, the students overall language learning achievement is the mean average that is obtained in both semesters of their learning. We believe that this procedure is more appropriate for assessing language learning achievement, since the overall average gives insights about general linguistic and communicative abilities of the students at specific levels of proficiency. This means that the students are assessed according to the standards and objectives of learning. The students' marks in each module assess different aspects of proficiency; for example, Grammar and Phonetics modules assess primarily linguistic proficiency (i.e. sounds and structures of the foreign language). Oral Expression and Written Expression modules assess mainly communicative competence (which is viewed as an aspect of proficiency, c.f. section 2.2) as they assess language on the one hand and the ability to communicate on the other hand. English Culture and Literature modules assess the individual's memory ability that is also viewed an important component of Commins' CALP. Assembling the students' outcomes in all the modules could, then, be a good prediction of their proficiency.

4.2.4. The difference between achievement measures and aptitude measures

We have stated earlier in Baecher's quote (c.f. p.168) that both language achievement and language aptitude deal with issues of language assessment. However, the two concepts are believed to be different. Language aptitude tests predict how well students will learn a language in the future; conversely, language achievement tests measure students' language learning outcomes after a specific period of time. In other words, language aptitude measures predict future outcomes, whereas language achievement tests describe past acquired skills.

Another distinction is provided by Ary, Jacobs and Sorensen (2010) who claimed that aptitude tests measure the individual's general ability and readiness to acquire a number of skills and knowledge (e.g. problem solving, perception, language, etc.) in the future without the consideration of any previous instruction, whereas language achievement tests measure the individual's language acquired skills after having engaged in a pedagogical instruction. Aptitude tests were referred to as intelligence tests. However the term intelligence diminished for the belief to be innate, making aptitude subject to acquisition. Individual aptitude tests are illustrated by Binet's and Wechsler's scales. Group aptitude measures emerged during the period of World War I (1914-18), mainly when testing men in the military service became necessary. Examples of group aptitude tests are the Cognitive Abilities Tests (CogAT), Test of Cognitive Skills (TCS/2), and the Otis–Lennon School Ability Tests (OLSAT-7).

4.3. Psychological testing

The primary purpose of the current research is to provide a battery of psychological tests for the concept of linguistic intelligence. It is, then, required from us to clarify the term psychological testing with an identification of its main conditions.

4.3.1. Definition of a test

Linguistically speaking, a test refers to a critical examination, observation, or evaluation. It is the procedure of observing a hypothesis under certain conditions that leads to its acceptance or rejection. (*Merriam Webster's online dictionary*, 2014)

Although this definition does not tackle all aspects of testing in psychology, it highlights some important characteristics. One of them is that a test is used in different contexts, viz. academic institutions, laboratories or in real life. Besides, it is used as a means to reach a conclusion.

A variety of tests are applied for varying purposes. We include here two broad types: educational tests (e.g. aptitude tests, achievement tests, and proficiency tests), and psychological tests (e.g. personality tests, intelligence tests and clinical assessments). In the previous chapters we have provided an overview of these types: chapter one and three have reviewed some psychological tests: intelligence tests, reasoning tests, and memory tests, while chapter two and four have reviewed some educational tests: aptitude test and achievement test. Psychological tests are the focal point of this section.

In psychology, a broad definition of a test was provided by Cronbach (1984, p. 26). According to him a test is "... a systematic procedure for observing behaviour and describing it with the aid of numerical scales or fixed categories". In his definition, Cronbach (1984) highlights two main purposes for the test use: observation and description of behaviour. This description and observation are done through the use of numerical scales or given categories.

Urbina (2004, p. 1) adds that a psychological test is “a systematic procedure for obtaining samples of behaviour, relevant to cognitive or affective functioning, and for scoring and evaluating those samples according to standards”. To explicate this definition, a test is called systematic because it requires planning before its administration. The items selected in a test measure a sample of behaviour and then draw a conclusion about larger domains. Urbina highlighted two facets of psychological testing: cognitive tests and personality tests. Evaluating and interpreting test results require going through a set of statistical procedures which will be explained later. A further aspect of a psychological test is the concept of standardization. All psychological tests are also called standardized tests since they require the same conditions of the testees as with the same evaluation and interpretation procedures. (Urbina, 2004)

4.3.2. Conditions of a psychological test

In order for a test to be called a good measure and hence be put into practice, three main qualities should be met, viz. reliability, validity and practicality. An explanation of each quality is provided below in the section.

4.3.2.1. Reliability

The term reliability is used to refer to “the consistency and precision of the results of the measurement process” (Urbina, 2004, p. 117). It also refers to ‘trustworthiness’ in terms of test scores. A test is considered reliable if the same scores are obtained whenever it is given to the same individuals under the same conditions. It is also considered consistent if it contains no measurement error. However, in human and behavioural sciences, unlike physical sciences[13], tests are subject to errors because of the nature of the constructs to be measured. This means that the test results are influenced by a variety of factors from the side of the test taker, examiner, or test condition.

Test reliability can be assessed through the use of four methods, namely test-retest reliability, split-half reliability, alternate form reliability, and interrater reliability (Marczyk, DeMatteo & Festinger, 2005). The first method requires at least a second administration of a test and a comparison of the results. Split-half reliability, as its name indicates, requires a division of the test into two parts, and making correlations to compare the results. Alternate form reliability is used through giving two forms of the same measure at a different time and then comparing the obtained results using correlations. The last method is followed through bringing more than one evaluator to the judgement and examination of the test findings.

Ary et al. (2010), on the other hand, suggested three methods referring to them as reliability coefficients, viz. test-retest coefficient, equivalent-forms coefficients, and internal consistency coefficients. They indicated that the first two methods require two administrations of a test, while the third one requires a single administration. They further proclaimed that the first method is not appropriate in cognitive testing and mainly in memory tests, because repeating the test for more than one occasion allows the learners remember the answers and, hence, affects the results. They also speculated that equivalent-forms reliability is the most demanding method because of the difficulty to assume another form of the same measure which would result in the increase of the measurement errors. The third method is appropriate when all items in a test measure the same factor. Split-half

[13] Physical sciences are free from measurement errors because the results obtained are relatively constant (e.g. in measuring heights or distances, the values are true values)

reliability is an example. It is claimed to be the easiest as it requires a division of the test into two halves and dividing individuals' scores according to these halves and comparing the results using correlations. (Ary et al., 2010)

Urbina (2004) proposed another method for assessing the reliability of a test that consists of a number of subtest scores. Reliability of this kind is determined through calculating the correlation between the subtest scores with the total test scores. Concerning our current study, as our administered measures include different subtests, we will test the reliability of each measure through the calculation of the correlation between the test whole score and the scores of its subtests (c.f. chapter 6.5). We believe that this method is easier, simpler and less time consuming.

Concerning random errors that appear in a measurement, Leary (2004, in Marczyk et al., 2005) asserted that it is impossible to remove them, claiming that any obtained score should be divided into two scores: true score and measurement error (or random error of measurement, Ary et al., 2010). A true score is the one assumed with perfect conditions and error free measure, whereas the measurement error is a score proposed to be under impaired conditions when there is an influence of other factors such as inappropriate conditions, anxiety, lack of motivation, inadequacy of data recording, or the poor design of the measurement. Ary and colleagues (2010) provided a mathematical expression to any score through the formula: $X=T+E$ (when X is the observed score, T is the true proposed score, and E is the error of measurement component). They provided a mathematical definition of reliability through stating that it is the ratio of true score variance to the error score variance. The formula is: $rxx = \frac{\sigma^2 t}{\sigma^2 x}$ (where rxx is the reliability of the test, $\sigma^2 t$ is the variance of the true scores, and $\sigma^2 x$ is the variance of the observed scores).

Reliability can be enhanced through the use of different techniques. Miller (2008) proposed two different ways in which reliability can be increased, viz. Greater standardization and increasing the items in a test. Greater standardization indicates that the administration of a test as with the test procedures should be standardized, so that no random errors can be introduced. An example of standardized procedures is ensuring the same conditions for all the test takers. Increasing the number of the test items indicates that the more items are used to assess the same variable, the more likely the test is considered reliable.

4.3.2.2. Validity

Validity is another critical aspect that should be considered in evaluating measurements. A valid test is a test that measures what it purports to measure (National Association of the Directors of Educational Research, 1921, in Urbina, 2004).

Gronlund (1981, in Cohen, Manion & Morrison, 2000) opined that the concept of validity is perceived differently in different types of research. For example, in qualitative research, it refers to truthfulness, faithfulness and richness of the data, whereas in quantitative research, it refers to "careful sampling, appropriate instrumentation and appropriate statistical treatments of the data (...) (it) should be seen as a matter of degree rather than as an absolute state." (p. 105)

Messik (1989, in Urbina, 2004, p. 152) provided a comprehensive definition through stating that "validity is an integrated evaluative judgment of the degree to which empirical evidence and theoretical rationales support the adequacy and appropriateness of inferences and actions based on test scores or other modes of assessment”. Validity of a test involves answering two questions: “what” a test measures and “how well” it measures.

Any test should be given scores, yet these scores require interpretation. The examination of test scores interpretation is used when checking validity. Inadequate interpretation affects validity. However, someone cannot say that a measurement instrument is not valid, but instead they can make this judgement to the interpretation or to the drawing of inferences from scores. This is because a test might be valid with one sample but not with another. (Ary et al., 2010)

Similar to reliability, validity can be assessed in different ways. Urbina (2004) identified three types of validity, viz. content validity, criterion-related validity and construct validity. Content validity refers the degree of adequate measurement of the topic. In other words, one has to make sure that a measure should assess a variable and nothing more than this variable. For example, if one attempts to measure grammatical sensitivity that is a component of language aptitude, all the given items should assess this component excluding all the other components (e.g. phonemic ability and inductive language learning ability). This type of validity doesn’t require mathematical calculations to prove it; rather, validity can be checked through giving the measure to a number of experts. Concerning Criterion-related validity, two other types can be identified within it: predictive validity and concurrent validity. The former refers to the appropriateness of the measure in predicting performance in the future, whereas the latter refers to the correlation of the current measure with other valid measures. Construct validity is the most complex type. It refers to the predicted correlation with other theoretical assumptions. This means that a test has construct validity if the results are explained with reference to valid theoretical evidence. (Kothari, 2004)

Urbina (2004) shed light on the importance of validity to reliability. She advocated that the former leads to the latter. In other words, if a test measures what it purports to measure (i.e. valid), it is necessarily reliable. But the other way is not true. This means that, a test might be reliable, in that the scores might be free from errors but cannot be used in markets as a valid measure.

4.3.2.3. Practicality

Another condition added to reliability and validity is practicality (Urbina, 2004). A practical test is defined in terms of three aspects: economy, convenience and interpretability. Economy aspect indicates that the test should cost the amount of money that the budget can afford. A test is convenient if it is easily administered; that is, if the items are clear and understood by the test takers. An interpretable test is the one that can be interpreted by simple people other than specialists if the scoring keys are clear. Oller, Kim, & Choe (2000) highlighted the aspect of comprehension that is included under the condition of practicality (Kothari, 2004) as a fourth condition. They asserted that foreign language tests should include clear and simple items that are understood by the test takers. It is noteworthy that the assessment of practicality of the current cognitive linguistic measures, i.e. language aptitude measure, working memory measure and verbal reasoning measure, is done through the administration of a pilot test for each (c.f. chapter 5.2).

4.3.3. Statistical procedures used in a psychological test

We have stated earlier (c.f. conditions of a psychological test) that some statistical procedures are used to determine the test reliability. Examples of these procedures are correlation and factor analysis. A description of each procedure is provided in this part of the section.

4.3.3.1. Correlation

- **Definition of correlation**

In everyday language, a correlation is defined as the connection between two things. In statistics, it refers to measuring the degree of association between two or more variables. A correlational research is a non-experimental research that does not involve a manipulation of a variable so to investigate cause-and-effect relationship. It rather investigates the direction and the strength of relationship among variables. These relationships are studied using the technique of "correlation coefficient". (Ary et al., 2010)

The direction of a correlation is studied through the signs (+ or -). These signs reflect a positive or a negative correlation. A positive correlation shows that whenever one variable increases, the other one increases as well. A negative correlation indicates that when one variable increases, the second one decreases. An example of a positive correlation is height and weight relationship, this means that tall people tend to be heavier than short people. A negative correlation is illustrated through the example of students who do not attend lectures and who, quite often, obtain lower marks when compared to students who attend lectures (less attending----- lower marks).

The strength of a correlation ranges from 0 to 1. When (1) indicates a perfect correlation, (0) refers to no relation at all. In statistics, reaching a perfect correlation is rarely achieved, especially in dealing with human sciences. The stronger a correlation, the closer it is to (1); the weaker correlation, the closer it is to (0). (Ary et al., 2010)

According to the direction and the size of a correlation, this latter ranges from (+1) indicating a perfect positive correlation to (0) indicating no correlation to (-1) revealing a perfect negative correlation. Concerning (0) correlation, two variables might show a correlation of (0); however, they might not be completely separate. An example is being young and having white hair. This means that some young people are also shown with white hair.

Concerning the significance of a correlation, determining whether a correlation is significant or not depends on two aspects: sample size and level of significance. For example, in Pearson Product Moment Correlation Coefficient with 60 degrees of freedom at 0.05 level of significance, (r= 0.25) is considered significant; for 70 degrees of freedom at 0.05 level of significance (r= 0.23) is significant[14].

- **The correlation coefficient between variables**

A number of statistical methods are used to assess the correlation coefficient between variables. Choosing the right method depends on the scale used and the number of variables. Two methods are reviewed in this section: Pearson correlation and Spearman correlation.

1. Pearson correlation

Pearson correlation (r) refers to a measure of linear relationship between two or more variables using the technique of the Pearson Product Moment Correlation Coefficient. The degree of the association ranges from (-1) to (+1). This type of correlation is appropriate when the investigated variables are ranked in an interval scale or ratio scale. Interval scale

[14] C.f. Guilford and Fruchter (1978)

is defined is terms of placing people or objects (in our case scores) in order and is marked in equal intervals. Testing in general and psychological testing in particular use this type of scale. In intelligence tests, observation of scores in the tests is inferred to approximation of ability intervals. For example, the difference between the score 90 ad 95 in IQ is not the same as the difference between 105 and 110. Another example could be the difference in the temperature (Celsius) between 20º and 30º, and between 30º and 40º (the intensity in heat is many times multiplied between 30 º and 40 º than between 20 º and 30 º). Ratio scale, on the other hand, is used in exact sciences (e.g. physical sciences) when 0 is a true and meaningful value. Examples of this type of measurement are length, weight, etc. (Ary et al., 2010)

2. Spearman correlation

Similar to Pearson correlation, Spearman correlation (rho) is also a method applied to study the degree of association between two or more variables. It differs from the former type in that while Pearson correlation investigates a linear relationship between two or more variables, the latter is used to compare two or more "monotonically" related variables. An example of this type of correlation is to ask both a headmaster and his assistant to rank fifteen teachers from the first (i.e. most helpful) to the last (i.e. least helpful), then to examine whether or not their ranks show agreement. This method also ranges the correlation from -1 (indicating perfect negative correlation) to +1 (showing perfect positive correlation). This type of correlation is appropriate for distributed variables in an ordinal scale. This latter is used to rank data in order without having a relative degree of difference between them (e.g. the ranking of opinions from totally disagree, mostly disagree, mostly agree, to totally agree). (Ary et al., 2010)

It is noteworthy that both methods for calculating the correlation lead approximately to the same results. In case there is a difference, it would be a very small one. The method we opt for in measuring the correlations in the present study is Pearson correlation (r) (c.f. chapter 7). The reason behind such a choice is that on the one hand our variables are distributed in interval scales, and on the other hand they show a linear relationship.

4.3.3.2. Factor analysis

- **Definition of factor analysis**

Factor analysis is a set of statistical procedures used when dealing with a large number of constructs in order to reduce them and identify common factors. In our study, this technique is applied through making correlations between the various subtests used in our three administered measures to reduce these subtests and determine the different factors, using a set of mathematical operations.

The technique of factor analysis has long been opted for in the literature of psychological testing in general, and mainly in the realm of intelligence and personality tests. Concerning intelligence testing, psychologists disagree about the number of factors underlying cognitive abilities. Spearman (1904) used factor analysis between all cognitive ability tests and has come up with a general aspect called 'g factor' in 1927. Similarly, Thurstone (1938) employed the same technique between fifty seven cognitive tests and subsequently identified seven distinct factors namely: word fluency, number facility, verbal comprehension, perceptual speed, associative memory, spatial visualization, and inductive reasoning. Vernon (1961) was the first to adopt the term 'factor analysis theory'. This latter has decomposed intelligence into two general factors: verbal educational ability (v :ed); and spatial practical ability (k :m), and specific factors like verbal fluency, rote memory, perceptual speed, etc.. In addition, Guilford's use of factor analysis (1959) led him to discover a large number of abilities, i.e. 150 abilities. Moreover, the application of factor analysis for Cattell (1967) revealed two distinct factors: fluid intelligence and crystallized intelligence. Modern researchers, as well, have employed this technique to define abilities underlying intelligence. For Gardner (1983), seven intelligences have been identified, namely linguistic, logical mathematical, musical, bodily-kinesthetic, spatial, interpersonal, and intrapersonal; while for Sternberg, three intelligences were highlighted, viz. analytic, practical and creative. A clarification of each type is described further in the theory (c.f. chapter one).

- **Types of factor analysis**

Two major types of factor analysis are distinguished, viz. exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). The former is used to investigate the different factors underlying a construct without a predefined structure, while the latter refers to the confirmation of already existing factors that were argued by previous researchers (Urbina, 2004). As the present study aims at exploring the different factors of Linguistic intelligence and, hence, the components of Linguistic intelligence test, we use the former type (i.e. EFA).

- **Steps used in exploratory factor analysis**

Urbina (2004) identified four main steps used in factor analysis study. The first step is making a correlation matrix. A correlation matrix refers to a table showing inter-correlations among tests or subtests scores obtained by a sample of participants. The second step is to show the loading of variables on factors through the choice of an appropriate statistical method; and then select the variables that are highly loaded on factors. The third step is making a factor matrix. The matrix contains the loading of variables on the factors extracted from the analysis. It provides information about the correlations found between the original measures in the correlation matrix and the factors that have been extracted. The final step is interpretation of the results. This step requires giving new labels to the found factors, using a bottom-up process[15]. Labeling the factors requires an examination of the features shared between the variables showing high relations with each other and low connections with the other factors.

Conclusion

SLA is a vast discipline tackling myriad issues germane to second/foreign language acquisition. The chapter has provided a clarification of commonly employed concepts in this discipline (e.g. learning and acquisition, second language and foreign language) with drawing attention to the distinction that might sometimes exist. Major theories of second language acquisition, notably those which provide linguistic and psychological explanations have also been reviewed, and different stages have been identified. The chapter has put emphasis on some factors that affect second language acquisition, highlighting mainly age and cognitive factors.

Language learning achievement is another concept deployed in SLA research to deal with language assessment. The chapter has clarified this term and highlighted other terms that are sometimes used interchangeably to accomplish assessment purposes. Some

[15] Bottom up process requires the identification of all the items used in testing linguistic ability then the clustering of the items in general factors or subtests.

standardized language achievement (proficiency) tests that are recognized in research in both areas of educational and applied linguistics research have also been reviewed. Within assessment, the chapter has highlighted the concept of psychological testing that is critical for the current work. The main conditions of a psychological test have been identified, and different statistical procedures have been described. The coming chapters are devoted to empirical analysis of the three chosen tests of cognitive linguistic ability.

Chapter Five

Methodology and Pilot Study Analysis

Introduction

5.1. Methodology

5.1.1. Restatement of the purpose of the study

5.1.2. Research questions and hypotheses

5.1.3. Research design

5.1.4. Instrumentation

5.1.4.1. Language aptitude measure

a. Aim of the measure

b. Description of the measure

5.1.4.2. Working memory measure

a. Aim of the measure

b. Description of the measure

5.1.4.3. Verbal reasoning measure

a. Aim of the measure

b. Description of the measure

5.1.5. Procedure

5.1.6. Participants

5.2. Pilot study analysis

5.2.1. Aim of the pilot study

5.2.2. Sampling in the pilot study

5.2.3. Measures and procedures

5.2.3.1. Language aptitude pilot test

5.2.3.2. Working memory pilot test

5.2.3.3. Verbal reasoning pilot test

5.2.4. Results and discussions

5.2.4.1. Language aptitude pilot test results

5.2.4.2. Working memory pilot test results

5.2.4.3. Verbal reasoning pilot test results

Conclusion

Methodology and Pilot Study Analysis

Introduction

Under the sphere of individual differences (ID), the current research provides thorough scrutiny of an aspect of human cognition. The study tackles a set of cognitive capacities that are believed to affect foreign language learning. Language aptitude, working memory and verbal reasoning are considered as the major areas of focus. The study departs from the belief that these capabilities are distinct factors of a general cognitive linguistic ability that is referred to as “linguistic intelligence”.

This chapter is divided into two main sections. The first section is primarily concerned with the methodology of research. The section restates the purpose of the study, the research questions and hypotheses; and explains the research design through delineating the methods of data collection and data analysis. The administered measures, participants, and procedure are further accounted for in this section.

The second section is entirely devoted to the analysis of the pilot tests. Language aptitude pilot test, working memory pilot test, and verbal reasoning pilot test are further gauged in this section through the analysis of the obtained results.

5.1. Methodology

5.1.1. Restatement of the purpose of the study

As has been mentioned earlier in the thesis introduction, the current research aims primarily at designing a test on the basis of a number of cognitive linguistic abilities, with the intention to make it an entry test for students who engage in a language program at university. The test is designated as 'Linguistic intelligence measure'. In fact, linguistic ability has always been a sine qua non condition of intelligence. Major intelligence tests (e.g. Binet's tests of intelligence, Wechsler's scales, Raven's battery, and Woodcock Johnson's test) (c.f. chapter 1.1.3) deal with the assessment of linguistic skills. To illustrate, Binet's language items are reasoning, knowledge, and working memory. Similarly, Wechsler's verbal ability measure incorporates vocabulary, Similarity, Arithmetic, Digit Span, Information, and Comprehension. Raven, as well, develops another test for measuring verbal ability (Raven's Mill Hill Vocabulary Scale, 2000) in addition to his analogical reasoning battery. In addition, Woodcock Johnson's verbal tasks encompass comprehension knowledge, short term memory and long term retrieval.

Despite the fact that verbal skill has been overwhelmingly considered in psychometric tests, the concept of 'linguistic intelligence' has not been explicitly employed until the emergence of Multiple Intelligences (MI) Theory by the American psychologist Howard Garnder (1983). Gardner provided a comprehensive explanation of his seven intelligences through a variety of arguments and instances; however, linguistic intelligence was not, as yet, empirically proved.

To this end, the present work comes as a reaction to put the theoretically hypothesized ability (linguistic intelligence) into practice through providing empirical evidence of its existence and proposing an adequate measure. A set of cognitive linguistic abilities- language aptitude, working memory and verbal reasoning- have been highlighted and elected as its distinct factors and, subsequently, the different components of its measure. The study, accordingly, purports to examine the effects of this overall capability on foreign language learning achievement.

5.1.2. Research questions and hypotheses

As we aim primarily at designing a Linguistic intelligence measure through the incorporation of a set of cognitive linguistic skills (i.e. language aptitude, working memory, and verbal reasoning) if high correlations are substantiated, and because examining the effects of this overall cognitive capacity, as with its ultimate proved constituent factors, with foreign language learning achievement, is also placed among our major research objectives, the following questions have been raised:

5. Are language aptitude, working memory and verbal reasoning significantly interrelated?
6. Would these capacities be considered as the final constituent factors of linguistic intelligence?
7. Does Linguistic intelligence affect foreign language learning achievement?

In the light of these questions, we would extract two main hypotheses and a number of sub-hypotheses:

- **Hypothesis one:** There would be a close association between language aptitude, working memory, and verbal reasoning, and Linguistic intelligence test would, accordingly, comprise these three variables. The following statements would, accordingly, be built up from this hypothesis:

  - **Sub-hypothesis 1**: Language aptitude would have a strong correlation with working memory capacity.
  - **Sub-hypothesis 2**: Language aptitude would be closely related with verbal reasoning ability.
  - **Sub-hypothesis 3**: Working memory capacity and verbal reasoning skill would show a significant correlation.

Hypothesis two. We predict that the overall Linguistic intelligence would have a noticeable effect on foreign language learning achievement. This general statement could also be divided into three main sub-hypotheses:

- The first predicted factor of linguistic intelligence, language aptitude, is expected to show a strong relationship with foreign language learning achievement.
- Working memory, as the second hypothesized factor of linguistic intelligence, would be closely related to language learning achievement.
- The third hypothesized factor of linguistic intelligence, verbal reasoning, would have a significant correlation with language learning achievement

5.1.3. Research design

The nature of the current study is correlational. This means that the examination of the previous hypotheses requires the use of three distinct types of correlation: the correlation between tests scores, within tests scores, and between the final Linguistic intelligence scores and foreign language learning achievement results. The first type is used between the scores of the administered measures (language aptitude measure, working memory measure and verbal reasoning measure) in order to examine whether or not strong relationships are established and, thereby, help us predict that obtaining high scores in one capacity would entail obtaining high scores in the other skills, and that the three capabilities would be viewed as the constituent factors of the same dimension ‘linguistic intelligence’. Correlations within tests scores are used between the different subtests of each administered measure. This type of correlation is opted for as a technique for checking the reliability of language aptitude test, working memory test and verbal reasoning test. In so doing, the scores obtained in the different subtests of each measure are correlated with the total scores of this measure, and then the results are compared with the standard (i.e. the required value for significance): if the obtained value is higher than the required value, the test might be considered reliable. The third type of correlation is used between the final Linguistic intelligence scores and foreign language learning achievement scores, so to examine whether this cognitive ability has an impact on foreign language learning.

A further statistical technique that was carried out in our investigation is factor analysis. This technique is employed to help uncover relationships that might exist between independent variables so to reveal some common aspects. In our study, factor analysis is conducted between all the subtests of the three administered measures: language aptitude, three subtests; working memory, four subtests; and verbal reasoning, five subtests to reveal what is common to them and, accordingly, aid in the identification of the final factors of Linguistic intelligence and the final components of Linguistic intelligence test.

As far as data collection is concerned, the data in the present research are primarily quantitative. This is because we have relied on a number of cognitive linguistic tests in the examination of our hypotheses. It is worth noting that the administered measures are not standardized measures; rather, they are developed according to theoretical evidence and testing standards. Language aptitude test, for example, is designed according to the famous MLAT and PLAB measures (Stansfield, 2013; Dörnyei, Z. 2005). However, it differs from them in that while these measures are directed to learners who opt to engage in a foreign language instruction for the first time, the current aptitude test is administered to students who have previous contact with the foreign language, i.e. they have been learning the language for at least seven years. This has pushed us to select the tasks carefully according to the participants' linguistic ability and proficiency as well. A description of this test is discussed in this section. Similarly, working memory tasks are designed according to the standardized working memory tasks. Despite the fact that working memory famous tasks (RSPAN, OSPAN, and LSPAN) assess the two intended-to-measure abilities (process ability and recall ability: Baddeley & Hitch, 1974), they contain complex vocabulary as they are administered to native speakers. Since our test is directed to foreign language learners, the vocabulary is selected on the basis of the participants' proficiency level. A description of this measure is also discussed below in the section. The same case for verbal reasoning measure, all the items used in this measure are identical to the standardized reasoning tests (Online adult Wechsler intelligence scale test, 2013; IndiaBix, 2008; Team examsbook, 2013). One additional item, that is syllogisms or syllogistic reasoning, is included according to scholars views that it is an aspect of deductive reasoning. A description of this measure is provided in the same section as well.

It is necessary to acknowledge that the administration of the cognitive linguistic measures was preceded by a pilot measure for each. This latter allows for making some adaptations based upon the revealed shortcomings of these measures. A detailed description of language aptitude pilot test, working memory pilot test and verbal reasoning pilot test and the analysis of the results are discussed in the second section of the chapter.

5.1.4. Instrumentation

In order to address the research questions and establish the relationship between the so predicted cognitive linguistic skills, three measures were administered: language aptitude measure, working memory measure, and verbal reasoning measure. These measures aim at decomposing a general dimension, that is, 'Linguistic intelligence test' and revealing the different constituent factors of the overall capacity 'linguistic intelligence' if strong correlations are found. This part of the section is mainly concerned with a description of the administered measures as with highlighting the aim of each.

5.1.4.1. Language aptitude measure

a. Aim of the measure

Language aptitude test, as its name suggests, aims at measuring the subjects capacity in acquiring a foreign language. Unlike standard aptitude and intelligence tests which are considered humiliating for excluding learners freedom to choose their preferred field of study, this test purports to uncover the learners areas of strength and weakness in the different aspects of language learning and, accordingly, gives insights to classify these learners in similar ability groups so to increase the rate of achievement. Besides, the findings of this measure will, principally, aid us in testing our hypothesis which addresses the relationship between language aptitude, working memory and verbal reasoning.

Although the MLAT measure of language aptitude has received extensive criticism, for it goes with the audio-lingual method of language teaching, it remains useful to predict success with current methods, e.g. communicative language teaching method, (c.f. chapter 2.4) due to tackling different aspects of language (phonetics, grammar and vocabulary) in its assessment. This has directed us to design an identical measure yet with some adaptations; for example, adding further tasks that were not well covered in the MLAT but were in the PLUB (inductive language learning subtest) and carefully selecting the vocabulary so to fit the learners' proficiency and culture.

b. Description of the measure

Language aptitude test is a paper and pencil test that assesses three primary capacities: phonemic ability, grammatical sensitivity and inductive language learning ability, plus two secondary skills: vocabulary and memory. The first three abilities have been proved to be components of aptitude since the emergence of aptitude research (e.g. the MLAT: Carroll and Sapon, 1959; the PLAB, Pimsleur, 1966) (c.f. chapter 2.2.1). Vocabulary and memory, as well, have been claimed to be aspects of this ability by some theorists (vocabulary: Ganschow et al., 1992; Sparks et al., 1995; memory: Carroll and Sapon, 1959; Miyake and Friedman, 1998; Skehan, 2002; Sparks et al., 2011, and Wen and Skehan, 2011) (c.f. chapter 2.2.1). This section provides a description of the components of the current language aptitude test.

- **Phonemic ability subtest**

Phonemic ability subtest, as called by Carroll and Sapon (1959), measures primarily the learners' sensitivity to foreign language sounds. Different appellations have been adopted by other researchers to refer to this component. For example, phonological memory and phonological awareness have been used by Wen and Skehan (2011, c.f. chapter 2.2.1), and phonetic coding by Sasaki (2012, c.f. chapter 2.3.1). This component has long been asserted to be the major aspect of language aptitude (e.g. Carroll and Sapon, 1959; Pimslleur, 1966; Dörnyei, 2010). As language aptitude measures are directed to learners who engage in a new language program, phonemic ability is normally assessed through listening to a particular pronunciation in the foreign language and choosing the right word that corresponds to that pronunciation. In our case, however, the participants have had a previous contact with English for a considerable period of time. For this reason, we have decided to select tasks that go with their level of proficiency so to determine their actual aptitude to learn this language.

In the first task, which is a measure of phonetic coding ability (Carroll and Sapon, 1959) or phonological awareness (Sparks et al., 1995; Wen & Skehan, 2011, c.f. chapter 2.2.1), the subjects were examined in their sensitivity to the different sounds, i.e. the different pronunciations, of the foreign language. They were asked to cross the differently pronounced word from a list of four words (c.f. appendix 2). A variety of phonetic rules the participants were taught was presented (e.g. final ‘s’, final ‘ed’, the diphthong /ɪə/ and the long vowel /ɔː/).

In the second task, which is another measure of phonetic coding ability and particularly sound-symbol association (Pimsleur, 1966) and that is also referred to as word decoding (Sparks et al., 2011, c.f. chapter 2.2.1), the examinees were instructed to choose the right spelling of words. The presented words were of frequent use to ensure their recognition, yet the spellings given were divergent with the inclusion of the right one.

In the third task that also assesses sound-symbol association (Pimsleur, 1966), the testees were presented with lists of transcriptions and were asked to write corresponding words. The presented words increased in the number of syllables they contained. It is worth noting that phrase and sentence transcription were omitted from the final language aptitude measure, as the findings of the pilot measure revealed the students inability in performing the task. This aspect is tested in the original aptitude tests (e.g. MLAT and PLAB) through reading aloud words in the foreign language. In the current language aptitude measure, however, we have opted for giving transcriptions instead of oral performance for the fact that it is a paper-and-pencil measure and that the subjects are not novices in the foreign language. What matters in this task is the subjects' recognition of the different vowels (i.e. sounds) rather than knowing all phonetic symbols. (c.f. appendix 2)

The fourth task handles pseudo-word decoding or pseudo-word reading. This task is referred to by Sparks, Patton, Ganschow & Humbach (2011) as phonetic coding (c.f. chapter 2.2.1). A pseudo-word, as defined early in the literature review (c.f. chapter 3.2.2.), is a fake word, that is, a string of letters that resemble a real word in terms of orthographic and phonological structures, but doesn't actually exist in the language. The pseudo-words given to the students had the same English phonotactic[16] rules. Again, because this test is a paper-and-pencil test, the students, instead of reading aloud the pseudo-words, they were told to read them silently and produce corresponding transcriptions. Our main concern in this task also is to assess the ability to distinguish between diphthongs, short and long vowels of the foreign language rather than presenting a whole transcription for the pseudo-words.

The fifth task is termed 'spelling clues'. This task was introduced in the original MLAT test (Carroll and Sapon, 1959). It is also considered as a measure of sound-symbol association. The items in this task depend, somewhat, on prior knowledge of English vocabulary (Baddeley et al., 1998, in Altarriba & Isurin, 2012). The role of the subjects was to recognize the disguised word from the presented spelling and select one from the four words that is closest in meaning to it.

The sixth and the ultimate task in phonemic ability measure assesses two main aspects of aptitude: auditory ability (Pimsleur, 1966; Skehan, 1998) and vocabulary skill (Baddeley & Gathercole, in Altarriba & Isurin, 2012) (c.f. chapter 2.2.1.). Since it is primarily a listening task, each participant was given a number of sentences to listen to in a

[16] The combination of phonemes, the structure of syllables, the clustering of consonants and the sequencing of vowels in pseudo-words are all English-like.

recorder and was instructed to jot down all what s/he could remember on the test paper. The sentences were ordered in increasing length and proficiency level. The subjects with a better auditory ability, higher memory capacity and richer vocabulary were expected to remember better than their peers.

It is necessary to mention that the tasks we opted for in phonemic ability subtest were adapted from a variety of aptitude measures (Stansfield, 2013; Psychometric success, 2013; Kelly, 1998) in addition to some activities of phonetics that go with the participants' level.

- **Grammatical sensitivity subtest**

While phonemic ability subtest centres on the assessment of sensitivity to foreign language sounds, grammatical sensitivity subtest, as its name indicates, puts focus on the evaluation of sensitivity to foreign language structures. This component has also received considerable attention of most, if not all, researchers in the field of language aptitude (e.g. grammatical sensitivity by Carroll, 1959; inductive language learning ability by Pimsleur, 1966; language analytic ability by Skehan, 1998; language analysis for Sparks and Ganschow, 2001) (c.f. chapter 2.2.1). As we intend to measure sensitivity to foreign language structures, the assessment of grammatical functions is emphasized. Similar to the previous subtest, the selected structures already exist in the participants' repertoire as they have had previous exposure with the foreign language. Multiple-choice (MC) questions were opted for in the assessment of this capacity. The rationale behind this choice is that the original language aptitude measures (i.e. the MLAT and the PLAB) are designed in this form. In addition, language ability multiple-choice tests, in spite of deemphasizing the assessment of communicative competence, are considered more reliable, valid and less time consuming (Michael, 1993, c.f. chapter 2).

The first task in our grammatical sensitivity subtest is referred to by Carroll (Carroll & Sapon, 1959) as 'words in sentences'. The examinees, in this task, were instructed to induce the right functions that best correspond to the underlined words in the given sentences. Here a variety of grammatical functions, i.e. language components, were presented (e.g. subject, verb, object, conjunctions, etc.) (C.f. Appendix 2). Provided that the presented structures do exist in the participants' repertoire, the subtest attempts to identify those who are more able in internalizing them. As far as information processing is concerned, the participants employ a number of mental processes: reading, recognition of the structure, associating the structure with LTM, and inferring the function that corresponds to the underlined word.

In the second task that is another measure of grammatical sensitivity or language analytic ability (Skehan, 1998), the subjects were asked to fill in the blanks with the right word category. Further grammatical functions were presented in this task (e.g. tenses, interrogatives, conditional, preposition +noun, Not+ infinitive, 'wh' questions, and relative pronouns, etc.) (cf. Appendix 2).

The third task is another phase in grammatical sensitivity assessment. Unlike the two previous tasks, the subjects were given a set of sentences holding a mistake in the use of functions, and then they were asked to identify it. Again more functions were presented (e.g. auxiliary+ past participle, modals, direct and indirect object, and the conditional (c.f. Appendix 2). To mention, the questions in this subtest were also adapted from online aptitude measures (Stansfield, 2013; The Colleges of Oxford University, 1996).

- **Inductive language learning subtest**

A variety of appellations have been utilized by many researchers in the sphere of aptitude when referring to this subtest (e.g. inductive language learning ability by Carroll, 1973; language analysis by Pimsleur, 1966; and language analytic ability by Skehan, 1998). Unlike the original PLAB measure which gives the sentences in English as the first language and an invented language as the foreign language, the four tasks in this subtest were presented in two foreign languages: English, which is expected to be known by the participants; and an artificial language, which is considered as the foreign language. The words given in English were expected to be accessible to all the subjects so to aid in the recognition of the presented functions. This subtest was kept the last since it requires higher cognitive abilities from the part of the participants, e.g. examination of the two languages, recognition of their structures and the different functions of words, making comparisons, deducing the right word, and then inducing the right grammatical function or syntactic structure. The task, therefore, measures inductive and deductive reasoning skills as well.

In the first task, a list of sentences was presented in the foreign language (i.e. an artificial language) with a translation of each into English. The examinees were instructed to read the sentences, make comparisons, and then deduce how each word in English is expressed in the foreign language. In the second task, they were presented with a variety of words in the foreign language and their English counterparts, and then they were asked to select the right translation of the presented English sentence from the translation of the given words. The third task is, somehow, more advanced than the two previous ones, in that the subjects were asked to induce the translation of a sentence from the translation of individual words. The fourth task is rather more demanding as the participants produce their own translation of the foreign sentence from the observation of a set of foreign sentences and their English counterparts. The questions in this subtest are also adapted from a variety of language aptitude measures (Stansfield, 2013; the Colleges of Oxford University, 1996; and Dörnyei**,** 2005).

5.1.4.2. Working memory measure

a. Aim of the measure

Working memory, in addition to language aptitude, is assumed to be the second constituent factor of the so referred capacity 'linguistic intelligence' and a further component of the overall dimension 'Linguistic intelligence test'. The rationale behind this choice is twofold:

- First, working memory has been highly argued to correlate with intelligence. Many, if not most, research findings on the link between the two constructs have substantiated a strong relationship. For instance, Kyllonen and Christal study (1990) (c.f. chapter 3.4.2) has found a correlation of (.80) and (.88), between reasoning ability, which is considered the main aspect of intelligence, and working memory capacity. Similarly, Conway et al. findings (2002) have also revealed a very high correlation between working memory and one type of intelligence, namely fluid intelligence (Gf). Further evidence (Engle, 2002) has indicated that working memory can be considered isomorphic to Gf. Even more, all standardized intelligence measures, e.g. all the versions of Binet's tests as well as the four Wechsler intelligence scales (c.f. chapter 1.1.3) do assess memory capacity.
- Second, working memory active component has also been speculated to relate to language aptitude. Recent research evidence (e.g. Miyake and Friedman, 1998, in Dörnyei, 2005; Dörnyei, 2005; Wen & Skehan, 2011) (c.f. chapter 2.6) has

highlighted working memory capacity as the central component of language aptitude.

b. Description of the measure

Having considered the association between working memory construct and the other cognitive linguistic capacities- intelligence and aptitude-, we will delineate the administration of working memory measure. Unlike standardised working memory tests that are adopted in psychology and that require clinical and laboratory assessment, the present test attempts to measure the subjects working memory capacity in the foreign language. Four subtests, namely RSPAN, OSPAN, anagrams and LSPAN, have been administered to the subjects in order to assess the simultaneous manipulation of information and recall. All the tasks in the four subtests centre focus on the assessment of verbal working memory capacity. For instance, RSPAN tasks measure primarily visual-verbal WMC (i.e. stimulus perception was on a data show), while LSPAN measures auditory-verbal WMC (i.e. the participants perceive information through listening), and OSPAN assesses both numerical working memory (i.e. solving mental operations and recalling numbers) and verbal working memory (recalling letters or words). A description of each subtest is discussed further down in the section.

- **Reading span tasks (RSPAN)**

This task was initially adopted by Daneman and Carpenter (1980, c.f. chapter 3.3.2) to be a prominent measure of working memory capacity. As mentioned earlier, RSPAN is a dual-task measure that assesses both manipulation of information capacity (i.e. reading process) and recall ability (i.e. storage process). The task has also been referred to as verbal span (Bailey, 2012). It is called so since it measures verbal working memory capacity and particularly visual-verbal working memory ability. This task was presented on a data show where there was a visual perception of stimuli.

The subjects in this subtest were presented with an increasing number of sentences (from 2 to 8) to read and an element (i.e. a letter, a number, or a word) next to each sentence to remember (e.g. The mechanic fixed the broken car. **R**). At the end of each span, they were instructed to recall the elements in the order of their presentation on a paper given by the experimenter. Fifteen sets of sentences were presented; each set holds an increase in memory span (from span 2 to span 8). Working memory capacity is determined by the number of the recalled items. In the first span, which is considered the simplest in WM measure, the subjects were presented with a pair of sentences with a letter next to each; in the second, three sentences were given and each one was associated with a number; in the third, four sentences were shown with a separate word next to each. The aim behind opting for a variety of items for recall is to compare whether recall results are similar with all items or not. The number of sentences increased until the participants felt unable to proceed in recall. The results of the pilot test informed us that recall ability starts to impede when given more than seven items. Eight items were, subsequently, presented and were assumed to reveal those with higher memory ability. (C.f. appendix 2)

It is important to note that the sentences to-be-read were taken from Jennifer and Caplan WM automated tasks (c.f Acknowledgement) in addition to online language Reading Span Test (Cognitive fun, 2012) and were adapted to fit the Algerian socio-cultural context. This means that the words that seemed unfamiliar to our participants' culture and that exceeded their level of proficiency were omitted and replaced by more familiar words to ensure the results.

- **Operation span tasks (OSPAN)**

OSPAN is the second administered subtest in working memory measure. Similar to the previous subtest, this task has also been claimed to be a reliable measure of working memory capacity. The task has been adopted by Turner and Engle (1989, c.f. chapter 3.3.2). Two processes are also activated in this task: manipulation of information process (i.e. performing mental operations) and storage process (i.e. recall of elements that are associated with the mental operations). While RSPAN emphasizes the measurement of the participants' verbal working memory capacity, this task attempts to measure mainly their numerical working memory ability (Dang et al., 2012). In each task, the participants were presented with a set of mathematical operations to solve and an element at the end of each operation to recall (e.g. Is (8+2)-5= 5? **P)**, or a set of operations to solve and then to recall the results obtained. The recall of the elements must be in order.

It is worthwhile noting that the operations were presented on a data show and the recall was done on a paper given by the experimenter. The number of operations increased in increasing memory span (from 2 to 7) (c.f. appendix 2). The latter number reflects the participants' maximum effort to maintain the operations in the pilot test. As the focus is on recall ability over process capacity, the operations given were assumed to be easy and manageable to all the participants.

- **Anagrams**

Anagrams are words formed from a set of jumbled letters by changing their order. This task was added to the three prominent working memory tasks (RSPAN, OSPAN, and LSPAN) and was selected as a further measure of working memory capacity for the belief that it requires the activation of the same two processes: storage process (i.e. recall of the jumbled letters), and manipulation of information process (i.e. making meaningful words). Besides, various memory components are observed to interact in this task. For example, the phonological loop functions for the perception of letters, the episodic buffer for linking the jumbled letters with information stored in LTM, and the central executive for making relations between information stored in LTM, and new perceived stimuli to give the desired response (i.e. inferring meaningful words). Anagrams task does not only assess working memory capacity but vocabulary and reasoning skills as well. One should mention that the task was adopted from Carter’s book of intelligence testing (2005). Here again, the words selected were made sure to exist within the participants culture.

Concerning the presentation of stimuli, a set of jumbled letters appeared on the data show for few seconds, then the subjects were instructed to extract as many meaningful words as they were able to. Ten anagrams were given and ordered in increasing memory span, that is, the number of letters they contained (e.g. three letters: EGA to nine: LUBETTYFR) (c.f. appendix 2).

- **Listening span tasks (LSPAN)**

As indicated above, LSPAN is considered another useful measure for the testing of working memory capacity (Dehn, 2008). This subtest emphasizes the evaluation of two processes as well: manipulation of information process, or judging the semantic accuracy of the given sentences; and storage process, or the recall of elements that appeared at the end of each sentence. This subtest is mainly concerned with the assessment of auditory verbal WMC. For this reason, the tasks were presented orally and not on a data show, which is the followed procedure in the three previous subtests.

The subjects were asked to listen to a set of sentences read-aloud by the experimenter and to judge whether they made sense on the same paper they were given. The letter (T) was recommended if the sentence was meaningful, and the letter (F) was required if the opposite was true. The sentences were read at a normal pace so that all the subjects were made sure to perceive the stimuli. The recall of the last elements was kept at the end of each span. In addition to assessing working memory capacity, this task measures the participants' proficiency and mainly grammatical proficiency in the foreign language as well. The tasks given required understanding of complex structures that involve subject-object inversion (e.g. It was the pie that cut the **cooker**). (c.f. appendix 2)

The number of the to-be-evaluated sentences ranged from one to seven, i.e. the number that corresponded to the so claimed memory span (c.f. chapter 3.2.2.2). The sentences in this task were also adopted from online reading span test (cognitive fun, 2012) with making some adaptations. As the focus was on measuring working memory rather than proficiency, the vocabulary used in the sentences was assumed to be accessible to everybody.

5.1.4.3. Verbal reasoning measure

a. Aim of the measure

The third administered measure aims primarily at assessing one further aspect of the cognitive linguistic ability that is referred to as verbal reasoning. Unlike standardized reasoning tests (e.g. Raven's Progressive Matrices Test) which centre focus on the evaluation of abstract thinking capabilities, this test assesses the subject's linguistic reasoning skills. Past research (e.g. Horn & Cattell, 1967; Conway et al., 2002; Engle, 2002; Kane, Hambrick & Conway, 2005) has viewed reasoning as a prerequisite aspect of intelligence, which has directed us to hypothesize this ability as an underlying factor of linguistic intelligence.

b. Description of the measure

Verbal reasoning measure is another paper-and-pencil test containing five subtests that assess inductive and deductive reasoning skills, on the one hand, and vocabulary proficiency, on the other hand. The five subtests are: knowledge, similarity, syllogisms, understanding relations, and analogies. These subtests were found to be the major components of verbal intelligence tests (e.g. online Wechsler Adults Intelligence Scale, 2013). The tasks in this test were adapted from a sample of online verbal intelligence as well as verbal reasoning measures (i.e. online Wechsler Adults Intelligence Scale, 2013; IndiaBix, 2013, Fibonicci, 2011, AllIQTests.COM, 2008-2013; Team examsbook, 2013; and BankersALgo.com, 2013)) with some adaptations to fit the Algerian socio-cultural context as well as the participants' cognitive capacity level (the findings of the pilot study have aided us in the choice of challenging questions). A description of the five subtests is discussed in the section.

- **Knowledge subtest**

As mentioned above, this subtest attempts to assess the subjects' deductive and inductive reasoning skills in addition to their vocabulary proficiency. A set of five scrambled letters was presented to the participants (e.g. MANGERY) to deduce corresponding words, and then induce what the obtained words represented. The mixed-up letters represented respectively a name of an animal, a country, a city, an ocean, and a disease (c.f. appendix 2). The examinees were required to use a set of information processes in answering the task: they perceived the given letters (i.e. stimulus perception), made connections with information stored in their LTM (i.e. activating WM processes), retrieved the right word (i.e. retrieval), compared the obtained word with the list of propositions (i.e. using reasoning processes), and then inferred the right conclusion (i.e. induction). As the name of the subtest indicates, finding what the word represents requires knowledge of English vocabulary as well as knowledge of the difference between country, city and state. For the nature of intelligence tests, the questions in this subtest were ordered in gradual increase in difficulty, i.e. they were ranged from easiest to most difficult. The pilot study aided us in arranging the questions.

- **Similarity subtest**

The items selected for this subtest also intend to measure deductive reasoning skills as well as vocabulary proficiency. The subjects were asked to examine a list of words, understand the shared relationship between them and deduce the odd word out. Six items were presented, and each one contained a number of words sharing a common relationship (e.g. family members, four-legged animals, etc.)(c.f. appendix 2). The task is considered a measure of vocabulary as it requires knowledge of the presented words so to exclude the odd one. For example, the participants must understand that: ‘bottle’, ‘cup’, ‘tub’, and ‘bowl’ are all containers, while ‘funnel’ is not and is just used for channelling liquid. Here again the questions were presented in increasing difficulty in terms of words complexity (the pilot study aided us to decide on the ordering of items).

- **Syllogisms subtest**

Syllogisms subtest is administered to assess basically deductive reasoning skills. The participants were presented with a number of statements, i.e. premises, to read and were asked to choose the right conclusion. The given premises should not be semantically true, yet the derived conclusions must be logically related to them. This subtest contained four tasks (after having added one further task to the pilot study); in the three first tasks two premises were given to understand and a conclusion to judge, while in the fourth task the conclusion is deduced from the given premises (c.f. appendix 2). As we attempt to investigate individual differences in reasoning ability, the given items were predicted to be complex and require high attention and working memory capacity; nevertheless, for the nature of intelligence tests, these items were ordered from easiest to most difficult according to the answering percentages of the pilot study.

- **Understanding relations subtest**

The fourth subtest is a further measure of deductive reasoning skills. A set of sentences containing confusing relationships (e.g. arrangement of people) were presented and the subjects were instructed to deduce the right relationship. The selected items were assumed to be cognitively demanding as they aim to identify individual differences. For example, stimulus perception requires high memory load since the names of the given people (e.g. Bindu, Rani, Reeta, Mary) and the information regarding their arrangement are somehow confusing (c.f. appendix 2). The comparison of the percentages of the correct answers in the pilot study aided us in ordering the tasks from easiest to most difficult.

- **Analogies subtest**

This subtest is mainly concerned with the assessment of inductive reasoning skills. The subjects were given a pair (two items) to understand the shared relationship between its items, and were asked to induce the same relationship to the second pair. Nine tasks were presented, and the pairs in each task share a common relationship (e.g. synonyms; antonyms, etc.). In addition to inductive reasoning, the subtest assesses vocabulary proficiency as well due to the fact that inducing the right relationship requires understanding of the presented words. The tasks were arranged in increasing difficulty according to the findings of the pilot study.

5.1.5. Procedure

Language aptitude measure, working memory measure and verbal reasoning measure were handed out to approximately seventy subjects who were submitted to the three measures (i.e. 69 were involved in language aptitude measure, 70 in working memory, and 68 in verbal reasoning) at the department of Letters and English Language, University of Mentouri Brothers- Constantine. The subjects were divided into four groups, i.e. their actual division by the administration. These tests were administered in the same week at the end of November 2013, after the evaluation of the three pilot tests which were themselves administered in the second week of the same month. Choosing identical time for the tests administration stems from the belief that the same conditions will be provided and, hence, will not affect the tests scores. A detailed description concerning the administration of the three cognitive linguistic measures, physical environment, time allocation, and scoring procedure is discussed further down in the section.

a. Administration of language aptitude test

As mentioned above, sixty nine out of seventy examinees were ready to take the first cognitive linguistic test. The first group involved nineteen subjects, the second group seventeen, the third group twenty, and the fourth group thirteen. Language aptitude tests are normally administered at the beginning of the year before engaging in a language instruction so to decide on placing learners according to their abilities; however, because of some administrative problems (e.g. the late attendance of the students, late inscriptions, transfer, etc.) we were a bit late in handing out the test. Yet we made sure that its submission took place before the beginning of lessons so that the students' answers would not be affected.

Language aptitude test was administered the second, after working memory test, in our battery of cognitive linguistic measures in the mornings (at 09.30 am) of the same week: Sunday, Monday, Tuesday, and Wednesday, respectively. This time in the morning allows for the activation of high cognitive processes that led to best performance from the part of the testees. Before engaging in the test, the participants were given a break of thirty minutes after the first measure (i.e. working memory measure) so to refresh their cognitive abilities and avoid boredom. The test was given in the presence of the researcher himself with the help of another researcher to observe the participants when taking the test and ensure the results.

In order to decrease anxiety and increase interest, the subjects were told that the test scores will have no influence on their marks, and that they will receive a bonus for being a part of the study. The subjects were asked to sit one in a table and avoid guessing so that the marks will reflect their real abilities. As far as time allocation is concerned, sixty minutes were devoted to this test. This period is decided after the observation of the participants' notes on the time spent in the pilot test.

b. Administration of working memory test

Working memory measure was selected the first to start with (at 08 am) before the two other measures. The reason behind this is that this time in the morning allows for activating higher cognitive processes which are required for this test. As far as time allocation is concerned, sixty minutes were also devoted for WM test. This period of time was decided from the observation of the pilot test. The same four groups involving seventy participants engaged in this test. The four groups were themselves divided into nine subgroups. Each subgroup comprised approximately eight participants. The placing of the participants into small groups was done after a previous trial[17]. The nine sub-groups took the test during the mornings (at 08 am) of two consecutive weeks (i.e. Sunday, Monday, Tuesday, Wednesday, Thursday, Sunday, Monday, Tuesday and Wednesday).

Stimulus perception took place in two distinct ways: from the data show (e.g. RSPAN, OSPAN, and Anagrams) or from listening to the experimenter (e.g. LSPAN), while responding to test items was done on a paper given by the experimenter. Taking the test in small groups in small rooms in the morning drives the participants to feel more active, motivated, and controlled, which resulted in providing better conditions and, thus, increasing the reliability of the measure.

[17] The first attempt was placing the participants altogether in an amphitheatre and exposing them to the same data for the same time; and since it was impossible to manage the rather huge number of students, and provide calm atmosphere which affected test reliability, we decided to divide the groups into small subgroups.

c. Administration of verbal reasoning test

Verbal reasoning measure was the third administered test to the participants after a break of thirty minutes after the second measure (i.e. the test was undertaken at 11 a.m.). The same four groups containing sixty eight participants took this measure on the same four consecutive days (i.e. Sunday, Monday, Tuesday, and Wednesday). As stated earlier, this test was also a paper-and-pencil test handed out by the experimenter.

The same physical conditions were provided for verbal reasoning measure. Four whole rooms, a room for each group, were devoted to the participants so to provide appropriate atmosphere. To encourage the participants further, they were informed that engaging in such cognitive test will increase their cognitive performance. Concerning time allocation, this aspect is a sine qua non condition in intelligence tests. As verbal reasoning is believed to be an important aspect of this latter ability, we were so careful in determining the time span for each item in each subtest in this measure. The participants were instructed to identify the time spent in each activity on the test paper in the pilot test; therefore, forty five minutes were the overall allocated time for this test.

d. Scoring procedure

Since we have predicted that language aptitude measure, working memory measure, and verbal reasoning measure would be components of the overall dimension that is 'Linguistic intelligence test', all the three tests should be given equal scores to facilitate the examination of their interrelationship. To this end, the score 100 has been determined as the score of perfection for each measure, and the participants obtained scores have been classified according to it. It is necessary to note that this score has been divided into five quartiles (i.e. percentiles): mediocre, below average, average, above average, and superior.

More explicitly, the score 50 is considered as the mean representing average capacity level, while all the scores that surround the mean (from 25 to 75) indicate average ability. Scores below 40 indicate below average ability and scores above 60 indicate above average ability. Exceptional individuals would have a very high or a very low score; subsequently, the scores 95 or more reflect superior ability, and the scores below 5 show a deficit. The distribution of the scores for each test and for each subtest will be discussed in the coming chapter. (c.f. chapter 6)

Concerning language aptitude measure, the score 100 has been divided into its three subtests: phonemic ability subtest, grammatical sensitivity subtest and, inductive language learning ability subtest. Although the questions have been ordered in increasing difficulty, they have not been given increasing scores for the fact that each question has been expected to measure a different aspect of language aptitude. Phonemic ability subtest has received the highest score (60/100) for two main reasons: first, this subtest is believed to be the major component of aptitude; and second, it has contained the largest number of tasks in comparison with the other two subtests. Grammatical sensitivity and inductive language learning ability subtests have received equal scores (20/100). As for the distribution of scores in the different items in language aptitude test, the score 60 of phonemic ability subtest has been distributed on two parts: 34 points have been given to the first part (from item 1 to item 5), i.e. each item received 1pt, while 26 points have been given to the listening task where every remembered and accurately-written word in the five sentences has been given 0.5 pt (here fifty two words have been presented). The score 20 in grammatical sensitivity subtest has been distributed on the eighteen given items, while the first fourteen items have received 14 points (1pt for each item), the four last items have been given 6 points (1.5 for each for showing less answering percentages). The same procedure has been followed in inductive language learning test where the score 20 has been distributed on the 20 translated words, each one receiving (1 pt).

The same scoring procedure has been followed with regard to working memory measure. The score 100 has been distributed into the four subtests: RSPAN, OSPAN, Anagrams and LSPAN. In spite of the fact that two processes have been considered in the assessment of working memory capacity, i.e. manipulation of information and storage, the scores have been restricted to storage process. Manipulation of information process (e.g. reading, performing mental operations, or judging the accuracy of sentences) has been given in order to disrupt the participants' attention by something else rather than recall, an aspect claimed to reveal real memory capacity. While scoring, the more tasks the participants have been given, the higher score has been devoted. Therefore, RSPAN has received the highest score (40) for incorporating the largest number of tasks. OSPAN and LSPAN have been given equal scores (25), and anagrams has received the lowest score (10) as it has involved less items. Working memory capacity has been determined by the number of items the participant has been able to recall. Each recalled item has normally been scored out of (0.5); however, in initial tasks where the participants have been given few items, the score (0.25) has been favoured as these tasks have been accessible to everybody and, hence, have not revealed differences in WMC. One should state that the scores given have corresponded to the recall of information in order. This means that half of the score (0.25 pts in this case) have been dropped from each recalled item that have not respected its order of presentation.

As far as verbal reasoning measure is concerned, the very same score has been devoted and has been distributed into the five subtests: analogies, similarity, knowledge, understanding relations and syllogisms. Analogies subtest has been given the highest score (30) for encompassing the largest number of tasks. Similarity subtest, knowledge subtest and understanding relations subtest have received equal scores (20). Syllogisms subtest has been given the lowest score (10) as it contained a few items.

For the challenging nature of intelligence tests, and because reasoning is considered an aspect, the questions in this test have been ordered in increasing difficulty with a gradual increase in scoring. The scores have been distributed in accordance with the participants' correct answering percentage. This means that the highest percentage of correct answers have received the lowest score and vice versa[18]. The score (20) in knowledge subtest has been distributed as follows: the first item has received (2 pts), the second item (2.5 pts), the third (3 pts), the fourth (3.5 pts), the fifth (4 pts), and the sixth (5pts). Similarly, in similarity subtest, the score (20) has been divided as the following: the first item has been given (2 pts), the second (2.5 pts), the third (3 pts), the fourth (3.5 pts), the fifth (4 pts), and the sixth (5 pts). As for the score (10) in syllogisms, the first item has been given (1pt), the second (2.5 pts), the third (3 pts), and the fourth (3.5 pts). In understanding relations subtest, the score (20) has been distributed in the six items as follows: 2 pts have been given to the first item, 2.5 pts to the second item, 3 pts to the third item, 3.5 pts to the fourth subtest; 4 pts to the fifth item and 5 pts to the sixth item. Last but the least, the score 30 in analogies subtest has been distributed as follows: 0.5 pt has been given to the first task, 2.5 pts to the second task, 3pts to the third task, 3.5 pts to the fourth task, 4 pts to the fifth task, 5.5 pts to the sixth task, 5 pts to the seventh task. The last two tasks (i.e. task 8 and task 9) have received (1.5 pts) and (4.5) pts respectively.

[18] The participants' correct answers were counted and the results were converted into percentages. High percentages of correct answers will be given low scores, and low percentages will be given high scores.

5.1.6. Participants

Following the principle of a representative sample, four groups (one containing 19 students, the second one 17, the third 20, and the fourth 13) were randomly selected from the population of fourteen groups (i.e. from 379 students) of first year, Licence degree, learning English as a foreign language at the department of Letters and English Language, University of Mentouri Brothers- Constantine. Approximately nineteen subjects were involved in the first group, seventeen in the second group, twenty in the third group, and thirteen in the fourth group. Although the same groups were engaged in the three administered measures, the number of the participants in each test was not the same. Sixty nine subjects were found in language aptitude papers, seventy on working memory, and sixty eight on verbal reasoning.

In the pursuit of designing a Linguistic intelligence test, language aptitude has been chosen among its basic components and a test of this ability was subsequently administered. Assessing one's language aptitude requires him/her to be new university in English as a foreign language. Our subjects were, accordingly, made sure to have just passed their 'Baccalaureate' and have their first year of exposure with learning English as a foreign language at university. This means that the students repeating the year were excluded from the study. The whole population of new students excluding the repetitive ones became 300. Therefore, our sample (N=69) was somehow representative for representing 23% of the population, i. e. a little bit over 1/5 of the population, a proportion which is required for representativeness in statistical research.

As far as age is concerned, the overall age ranged between 18 and 29 with the mean (M= 19.61). A discussion of age differences is not of our concern in the present study for the reason that it might take us too far from our objectives of the main study, and because all the participants will have their first year of learning English as a foreign language at university (i.e. they are all new learners who have just got their Baccalaureate and engage in a tertiary language instruction). Regarding sex differences, 58 girls (representing 84, 05% of the population) and 11 boys (representing 15.94%) took the three cognitive linguistic measures. The phenomenon of the number of females exceeding the number of males is considered natural in the sphere of language learning. A detailed analysis of sex differences is not dealt with as well, yet the study will shed some light on these differences, for they are considered crucial in cognitive ability testing.

A further rationale for opting for freshmen in the current cognitive Linguistic measures, and particularly working memory measure, is the claim (Schneider and Detweiler 1987, in Miyake & Shah, 1999) (c.f. chapter 3.4.1) that both beginning and intermediate levels are more informative about working memory capacity in the foreign language than the advanced level. The activated processes of working memory are quite controlled and effortful at these levels in comparison with advanced levels when they become automatic.

5.2. Pilot study analysis

5.2.1. Aim of the pilot study

The pilot study- the pilot tests in our case- is the primary and essential step to go through in the present research. It aims at informing us about the usefulness of the designed cognitive linguistic measures. Besides, it uncovers the difficulties that are likely to appear in the final tests. In other words, some questions might not be understood by the participants, and it is the job of the pilot study to reveal them. In addition, the pilot tests are considered as an aid in the organization of the measures items from easiest to most difficult. This was done through comparing the percentages of the correct answers and ordering the questions according to these percentages.

Moreover, this attempt informs the researcher whether or not some adaptations should be made to the final measures before their administration. As an essential aspect of the current tests is to identify individual differences in cognitive linguistic ability, the items selected in these measures should be challenging, that is, neither too easy nor too difficult. It is the job of the pilot tests to reveal the questions that are accessible to everybody or extremely hard questions to avoid boredom and increase motivation to accomplish the tasks.

Even more, time allocation is a prerequisite aspect in testing in general and psychological testing in particular. The pilot study informs us about how much time should be taken in performing each test as well as each individual item. In so doing, the participants were instructed to take a chronometer and denote the time spent in each question (using their mobile chronometers).

As a further assistance the pilot study might provide in this investigation is to reveal whether or not the items we opted for in each measure are related. It is mentioned earlier that language aptitude measure, working memory measure and verbal reasoning measure are not ready-made tests and that the items are selected from a variety of cognitive linguistic measures that adhere to extensive theoretical evidence. (c.f. section 1.4)

5.2.2. Sampling in the pilot study

A sample of three groups was chosen randomly from a population of first year (i.e. 379 students) at the department of Letters and English Language, University of Mentouri

Brothers- Constantine, to take the primary cognitive-linguistic measures. The division of the groups was akin to the administration. Twenty three subjects including sixteen females and seven males were involved in language aptitude pilot test, twenty seven testees encompassing twenty one females and six males took working memory pilot test, and thirty participants containing twenty five females and five males engaged in verbal reasoning pilot test. The age of the participants varied from twenty to thirty three years with the mean (M= 20, 10). We should note that the subjects who were engaged in the pilot tests were dissimilar to those of the final tests in order not to lose trustworthiness of the measures.

5.2.3. Measures and procedures

In the previous section we have provided a detailed description of the administered cognitive linguistic measures. Since some adaptations have been made for these measures, it is necessary to go through the pilot tests.

5.2.3.1. Language aptitude pilot test

Language aptitude pilot test does not aim to measure the participants' aptitude for learning the foreign language; rather, it is administered to evaluate the understanding of the test items so to make some adaptations when necessary, in terms of the omission of difficult questions, addition of other items, or explication of the instructions. Besides, it is used as a means to decide on the time allocation for the final measures. In the light of these objectives, the participants were asked to underline ambiguous questions, and to write down the time taken performing each item using the mobile chronometer.

Similar to the final aptitude measure, this trial included three subtests: phonemic ability subtest, grammatical sensitivity subtest, and inductive language learning ability subtest. The first subtest comprised five tasks. In the first task, the subjects were asked to cross the word with a different pronunciation. In the second task, they were instructed to use the right spelling of the given words. In the third task, they were presented with a list of transcriptions to read and were told to write corresponding words, phrases or sentences. In the fourth task, the subjects were asked to read a list of pseudo-words (c.f. section 1.4.1) silently and produce corresponding transcriptions. In the last task, they were instructed to recognize the disguised word from the spelling presented and select the word that is closest in meaning to it. (C.f. appendix 1)

Three tasks were presented in the second subtest (i.e. grammatical sensitivity subtest). In the first task, the subjects were instructed to induce the right function that best corresponded to the underlined word in a sentence. In the second task, they were asked to select the right category to fill in the blanks. In the third task, they were presented with sentences containing a mistake in the use of some grammatical functions and were asked to find the mistakes out. (C.f. appendix 1)

The third subtest, that is inductive language learning ability subtest, contained three additional items. In the first item the examinees were given a set of sentences written in the foreign language (an artificial language: c.f. chapter 2.3) with their translation into English and were asked to extract the translation of individual words from the translation of the sentences. In the second task, they were asked to examine a list of words in the foreign language (the same artificial language) and their English counterparts and, then, deduce the best translation of the given sentence from the translation of the words. In the last task, they were asked to produce foreign sentences to the English given ones from the translation of individual words. In this task no choices were given and the participant should give the translation themselves. (c.f. appendix 1).

Concerning the scoring procedure, we have mentioned earlier that language aptitude measure aims at assessing the learners' aptitude in different aspects of the foreign language, which has directed us to devote a mark for each aspect in phonetic ability, grammatical sensitivity and inductive language learning ability. Like the final measure, the score of perfection for language aptitude pilot measure was (100). This score was divided on the different subtests as follows: the first subtest received the highest score (50); the second subtest was given the score (30); and the third subtest received the lowest score (20). We have determined to make adaptations to the scoring procedure once the results will prove unsatisfactory.

5.2.3.2. Working memory pilot test

Working memory pilot measure was presented via a data show. Three subtests were selected to assess the subjects' working memory capacity (WMC): Reading Span tasks (RSPAN), Operation Span tasks (OSPAN) and Anagrams. In the first subtest (RSPAN), the participants were asked to read an increased number of sentences (from 2 to 8) with an element, that is letter, a number or a word, next to each sentence to recall. As stated above in the previous section (c.f. section 1.4.2), the sentences were taken from online Language Reading span test (Cognitive fun, 2012) and adapted to fit the socio-cultural context of our participants. Eighteen items were presented to the students; each item involved a set of sentences or phrases to read and an element to recall. In the second subtest (OSPAN), the examinees were presented with a number of simple arithmetic equations (from 2 to 7) to judge or solve, with a letter, number or word at the end of each to recall. This subtest was adapted from online Automated Operation Span (Millisecond, 2013). In the third subtest (Anagrams), the subjects were presented with a list of jumbled letters to remember for a few seconds, and then they were instructed to form as many meaningful words as possible from them. (c.f. appendix 1)

Time allocation for this test was devoted to both working memory processes: manipulation of information process and recall process. As a procedure, when presenting the stimuli, the experimenter read the sentences with the subjects silently in RSPAN and solved the mathematical operations in OSPAN at a slow pace when observing the subjects simultaneously to ensure the perception. The next item appeared on the screen once the participants were noticed to finish the processing and the recall the previous item.

As far as scoring is concerned, working memory pilot measure was given the score (96) as a score of perfection. Similar to language aptitude pilot test score, adaptations will also be made to this score if the results will prove inadequate. This score was divided between the three subtests. RSPAN received the highest score (41), each recalled item was given half point; OSPAN was given the score (32), half point was also given to each correctly recalled item; and anagrams subtest was given the score (20), e.g. three-letter anagrams were given one point, four-letter one point and a half, and five-letter two points, etc..

5.2.3.3. Verbal reasoning pilot test

Verbal reasoning pilot test was a paper-and-pencil test containing five subtests that measure both inductive and deductive reasoning abilities. The five subtests are: analogies, similarity, knowledge, understanding relations, and syllogisms. In the first subtest, the subjects were presented with a pair sharing a common relationship and were asked to deduce this relationship and induce it to the second pair. In the second subtest, they were given a list of words that are related in some way and were told to cross the odd word out. In the third subtest, they were presented with lists of jumbled letters representing a name of a country, an animal, a state, an ocean or a city, and were told to order them and infer what the obtained word represented. In the fourth subtest, they were asked to understand the relations given between people or their arrangement and deduce the right conclusion. In the fifth subtest, they were given statements (premises) to read and were instructed to infer the right conclusions from them (c.f. appendix 1).

Concerning the scoring procedure, the score (100) was given to this test and was distributed as the following: Analogies received the highest score (30) as it contained more tasks; Similarity subtest, knowledge subtest and understanding relations subtest were given equal scores (20); and syllogisms subtest was given the lowest score (10) for including few items. An adaptation of will be made to the scoring procedure if unexpected results are found.

5.2.4. Results and discussions

5.2.4.1. Language aptitude pilot test results

We stated earlier that one of the aims of language aptitude pilot test is to evaluate whether the organization of the items was from easiest to most difficult so to keep the same ordering for the final test, or make adaptations when necessary. Arranging the questions in gradual increase of difficulty would allow to create challenge, that is a prerequisite element in cognitive ability testing. If the questions are found too easy or too difficult, the subjects' interest will be on finishing the tasks rather than producing genuine answers. In addition, the correct ordering of the test items would yield accurate scores. One should state that very easy or hard questions will be omitted in the final measure. In checking the gradual difficulty of the test items, the subjects’ answers are converted into percentages and a comparison is made between the percentages. The items indicating high answering percentages will be placed the first, while those showing low percentages will be presented the last. The results are discussed down in the section.

a. Phonemic ability subtest

Five tasks were presented in this subtest. Each task encompassed a number of items. Four items were given in the first task, nine items in the second task, eight items in the third task, eight items in the fourth task, and seven items in the fifth task. The following table exhibits the subjects’ answers in each item of this subtest and their conversion into percentages.

Tasks	**Participants correct answers and their conversion into percentages**								
	Item 1	**Item 2**	**Item 3**	**Item 4**	**Item 5**	**Item 6**	**Item 7**	**Item 8**	**Item 9**
Task 1	12= 52%	11= 47%	23= 100%	13= 56%					
Task 2	19≈ 83%	11≈ 48%	8≈ 35%	23≈ 100%	13≈ 57%	14≈ 61%	15≈ 65%	21≈ 91%	19≈ 83%
Task 3	9≈ 39%	5≈ 22%	7≈ 43%	2≈ 9%	4≈ 17%	00	00	1≈ 4%	
Task 4	6≈ 26%	9≈ 39%	7≈ 30%	7≈ 30%	3≈ 13%	1≈ 4%	2≈ 9%	1≈ 4%	
Task 5	9≈ 39%	11≈ 48%	18≈ 78%	5≈ 22%	18≈ 78%	6≈ 26%	9≈ 39%		

Table 4. Phonemic Ability Task, Correct Answers and Percentages

Discussion

Having observed that the percentages do not reflect a gradual difficulty of the test items, we come to realize that some adaptations must be made for the final language aptitude measure. The items of the first task will be reordered as follows: item 3, item 4, item 1, item 2; in the second task: item 4, item 8, item 1, item 9, item 7, item 6, item 5, item 2, item 3; in the third task: item 3, item 1, item 2, item 5, item 4. The above table shows that items 6, 7, and 8 in the third task revealed that the participants were incapable in transcribing sentences, which has directed to exclude sentence transcription in the final aptitude test. Concerning the fourth task, the items will be reordered as the following: item 2, item 3, item 4, item 1, item 5, item 7, item 6, item 8. The same adaptations are made to the sixth task. The items will be presented as follows: item 3, item 5, item 2, item 1, item 7, item 6, and item 4.

b. Grammatical sensitivity subtest

Three tasks were administered in this subtest. The first and the second tasks incorporated seven items, while the third task involved four items. The results are presented in the following table:

Tasks	**Participants' correct answers and their conversion into percentages**						
	Item 1	**Item 2**	**Item 3**	**Item 4**	**Item 5**	**Item 6**	**Item 7**
Task 1	16≈ 69%	15≈ 65%	12≈ 52%	16≈ 69%	13≈ 56%	16≈ 69%	15≈ 65%
Task 2	19≈ 83%	14≈ 61%	7≈ 30%	7≈ 30%	14≈ 61%	9≈ 39%	4≈ 17%
Task 3	16≈ 69%	16≈ 69%	14≈ 61%	7≈ 30%			

Table 5. Grammatical Sensitivity Subtest, Correct Answers and Percentages

Discussion

Table 5 indicates that some adaptations are also required for the second subtest of language aptitude measure regarding principally the first and the second tasks. The items in the first task will be ordered as follows: item 1 , item 4, item 6, item 2, item 7, item 5, item 3; and in the second task: item 1, item 2, item 5, item 6, item 3, item 4, item 7.

c. Inductive language learning ability subtest

The ordering of the tasks in this subtest will be kept the same for the belief that there is already a gradual increase in difficulty, i.e. starting with the selection of the right translation of words, then the right translation of sentences, then making corresponding translation of sentences. (c.f. Appendix 1)

Time allocation is another prerequisite aspect that should be considered in cognitive testing. Having asked the participants to notify the time spent in each activity, we have observed that the majority identified 50 minutes as the time span. Subsequently, the time span determined for the final aptitude measure will be 60 minutes (adding 10 extra minutes so to give an opportunity for less able participants).

We have also highlighted the importance of the pilot test in assessing the reliability of language aptitude measure before its administration. Assessing the consistency of any measure requires an observation of the test scores. If the scores of the different subtests of the same measure are convergent, then the test is considered reliable (Urbina, 2004). The technique of the Pearson Product Moment Correlation Coefficient has been adopted to examine the strength of association between the scores of the measure. Two types of correlation have been considered: whole-part correlation, or the correlation between language aptitude overall score and the score of its three subtests; and item-item correlation, or the correlation within the different subtests.

The first step we went through in measuring these correlations is converting all the subjects' raw scores in each subtest into percentages so that these scores will be explained according to the same value (i.e. the value 100 becomes the score of perfection for all the subtests). After this, we calculated the Pearson correlation using SPSS software. The results of these correlations are displayed in the following tables. Table 6 exhibits the results of whole-part correlation, and table 7 demonstrates the results of item-item correlation.

	Phonemic ability subtest	**Grammatical sensitivity subtest**	**Inductive language learning subtest**
Whole score	.92	.79	.56

Table 6. Whole-Part Correlation of Language Aptitude Pilot Test

	Phonemic ability subtest	**Grammatical sensitivity subtest**	**Inductive language learning subtest**
Phonemic ability subtest	1		
Grammatical sensitivity subtest	.63	1	
Inductive language learning subtest	.52	.19	1

Table 7. Item-Item Correlation of Language Aptitude Pilot Test

Discussion

The critical value of *r* for one-tailed test at (0.05) level of significance and with 22 degrees of freedom (i.e. the number of the participants involved in aptitude pilot test are 23)is (.34). As the obtained value for the correlation between language aptitude overall score and the score of each subtest is more than the critical value (.92, .79, .56), and the score of its two subtests (phonemic ability and grammatical sensitivity) is also higher than the required r (.63, .52), we would say that the results are, for most of them, very significant. One subtest (inductive language learning subtest) is not proved to have a significant correlation with grammatical sensitivity subtest (r= .19). We might attribute this to the small number of tasks that were administered. This has urged us to decide on additional tasks to enhance the reliability of aptitude final measure.

6. Adapting questions

In addition to helping determine the time allocation for the final aptitude measure, assessing its reliability, and reordering the questions in increasing difficulty, the pilot test works also as a useful aid in making some adaptations to the final test like a re-explication of some questions, addition of other items, adjusting the scoring procedure, to include but a few. Concerning the adaptation of questions, the students' findings of this trial indicate that the participants struggled with some items for their non-comprehension of the instructions. For example, in the first subtest (item 5) in the instruction "here is a list of words spelled approximately as they are pronounced, choose those which have a similar meaning to the given words" (Appendix 1), a re-explanation will be made through adding the expression "the pronunciation is not wrong but misses some other sounds" (Appendix 2) since the subjects thought that the pronunciation was wrong and went to select undesired responses. As for the omission of some items, the subjects' answers revealed their failure in recognizing the transcription of sentences which urged us to exclude this item from the final test. The addition of some items is primarily concerned with inductive language learning ability subtest. More items will be added for two main reasons: first, the participants' scores were found either very high or very low; and second, this subtest showed a non-significant correlation with the second aptitude subtest (grammatical sensitivity subtest: .19). Similarly, a whole task will also be added to phonemic ability subtest. This task is called a listening task. Listening ability, or as referred to as auditory ability (Skehan, 1998), is strongly believed to be an aspect of language aptitude (c.f. chapter 2.2.1). All the aforementioned adaptations require adaptations in the scoring procedure as well. Although the same score of perfection will remain the same (100) for the final aptitude measure, its distribution on the different subtests will vary. For example, phonemic ability subtest will be given the score 60 as a task of listening will be involved, and as this subtest indicated the closest association with the overall aptitude score (.92); grammatical sensitivity and inductive language learning ability will receive equal scores (20) since both of them assess knowledge of the grammatical structures and functions of the foreign language.

5.2.4.2. Working memory pilot test results

Similar to the previous pilot test, the rationale behind the administration of working memory pilot measure is twofold: deciding on the time allocation and assessing the reliability of this measure. As mentioned above, time allocation is indispensable in cognitive testing, and particularly in working memory testing, when the millisecond might affect the scores. Besides, reliability is an essential aspect that allows for the administration of any measure.

As far as assessing the reliability of WM pilot test is concerned, the same statistical technique used in language aptitude is adopted. Here again, two types of correlation are considered: whole-part correlation and item-item correlation. After the use of SPSS software, these are the results exhibited in the following tables.

	RSPAN	**OSPAN**	**Anagrams**
Whole score	.76	.83	.77

Table 8. Whole-Part Correlation of Working Memory Pilot Test

	RSPAN	OSPAN	Anagrams
RSPAN	1		
OSPAN	.55	1	
Anagrams	.40	.39	1

Table 9. Item-Item Correlation of Working Memory Pilot Test

Discussion

The critical value of r for one tailed test with (0.05) level of significance with 26 degrees of freedom (i.e. 27 participants were involved in working memory pilot test) is (.31). As the obtained value of both correlations: whole-part and item-item correlation is higher than the critical value (.76, .83, .77, .55, .40, and .39), we would conclude that this trial is considered reliable and will, hence, be considered in measuring the second variable that is working memory.

Concerning time allocation, the high observed scores from the part of the subjects in working memory trial are attributed to either giving more exposure time or focusing on recall rather than manipulation of information (e.g. reading, solving mental operations). Therefore, we have decided to decrease the time of exposure on the one hand, and tell the participants that both processes will be scored. The time span for the final WM measure will be 60 minutes instead of 90 minutes.

As a further adaptation, we have decided to add a fourth subtest –listening span or LSPAN- in order to measure another aspect of working memory capacity that is auditory WMC. This will be done since all the three tasks (RSPAN, OSPAN and anagrams) measure the visual-verbal WMC. Adding a whole subtest and reducing the exposure time necessitates the reducing the number of items used in each task. The items that will be kept for RSPAN subtest will, thus, be fifteen and for OSPAN eleven.

5.2.4.3. Verbal reasoning pilot test results

The results of verbal reasoning pilot test were also helpful basically in rearranging the test items from easiest to most cognitively demanding, deciding on the time allocation, as well as assessing the reliability of the measure. The same procedure was followed with regard to the arrangement of the test items. The subjects obtained scores were converted into percentages and a decision of placing the questions was made according to these percentages. Tables 10, 11, 12, 13, and 14 display the participants' correct answers and their corresponding percentages in the five subtests.

Items	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Correct answers+ percentages	21 = 70%	15= 50%	5≈ 17%	16≈ 53%	3≈ 10%	9≈ 30%	4≈ 13%	21= 70%	8≈ 27%	13≈ 43%	5≈ 17%

Table 10. Analogies Subtest, Correct Answers and Percentages

Discussion

In this subtest, eleven items were presented and only nine of them will be kept for the final verbal reasoning measure. Since analogical reasoning is believed to be an aspect of reasoning and, hence, intelligence, the questions should be carefully ordered in increasing difficulty. Easy questions were given low scores for the fact that they were directed to all the subjects including less able ones, while difficult items received high scores for being restricted to more able individuals. Having observed the participants' answers in the above table and made a comparison of the percentages, we decide to choose item 1, item 8, and item 4 as the three first tasks devoting low scores to each of them; item 2, item 10, and item 6 as the three second tasks giving them average scores; and item 11, item7, and item 5 as the three last tasks keeping high scores for each item. Item 3 and item 9 will be omitted for demonstrating close percentages. The final order of the kept items will be as follows: item 1, item 8, item 4, item 2, item 10, item 6, item11, item 7, and item 5.

As far as the second subtest is concerned, the same procedure will be followed in arranging the tasks from least to most difficult. The following table presented the subjects correct answers and their conversion into percentages.

Items	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Correct answers+ percentages	28≈ 94%	9≈ 30%	10≈ 34%	17≈ 57%	16≈ 54%	7≈ 23%	15≈ 50%	7≈ 23%	22≈ 73%	20≈ 70%

Table 11. Similarity Subtest, Correct Answers and Percentages

Discussion

Similarity subtest in verbal reasoning pilot test involved ten items; however, only six items will be kept for the final measure. Like analogies subtest, the same procedure was followed: the two first items will be considered the easiest and will be given low scores; the second two items will show average ability level and will be given average scores; and the two last items will be directed to more able individuals and will be given high scores. After the comparison of correct answering percentages in table 11 we decided to keep the following items in this order: item 1, item 9, item 5, item 7, item 6, item 8.

Regarding the third subtest, our intention is to present six tasks to measure the aspect of knowledge. Only five tasks were presented. This means that one extra task should be added. The tasks will be rearranged according to the answering percentages. These latter ones are presented in the following table.

Items	**1**	**2**	**3**	**4**	**5**
Correct answers+ percentages	20≈ 67%	16≈ 54%	19≈ 63%	10≈ 33%	13≈ 43%

Table 12. Knowledge Subtest, Correct Answers and Percentages

Discussion

Table 12 demonstrates close answering percentages, something which should be avoided in cognitive testing. For this reason, we decided to add two extra tasks: one substituting an already presented task and a sixth task. The items to be kept for this subtest are in the following order: items 1and 3 will be presented the first and will be considered as the easiest, items 2 and 4 will be given the second and will be given average scores. The addition of the two last tasks necessitates from us making another pilot test. A list of extra jumbled letters was also presented and the subjects answering percentages were compared. The two items showing the least percentages were kept for the final verbal reasoning measure.

In the fourth subtest, that is understanding relations subtest, six items were presented. The ordering of these items was done according to the participants answers. The following table displays these answers and their conversion into percentages.

Items	**1**	**2**	**3**	**4**	**5**	**6**
Correct answers+ percentages	14≈ 47%	19≈ 63%	14≈ 47%	13≈ 43%	11≈ 37%	4≈ 13%

Table 13. Understanding Relations, Correct Answers and Percentages

The table indicates that some adaptations should be made to the ordering of the items. Items 2 and 1 will be selected as the two initial tasks and will be given low scores, items 3 and 4 will be given the second and will be given average scores, and items 5 and six will be given the last and will be given high scores.

The items in the last subtest (syllogisms), as well, need an evaluation in terms of their order of difficulty. The same procedure is followed to assess the arrangement of these items. The following table exhibits the participants' answers and conversion into percentages.

Items	**1**	**2**	**3**	**4**	**5**	**6**
Correct answers+ percentages	21= 70%	19≈ 63%	8≈ 27%	5≈ 17%	11≈ 37%	13≈ 43%

Table 14. Syllogisms, Correct Answers and Percentages

Four out of six items will be kept for the final syllogisms subtest. The order of these items will be the following: item 1, 2, 3, 4. Item 5 and item 6 will be omitted as they demonstrate close percentages.

An observation of the aforementioned tables does not only inform us about the ordering of the tasks from easiest to most difficult, but gives us insights in ordering the subtests according to their level of difficulty as well. This latter is also a crucial aspect in cognitive testing for creating interest and challenge. The arrangement of the subtests was done through comparing the subjects overall correct answering percentages in each subtest. After a comparison of the above tables, we decided to place knowledge subtest the first in the battery of verbal reasoning for presenting (52%) as the mean of correct answers; Similarity subtest will be placed the second for showing (50%) as the mean; Syllogisms will be presented the third (≈43%); understanding relations will be given the fourth (≈42%); and analogies will be given the last for receiving the lowest overall percentage (≈31%).

Time allocation is another prerequisite aspect in intelligence testing. Similar to the previous pilot test, the subjects were instructed to notify the time spent in accomplishing all tasks. Forty minutes were identified as an average time. Therefore, 45 minutes will be given as the time span of verbal reasoning measure (adding 5 extra minutes to give the chance for less able individuals).

Concerning the assessment of the reliability of verbal reasoning measure, the Pearson correlation was used between the score of the whole test and the scores of its subtests (i.e. whole-part correlation), as well as the between the five subtests (item-item correlation). After the use of SPSS software to calculate these correlations, the results of (r) are exhibited in the following tables.

	Analogies	**Similarity**	**Knowledge**	**Relations**	**Syllogisms**
Whole score	R= .68	R= .54	R= .55	R= .72	R= .31

Table 15. Verbal Reasoning Pilot Test, Whole-Part Correlation

	Analogies	**Similarity**	**Knowledge**	**Relations**	**Syllogisms**
Analogies	1				
Similarity	.38	1			
Knowledge	.22	.04	1		
Relations	.41	.18	.20	1	
Syllogisms	.11	.16	.26	.08	1

Table 16. Verbal Reasoning Pilot Test, Item-Item Correlation

Discussion

The critical value of r for one tailed test with 29 degrees of freedom (i.e. 30 participants were involved in verbal reasoning pilot test) is (.29). Whole-part correlation results indicate that almost all the subtests are significantly related with the whole score (.68, .54, .55, .72, .31), while syllogisms subtest is just significant (for sharing one significant correlation with knowledge subtest: .26). However, the majority of item-item correlation results are not significant (e.g. .22, .11, .04, .18, .16, .20, .08). The items that will be added to and omitted from the pilot study are predicted to change the results of these correlations.

Conclusion

In this chapter we have provided a reconsideration of the research methodology as well as the three cognitive linguistic pilot tests (language aptitude pilot test, working memory pilot test, and verbal reasoning pilot test) analysis. In the research methodology, the purpose of the study was restated, the hypotheses were highlighted, and data collection and data analysis were discussed. The hypotheses at the level of pilot tests were confirmed (i.e. the questions were found challenging, which would go with the nature of intelligence tests), which will lead to move with some assurance to the main study. Two major hypotheses (one addressing the relationship between the aforementioned cognitive linguistic skills, and the other tackling the association between a general cognitive linguistic ability that is labelled as 'Linguistic intelligence' and language learning achievement) were made and will be investigated in the coming chapter (c.f. chapter seven). Since language aptitude, working memory capacity and verbal reasoning ability are the focal points in the present study, a thorough description of the tests that attempt to measure them was provided in this chapter. A pilot test for measuring each of these abilities was highly recommended and subsequently highlighted in this chapter.

The subjects obtained results in language aptitude measure, working memory measure and verbal reasoning measure and their interpretations will be dealt with in chapter six. The investigation of the final components of Linguistic intelligence and the testing of the research hypotheses will be considered in chapter seven.

Chapter Six

Results of Language Aptitude Measure, Working Memory Measure and Verbal Reasoning Measure

Results of Language Aptitude Measure, Working Memory Measure and Verbal Reasoning Measure

Introduction

The prediction of a common existing relationship between the three hypothesized cognitive linguistic capacities (i.e. language aptitude, working memory and verbal reasoning) requires knowledge of the obtained scores in their measures. The chapter is devoted to the analysis of the findings of these measures. Some aspects germane to descriptive and inferential statistics are further discussed. Concerning descriptive statistics, the chapter provides analysis of the distribution of the scores in each test. Inferential statistics is addressed through an interpretation of the tests scores as well as assessing the reliability of the measures.

6.1. Language aptitude test findings

Language aptitude measure incorporated three subtests assessing phonemic ability, grammatical sensitivity and inductive language learning ability, respectively. The findings of these subtests are discussed further below.

a. Phonemic ability subtest

The subjects' phonemic ability is measured by six tasks. The first task involves four items that assess the subjects' capacity to discriminate between FL sounds (e.g. the distinction between final'sʼ and final 'ed' sounds). The second task contains nine items measuring the capacity to associate between sounds and symbols through the choice of the right spelling (the presented words were: 'abduction', 'heavy', 'analysis', 'daughter's', 'handkerchief', 'conscientious', 'receive', 'apparent', 'revision', 'inconvenience'). Five items are incorporated into the third task for further assessment of sound-symbol association: each item represents a transcription of a word (e.g. /ˈbʌt.ə.flaɪ/). Eight items are presented in the fourth task, each presenting a pseudo-word[19] (e.g. pote, nool, suspex, etc.), and the role of the participants is to produce corresponding transcription. The fifth task encompasses seven items: each holding a disguised word[20] (e.g. klen, restrnt, grbj, etc.), and the subjects' job is to deduce the target word and then to choose a word from the list that is closest in meaning to it. In the last task, five sentences are presented for listening, and the testees must state what they can remember from each sentence (c.f. appendix 2). The participants' correct answers are displayed in the following table:

	Item 1	**Item 2**	**Item3**	**Item4**	**Item5**	**Item6**	**Item7**	**Item8**	**Item9**	**Mean of correct answers**
Task 1	59= 85.5 %	46= 66.66 %	37= 53.62 %	28= 40.57 %						M= 61.58 %
Task 2	61= 88.40%	57= 82.60 %	52= 75.36 %	53= 76.81 %	28= 40.57 %	42= 60.86 %	36= 52.17 %	14= 20.28 %	38= 55.07 %	M= 61.34%
Task 3	19= 27.53%	27= 39.13 %	24= 34.78 %	13= 18.84 %	06= 08.69 %					M= 25.79%
Task 4	19= 27.53%	43= 62.31 %	18= 26,08 %	25= 36.23 %	19= 27.53 %	2= 2.89%	02= 2.89%	02= 2.89%		M= 23.54%
Task 5	53= 76.81%	51= 73.91 %	20= 28.98 %	40= 57.97 %	13= 18.84 %	33= 47.82 %	21= 30.43 %			M= 47.82%

Table 17. Phonemic Ability Subtest, the Participants Correct Answers + Percentages

[19] C.f. chapter 3.2.2.1
[20] A word with some missing sounds

	0-6.5 pts 0-25% of correct answer	7-13 pts 25-50% of correct answers	14-20 pts 50-75% of correct answers	21-26 pts 75-100%
Number of subjects+ percentage	12= 17.39%	28= 40.57%	24= 34.78%	05= 07.24%

Table 18. Phonemic Ability Subtest, the Participants Answers in Task 6

Discussion

The findings of the above tables (table 17 and 18) indicate a variance in the variety of tasks in phonemic ability subtest. The percentages in the first and second tasks indicate above average ability (M= 61.58%; 61.34%); in the third and fourth tasks they reveal below average capacity (M= 25.79%, 23.54%); and in the fifth task they illustrate approximately average ability (M= 47.82%).

As far as the first task is concerned, the highest percentage of correct answers that is shown in item 1 (85.5%) indicate that the majority can discriminate between the sounds /ɔ:/ and /ʌ/ (e.g. 'ought' vs. 'cough'), whilst the lowest percentage (40.57%) that is associated with item 4 reveal apparent individual differences in distinguishing between the different pronunciations of the final's' (e.g. neighbours, blackboards, bridges, accessions).

Similar to the first task, variance is also apparent in the second task. The high percentages shown in the first four items demonstrate the subjects' facility to recognize the perceived words (e.g. abduction: 88.40%; heavy: 82.60%; analysis: 75.36%; daughter's: 76.81%). This means that the words were familiar to the subjects. On the other hand, the low percentages shown in item 8 reveal that the word 'apparent' was not easily recognized. The participants' answers were directed to the word 'appearent' instead, which might be attributed to the influence of the verb 'to appear'.

In the third task, differences are also evident with regard to word-length transcription. Mono or disyllabic words (e.g. strength; picture) represent high answering percentage (34.78%: 39.13%) in comparison to polysyllabic ones (e.g. butterfly; watermelon). Besides, the task is a further illustration of individual differences in language proficiency. This means that even though the participants are proved aware of the right pronunciation, they fail to give the right spelling (e.g. strenth and pickchure instead of strength and picture, respectively).

Similarly, the fourth task demonstrates a variation in recognizing the different sounds of the foreign language. Some mono-syllabic pseudo-words (e.g. 'nool') show higher answering percentage (62.31%) in comparison to poly-syllabic counterparts (e.g. 'overcrouhced': 2.89%). One additional aspect is worth to discuss in this task. In transcribing the pseudo-words, some subjects were interested more on the way they are spelled than their pronunciation. For example, instead of giving a word with the sound (/eɪ/) for the pseudo-word 'und**a**ses' (e.g. faces), they considered the final 's' and came up with the word 'gl**a**sses' which has a different sound (/ɑː/). Likewise, they confused between the sound /ɒ/ and the diphthong /əʊ/ when they gave 'got', 'not' and 'hot' for the pseudo-word 'pote'. They also confused between the sounds /uː/and /ʊ/ when they answered 'good' for the pseudo-word 'nool'. Nor could they distinguish between the diphthongs /aʊ/ and /əʊ/ when they answered 'approached' for the pseudo-word 'overcrouched'.

Regarding the fifth task, variance is as well patent, particularly in adherence to sound-symbol association. The data in the table 17 indicate that some words are easily recognized (e.g. 'klen', 'restrnt'), while others are proved difficult (e.g. 'grbj', 'kloz'). This might be attributed to the subjects familiarly or unfamiliarity with the given words. Another worthwhile observation is that some participants were more concerned with choosing words with similar sounds than words with similar meanings (e.g. ‘clothes’ for ‘Kloz’; ‘garage’ for ‘grbj’), which might be a sign of their inability to understand the instruction.

Last but not least, the subjects listening ability in the sixth task is divided into four quartiles: mediocre (0%- 25% of recalled words), average (25% -50%), above average (50%- 75%), and superior (75%-100%). Table 18 demonstrates that approximately the majority of the participants listening proficiency ranges from average to above average (i.e. between 50 % and 75% of the perceived words). The table shows also that few participants have difficulty in listening (only 25% of the overall given words), while very few display superior proficiency (75-100% of recalling the words). In addition to assessing listening ability in the foreign language, this task measures semantic memory, i.e. memory for words, as well. Listening and memory are observed to go together. The task informs us that those who can listen well, i.e. those with high attention capacity, are able to retain more information and subsequently recall more words.

b. Grammatical sensitivity subtest

The second subtest of language aptitude measure encompassed three tasks that assessed the subjects’ sensitivity to different functions of the foreign language. The first task involved seven items: each item holding a grammatical function (e.g. verb, conjunction, preposition, etc.). The second task incorporated seven items that contained more functions (e.g. tenses, word order in the interrogative mood, conditional, relative pronouns, etc.). The third task included four items: each item held a mistake in the use of some grammatical functions (e.g. present perfect simple form, model, indirect object, etc.) (c.f. appendix 2). The findings of this task are exhibited in the following table:

	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Mean of correct answers
Task 1	50= 72.46 %	39= 56.52%	48= 69.56%	47= 68.11%	49= 71.01%	38= 55.07%	30= 43.47%	62.61%
Task 2	54= 78.26 %	59= 85.50%	52= 75.36%	32= 46.37%	17= 24.63%	36= 52.17%	35= 50.72%	59%
Task 3	52= 75.36 %	57= 82.60%	57= 82.60%	24= 34.78%				68.83%

Table 19. Grammatical Sensitivity Subtest, Correct Answers+ Percentages

Discussion

The data in the above table indicate that that the subjects' performance in the grammatical sensitivity subset tends to be better than phonemic ability subtest. Likewise, the participants answers reveal that some grammatical functions are easily recognized by the majority (e.g. verb: 72.46%, past tense: 78.26%, interrogative: 85.50%, Preposition + gerund: 75.36%, Auxiliary 'to be'+ PP: 75.36%, model+ infinitive without 'to': 82.60%, and verb+ indirect object: 82.60%), whereas others receive very low answering percentage (e.g. he auxiliary 'to be' +PP: 24.63%).

c. Inductive language learning ability subtest

This subtest was administered to measure the subjects' sensitivity to foreign language structures. Four tasks were presented. In the first task, the subjects translated a set of English words into the foreign language (i.e. artificial language) from a comparison of the translation of a set of English sentences into that language. In the second task, they selected the foreign sentence that best translated the English sentence through a comparison of the translation of individual words. In the third task, they translated the English sentence into the foreign language from the translation of individual words. And in the fourth task, they translated the foreign sentence into English from a comparison of the translation of given sentences. (c.f. appendix 2). The findings of this subtest are displayed in the following table:

Tasks	**The students answers + percentages**					
	Unanswered	**Wrong**	**25% correct**	**50% correct**	**75% correct**	**100% correct**
Task 1	12= 17.39%	21= 30.43%	20= 28%	5= 7.24%	15.94%	/
Task 2	8=11.59%	39=56.52%	/	/	/	22= 31.88%
Task 3	9=13.04%	3=4.34%	10=14.49%	/	18=26.08%	29=42.02%
Task 4	14=20.28%	3=4.34%	6=8.69%	21=30.43%	19=27.53%	6=8.69%

Table 20. Inductive Language Learning Ability Subtest, Correct Answering Percentages

Discussion

The findings of table 20 reveal that the subjects' performance in inductive language learning ability subtest is inferior to the two previous subtests. This capacity is observed to range from weak (≈8%) to average (≈42%). The subjects' answers inform us that some participants (≈31%; 42%) could better translate from English to the foreign language than vice versa. We would attribute this to the familiarity with English. The data in the above table reveal also that the translation of sentences (i.e. tasks 2, 3, and 4) received higher answering percentage than the translation of individual words (i.e. task 1).

6.2. Working memory test findings

The second cognitive linguistic measure incorporates four distinct subtests: RSPAN, OSPAN, Anagrams and LSPAN. The findings of each subtest are discussed further in the section.

a. RSPAN results

Fifteen tasks were presented in this subtest, each task involved a set of sentences (2 to 8) to read and elements to recall. In the first task, which is considered the easiest, only two items were presented for recall. In the second task, three items; in the third and the fourth, four items were presented; in the fifth, sixth and seventh, five items were given; in the eighth and ninth, six items were presented; in the tenth, eleventh and twelfth, seven items were given; and in the thirteenth, fourteenth and fifteenth eight items were given. (c.f. appendix 2)

The subjects were instructed to read the sentences and focus attention on the element that appeared on the screen. Recall started immediately when the information shown in the data-show disappeared. The subjects span in the fifteen tasks is displayed in the following table. The columns related to each span represent the number of the participants with this span. The last vertical columns exhibit the total number of the participants for each span.

RSPAN tasks	Number of subjects								
	Span 0	**Span 1**	**Span 2**	**Span 3**	**Span 4**	**Span 5**	**Span 6**	**Span 7**	**Span 8**
Task 1	02	/	68						
Task 2	01	/	/	69					
Task 3	01	/	/	04	65				
Task 4	01	05	08	27	29				
Task 5	01	01	/	/	03	65			
Task 6	01	07	09	18	25	10			
Task 7	01	02	11	20	17	18			
Task 8	01	/	/	/	/	16	53		
Task 9	01	01	/	06	08	25	29		
Task 10	01	/	/	01	01	03	21	43	
Task 11	01	04	13	19	22	02	05	17	
Task 12	01	/	02	06	18	22	14	7	
Task 13	/	01	/	/	02	02	07	27	31
Task 14	01	/	/	02	04	05	24	17	17
Task 15	/	01	/	03	10	17	25	08	06
∑	∑= 14	∑= 22	∑=121	∑=175	∑=204	∑=185	∑=178	∑=119	∑=54

Table 21. Working Memory Capacity in RSPAN

Discussion

The data in table 21 demonstrate individual differences in working memory capacity in the fifteen RSPAN items. This capacity is observed to range between span 3 (∑=175) and span 6 (∑= 178). The highest number of the examinees are noticed to reside in span 4 (∑= 204). One would, subsequently, estimate a working memory capacity of $4(\pm 2)$ in RSPAN. The findings of this subtest support Cowan's view of WMC $4(\pm 1)$; they rather add an element to his capacity (4 ± 2).

Besides, some subjects are observed to have a very low WMC (e.g. span 1), while others are noticed to own a very high WMC (e.g. span 8). This could be explained by the fact that the subjects focused on only one of the two working memory processes: either recall or manipulation of information. Those who are found with a low span are assumed to focus on reading rather than storing the perceived stimuli, whereas those who are found with a very high capacity are assumed to direct more attention to recall.

Another worth mentioning issue with adherence to RSPAN subset is that letters and numbers (e.g. task 5, task 8, task 10, and task 13) are better recalled than words (e.g. task 7, task 09, and task 11). Regarding the recall of words, the participants' proficiency with the language is also noticed to have an influence. In other words, the items presented for recall in simple sentences (e.g. the candles started the fire. **House,** in task 3**)** are better recalled than the ones presented in complex sentences (e.g. It was the ocean that swallowed up the **boat, in** task 4**).**

Due to the fact that the primary objective of working memory measure was to assess WMC in the foreign language, the participants' language proficiency was quite emphasized. The subjects' lack of knowledge of some English words resulted in producing incorrect recall (e.g. 'hous' instead of 'house'; 'dul' instead of 'doll'; 'switt' instead of 'sweet'; 'fatched', 'fitched' or 'fetshed' instead of 'fetched', to name but a few), which subsequently affected their WMC. One should also mention that producing incorrect recall is not only due to lack of proficiency but might be attributed to activating less attention processes than required as well.

Primacy and recency effects are prerequisite aspects that should be dealt with in the analysis of working memory. Sometimes, the elements which appear early in the series of sentences, i.e. usually the first and the second element, are observed to be better recalled that the other items; and sometimes the items that appear at the end, i.e. usually the ultimate and penultimate items, are noticed to better retrieved. We would, hence, come up to say that first and last items are intended to be better recalled than items appearing in the middle. These findings add evidence to past research findings on primacy and recency effects that have been quite discussed within the phonological loop component (c.f. chapter 3.2.2.1.a).

Word-length effect is another worth discussing issue in the analysis of working memory. Researchers in the realm of cognitive psychology (c.f. chapter 3.2.2) speculate that short words are better recalled than long words, and that these latter ones require more attention, longer time to perceive, and are more exposed to decay. This study illustrates how words like ‘bird’, ‘doll’, ‘girl’, ‘try’, ‘key’ are better recalled that words like ‘investigation’, ‘delighted’, ‘surgery’. In addition, the study demonstrates stimulus-length effect. The recall appears better when processing short data, i.e. when reading words, phrases, or small sentences (c.f. task 5, task 8, task 10) than when being exposed to long stimuli, i.e. long sentences (c.f. task 6, task 7, task 9, task 14).

In addition to primacy and recency effects and word-length effect, interference is a further prominent aspect in the analysis of WM. Attention can be disrupted either by recently perceived stimuli, i. e. proactive interference, or by information stored in LTM, i.e. retroactive interference. The current WM measure illustrates both types of interference: proactive and retroactive. The subjects’ executive attention is observed to be distracted by recently perceived and recalled words. For example the word ‘fire’ which was recalled in task 3 was also recalled in task 4 although it was not mentioned. Similarly, attention is noticed to be interrupted by processing information, i.e. some words which appear in the to-be-read sentences like ‘movie’, in task 3, ‘prince’, in task 4, and ‘ship’, in task 9 are written among the recalled words. The influence of previously learned words (i.e.

retroactive interference) is also apparent in this task. For example, words like ‘TV’ and ‘woman’ have replaced respectively ‘television’ and ‘girl’. Another instance of retroactive interference is replacing the to-be-recalled words with other previously learned words having approximately similar spelling, e.g. ‘ghost’, ‘goast’ are given instead of ‘coast’; ‘boat’ and ‘born’ are given instead of ‘bone’; ‘bride’ is given instead of ‘bird’; ‘word’ is given instead of ‘world’; ‘door’ is given instead of ‘dog’; ‘bill’ is given instead of ‘bell’, ‘type’ and ‘top’ are given instead of ‘tape’. Likewise, the influence of some French words is another example of retroactive interference, e.g. ‘entre’ instead of ‘enter’ and ‘chambre’ instead of ‘chamber’.

b. Operation span tasks results

Similar to the previous task, the subjects in this subtest were exposed to a number of mental operations to perform with an element (i.e. a letter, number, or a word) to recall. Eleven mathematical equations were presented with an increase in memory span (1to 7). The first task incorporated the span 2, the second task the span 3, the third and the fourth the span 4, the fifth and the sixth the span 5, the seventh, eighth and ninth the span 6, and the last two tasks the span 7. The participants were instructed to judge the accuracy of the results that were shown on the data-show or perform the given operations, and then they were told to recall the items which appeared next to each operation or to retain the obtained results in their order. The mental operations varied between addition, subtraction, multiplication, and division (c.f. appendix 2). We have previously mentioned that the objective of working memory measure was to assess working memory capacity in the foreign language. The choice was, thus, based on simple and manageable mental operations. It is worth to state that despite the subjects were given two tasks (calculating the operations or judging their accuracy and recalling the perceived elements), the score was devoted to recall process. The first task was used as a means to disrupt the participants' attention so to clearly reveal their real capacities. The findings of this task are displayed in the following table. Each column presents the number of participants in each span.

OSPAN tasks	Number of subjects							
	Span 0	Span 1	Span 2	Span 3	Span 4	Span 5	Span 6	Span 7
Task 1	04	23	43					
Task 2	15	08	24	23				
Task 3	09	07	12	26	16			
Task 4	03	01	20	30	16			
Task 5	04	09	13	24	09	11		
Task 6	04	11	26	15	13	1		
Task 7	03	03	06	16	19	15	08	
Task 8	05	02	04	12	17	17	13	
Task 9	04	10	14	20	14	09	04	
Task 10	03	01	06	17	16	15	08	04
Task 11	07	09	17	20	09	03	04	01
∑	∑= 61	∑= 84	∑= 185	∑= 203	∑= 129	∑= 71	∑= 37	∑= 05

Table 22. Working Memory Capacity in OSPAN

Discussion

The observation of table 22 above indicates a decrease in working memory capacity (WMC) in OSPAN in comparison to RSPAN. While in the previous task WMC ranged between span 4 (∑=201) and span 7 (∑=107), in this task it ranged between span 2 (∑= 185) and span 4 (∑= 129). The majority of the subjects' working memory ability seems to reside in span 3 (∑= 203). Therefore, WMC in OSPAN is 3 (± 1). This deterioration would be attributed to activating higher attention processes. In other words, judging the mathematical operations require higher attention than reading in the previous subtest.

Likewise, this subtest illustrates focusing on a single rather than both memory processes. Some subjects were noticed to direct attention to performing the operations, while some others put emphasis on recall. We assume that the subjects with low span (span 0 to span 2) put more focus on performing the mathematical operations, while those with high span (span 6 and span 7) were more interested in recall. To illustrate the recall over manipulation of information process, the subjects gave the operations as they appeared on the data-show (e.g. task 3; 5; 7) without calculating them. One more example of activating less attention is not respecting the order of the to-be recalled items. This emerges mainly when more load was demanded from WM (e.g. task 4 to task 11).

Another issue is worth to highlight in this subtest. The tasks that involved the calculation of the mental operations and the recall of the obtained results are noticed to receive better recall than those assembling between judging the operations and recalling separate items (e.g. task 6, task 9, and task 11). In addition, it is observed that short data, i.e. letters and numbers (e.g. task 3, task 5, task 7, and task 8), are better recalled than long data, i.e. words (e.g. task 4, task 6, task 9, and task 11). This subtest, therefore, provides further evidence on the influence of long stimuli on executive attention and causing decay.

One should also indicate that the columns illustrating low memory span (span 0, span 1, and span 2) do not necessarily reflect the participants' inability to recall the items. They might illustrate their lack of proficiency in the foreign language. The misspelled words are not considered a span, which had a negative influence on the individuals' proficiency and hence their working memory capacity. Examples of the misspelled words are 'thoumb', ‘thumbs’, ‘thumbed’, and ‘thumber’ instead of ‘thumb’; ‘birn’ and ‘bride’ instead of ‘bird’; ‘folk’ and ‘forke’ instead of ‘fork’.

Primacy and recency effects are also quite apparent in this subtest. Unlike the previous subtest when they emerged in span 4, in this task they started to appear right from span 2. This is another illustration of the high required attention. Sometimes the first items, mainly the first and the second, are better recalled and sometimes the last items, particularly the ultimate and penultimate items, are better retrieved.

Moreover, interference is quite noticeable in this subtest. The subjects’ recall is observed to be affected by items perceived previously in the same task or in the previous tasks (proactive interference) or even by information stored in LTM (retroactive interference). An example of proactive interference is including the word ‘stone’, which appeared in task 6, in the to-be-recalled items in task 9. Another example of proactive interference is associating the words ‘cage’ and bird’ which were recalled earlier (task 6), and coming up with the word ‘bridge’ in the recall list (task 9). Retroactive interference is illustrated by including words that exist in LTM and that share phonetic similarity (e.g. ‘die’ instead of ‘pie’; ‘cube’ instead of ‘tube’) or semantic similarity (e.g. adding the word ‘milk’ to ‘meal’ and ‘cheese’ in task 9).

c. Anagrams subtest results

Similar to the two previous subtests, anagrams sub-measure required the activation of the same working memory processes, viz. manipulation of information and recall. The participants had to recall the jumbled letters (anagrams) that appeared on the data-show and then they induced as many meaningful words as they were able to. The given anagrams were ordered in increasing length (i.e. the number of letters they contain).

Memory load gradually increased (from three to nine letters, Millers view 7±2). The first two anagrams contained three letters; the third and the fourth anagrams encompassed four letters; the fifth involved five letters; the sixth included eight letters; the seventh, the eighth and the ninth incorporated seven letters; and the last contained nine letters (c.f. appendix 2). The following table exhibits the results of this subtest.

	Number of participants									
Anagrams	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Right answers	68= 97.14 %	68= 97.14 %	62= 88.57 %	47= 67.14 %	36= 51.42 %	27= 38.57 %	16= 22.85 %	01= 1.42%	17= 24.28 %	10= 14.28 %
Wrong answers	02= 2.85 %	02= 2.85%	08= 11.42 %	23= 32.85 %	34= 48.57 %	43= 61.42 %	54= 77.14 %	69= 98.57 %	53= 75.71 %	60= 85.71 %

Table 23. Working Memory Capacity in Anagrams

Discussion

The observation of the aforementioned table indicates that interruption in the whole process of WM starts to appear when the anagrams exceed four letters. Disruption in recall emerges when more memory load was required. It is noticed that the subjects were unable to focus on both recall and process abilities: they either recalled the jumbled letters as they appeared, or they omitted, added or altered some letters when they made meaningful words (e.g. omission: ‘chiken’ instead of ‘chicken’; addition: ‘kitchen’ instead of ‘chicken’; alteration: ‘paradice’ instead of ‘paradise’).

In addition to measuring working memory capacity, the task of anagrams illustrates individual differences in language proficiency. While it was difficult for some to make a single meaningful word (e.g. ‘earl’, instead of ‘real’; ‘nowpr’, ‘nomber’ ‘robenow’, ‘borne’, ‘bower’ instead of ‘brown’), others were able to induce a variety (e.g. ‘palm’ and ‘lamp’ for the anagram ‘PAML’; ‘bedroom’ and ‘boredom’ for the anagram ‘OMDEROB’).

Interference is also worth to discuss in this task. The influence of French (i.e. retroactive interference) affects the making of meaningful words. For example, some letters were altered like the word ‘Nombre’ instead of ‘Brown’, and some were omitted like ‘paradis’ (e) instead of ‘paradise’.

All the aforementioned observations could be attributed to the inability to activate a set of working memory processes, viz. the phonological loop, the central executive and the episodic buffer. Inability in activating the phonological loop is illustrated through the participants’ failure in remembering all the perceived letters in their order of presentation, for instance adding some letters or making some alterations. Incapacity in activating the central executive is illustrated through recalling the letters as they appeared on the data-show without making meaningful words out of them. Failure in activating the episodic buffer is producing incorrect words instead of the required ones (e.g. ‘laboratory’ instead of ‘butterfly’; ‘verage’ instead of ‘average’).

d. Listening span tasks results

LSPAN is the fourth administered subtest in working memory measure. As has been previously mentioned, it is used to assess chiefly auditory working memory capacity. Two processes were also highlighted in the listening tasks: one is judging the semantic accuracy of the perceived sentences; and the other is recalling the last word of each sentence. Judging the semantic accuracy required knowledge of the vocabulary and the grammar of the foreign language. Concerning grammar, sometimes the subject of the sentence or the doer of the action functioned as its object (i.e. it becomes the receiver of the action), and in this case the subjects were told to answer ‘bad’ (e.g. it was the man that pleased the **tie)**, but if there was no subject-object inversion which affected meaning, they must say ‘good’ (e.g. it was the housewife that lost the **key)**. Judging the accuracy of sentences was done immediately after listening to each sentence, however the recall of the last words was kept until the participants were asked to, i.e. at the end of each span. As this subtest is a measure of working memory, the choice of sentences was based on complex rather than simple structure (e.g. It was the test that took the students) so to disrupt recall. The given sentences were assumed to be of intermediate proficiency. The number of sentences increased in increasing memory span (from one sentence to seven sentences) (c.f. appendix 2). The results of this subtest are displayed in the following table:

LSPAN tasks	**Number of subjects**							
	Span 0	**Span 1**	**Span 2**	**Span 3**	**Span 4**	**Span 5**	**Span 6**	**Span 7**
Task 1	16	54						
Task 2	05	11	54					
Task 3	03	06	25	36				
Task 4	04	11	12	22	21			
Task 5	05	06	14	25	20			
Task 6	04	09	17	15	15	10		
Task 7	02	03	10	16	22	17		
Task 8	05	13	13	10	12	13	04	
Task 9	03	06	11	16	13	17	04	
Task 10	01	04	04	16	17	11	11	06
Task 11	02	07	16	19	12	07	07	00
∑	∑= 50	∑= 130	∑= 176	∑= 175	∑= 132	∑= 75	∑= 26	∑= 06

Table 24. Working Memory Capacity in LSPAN

Discussion

The observation of the above table indicates that working memory capacity in LSPAN is lower than RSPAN and OPSAN. Interruption in attention emerges right from span 1. The subjects working memory capacity in this task ranged between span 1 (∑= 130) and span 3 (∑= 132) where the majority of the participants capacity seems to reside in span 2 (∑= 176).

The observation of the participants' answers also reveals that even though some participants could recall four items, they failed to place them in their order. The reason behind this is the high activated attention that is illustrated through listening to the sentences, judging their semantic accuracy and storing the perceived items. The overall working memory capacity in LSPAN is thus estimated to be 3 (± 1).

Individual differences in auditory working memory are quite identifiable in LSPAN. Some individuals are struggling with assembling between manipulation of information and recall from the beginning of the task, i.e. they recalled without judging, judged but gave a wrong word in recall, or judged without recall. Other individuals had no difficulty in doing both the judging and the recall, they rather recalled long data (up to 6 items) successfully.

In addition to differences in auditory working memory, this subtest also reveals differences in language proficiency. As judging the semantic accuracy of sentences required knowledge of both FL vocabulary (i.e. words) and grammar (i.e. the structure), some sentences were a real problem for some participants to judge, i.e. their non-understanding of the sentences made them say correct for incorrect sentences and vice versa. Differences in language proficiency are also illustrated in recalling words. For example, the words 'read', 'rode', 'roth', were presented by some subjects in recalling the word 'road'. Another example is the words 'ti'; 'tight', 'time' were given as a recall of ‘tie’. Similarly, the words ‘plain’, ‘plan’, ‘planning’ were given instead of ‘plane’; the words ‘coker’ and ‘kooker’ replace the word ‘cooker’. It is worth to note that we shut an eye on the mistakes committed by some participants when they did not affect meaning in this task (e.g. when ‘road was given as roade’; ‘hous’ as ‘house’, etc.), yet we did not in the previous tasks for the reason that the to-be-recalled words in RSPAN and OSPAN were seen by the subjects and that not only proficiency was tested but also attention.

Primacy and recency effects appear early in this subtest (i.e. in span 3) to increase in span 4. This is also due to the high attention that is required in this task. Some participants could recall but the first elements, others were not able to recall more than the two last items.

Interference is also worth mentioning in this task. Sometimes words from the previous tasks appeared (e.g. recalling the word ‘bone’ which appeared in RSPAN), and sometimes other words, mainly the first words, from the listening sentences emerged. These are instances of proactive interference. Retroactive interference is illustrated through retrieving words from LTM and recalling them instead of the-to-be recalled words. The interfered words were retrieved through either making semantic associations (e.g. recalling the word ‘street’ instead of ‘road’) or phonetic associations (e.g. ‘foot’ was given instead of ‘food’; ‘eyes’ was given instead of ‘ice’; ‘dinner’ instead of ‘cleaner’; ‘cheat’ instead of ‘cheese’, ‘soft’ instead of ‘solved’, ‘lion’ instead of ‘line’). The recall of French words is also an example of retroactive interference. For instance, the French words ‘clé’ and ‘lignes’ are given to replace the words ‘key’ and ‘lines’, respectively.

Chunking process in best illustrated in this task. Some words were shown together in their recall though they were not presented in their order. For example, in the following list (plane, food, dress, note, dress, cheese, woman), some subjects recall the words ‘dress,

dress, woman' together and the words 'cheese and food' together. Chunking is made in this subtest according to semantic similarity.

6.3. Verbal reasoning test findings

Five tasks were administered to measure different aspects of verbal reasoning skill. The analysis of each subtest results is provided below in the section.

a. Knowledge subtest results

Six items were given to the participants in order to measure their inductive and deductive reasoning skills. Each item involved a set of scrambled letters representing different concepts, e.g. animal, country, etc. (c.f. appendix 2). The findings of this subtest are shown in table 25. The columns exhibit the subjects' correct and incorrect answers.

	Item 1	**Item 2**	**Item 3**	**Item 4**	**Item 5**	**Item 6**
Correct	56=82.35%	49=72.05%	38=55.88%	33=48.52%	34= 50%	10=14.70%
Incorrect	16=23.52%	12=17.64%	29=42.64%	21=30.88%	11=16.17%	23=33.82%
Unanswered	04=05.88%	01= 1.47%	02= 2.94%	15=22.05%	24=35.29%	36=52.94%

Table 25. Knowledge Subtest, Correct Answers+ Percentages

Discussion

The data in the above table indicate that the questions are confirmed to range in increasing difficulty, that is, from easiest (e.g. item 1) to most difficult (e.g. item 6). This corresponds to the challenging nature of intelligence tests. Since the current measure purports to assess verbal reasoning capacity, the questions assembled between vocabulary and both types of reasoning (i.e. deductive and inductive). Deducing a meaningful word from a list of scrambled letters and inducing what the obtained words represent require knowledge of the vocabulary of the foreign language.

One aspect is worth to discuss in this task. Some subjects, in spite of their ability to deduce the right word, failed to induce what it represented. Some were not able to make a distinction between a country, a state, and a city. For example they were able to obtain the word 'Germany' from the jumbled letters 'MANGRY', yet they failed to answer that it represented the name of a country not a city or a state.

b. Similarity subtest results

Similar to the previous subtest, six items were presented in this subtest to assess vocabulary and the aforementioned reasoning skills. The participants were instructed to exclude an odd word from the given list (c.f. appendix 2). The following table displays the results of this task.

	Item 1	**Item 2**	**Item 3**	**Item 4**	**Item 5**	**Item 6**
Correct	68=100 %	51= 75%	36=52.94 %	34= 50%	19=27.94 %	17= 25%
Incorrect	00	18=26.47 %	30=44.11 %	31=45.58 %	33=48.52 %	51= 75%
Unanswered	00	00	03= 4.41%	04=05.88 %	17= 25%	01=1.47 %

Table 26. Similarity Subtest, Correct Answers+ Percentages

Discussion

The data in the above table confirm the increasing difficulty of the task items (easiest, item 1 and 2, to most difficult, item 5 and 6). The subjects' lack of proficiency with some English words is quite noticeable in this task. To illustrate, the majority of the participants (item 6) excluded the word 'deer' from the list of animals confusing it with the word 'dear' that is totally different.

c. Syllogisms subtest results

In this subtest, the subjects were presented with four items, each holding a set of premises. In the three first items two premises were presented with the conclusion, and the participants' job was to judge whether or not the conclusion was logically drawn from them. In the fourth item two premises were presented, and the participants should deduce the right conclusion from the given choices (c.f. appendix 2). The results of this subtest are presented in the following table.

	Item 1	**Item 2**	**Item 3**	**Item 4**
Correct	56= 82.35%	27= 39.70%	20= 29.41%	04= 5.88%
Incorrect	13= 19.11%	42= 61.76%	49= 72.05%	65= 95.58%

Table 27. Syllogisms Subtest, Correct Answers+ Percentages

Discussion

The items in this task are also observed to follow an increasing difficulty (easiest, item 1 to most difficult, item 4). Concerning the participants reasoning capacity, we have noticed that syllogisms containing universal affirmative relations, i.e. all A are B and All B are C then all A are C (e.g. item 1), were best understood and were hence accessible to most of the subjects. However, if a negative statement was included in the premises, i.e. All A are B and no A are C (e.g. item 2), or if any particular relationship was added, i.e. All A are C and some B are C (e.g. item 3), the subjects attention got disrupted and the ambiguity of the conclusion raised. More interestingly, the subjects found it rather difficult when they were asked to deduce the conclusion themselves, especially when they were given universal negative relation, i.e. no A are C and no B are A (item 4).

d. Understanding relations subtest results

This subtest encompassed six tasks that assessed basically deductive reasoning skills. It was presented the fourth for the assumption that the given tasks were relatively more advanced in comparison to those of the previous subtests. The rather confusing relationships between people and their names, in this task, disrupted the subjects' attention which made the conclusion somehow difficult (c.f. appendix 2).The findings of this subtest are exhibited in the following table.

	Item 1	**Item 2**	**Item 3**	**Item 4**	**Item 5**	**Item 6**
Correct	55=80.88 %	41=60.29 %	35=51.47 %	33=48.52 %	31=45.58 %	13=19.11 %
Incorrect	14=20.58 %	28=41.17 %	34= 50 %	36=52.94 %	38=55.88 %	48=70.58 %
Unanswered	00	00	00	00	00	08=11.76%

Table 28. Understanding Relations Subtest, Correct Answers+ Percentages

Discussion

The findings of understanding relations subtest also confirm the challenging order of the items, i.e. from easiest (item 1: 80.88%) to most difficult (item 6: 19.11%). In addition, the participants' answers indicate that relations holding less information (e.g. height relations) receive higher answering percentage than relations holding more information (position relations or blood relations). This means that more information cause disruption in memory and accordingly better reveal individual differences. It is worth to note that the last task received the lowest percentage since it measure problem solving skills in addition to reasoning.

e. Analogies subtest results

Analogies was the last verbal reasoning subtest that was administered to assess inductive reasoning skills as well as vocabulary proficiency. Nine items were presented to the subjects, each item involved a common relationship between its pairs, and the subjects were required to induce the missed word in the second pair from a comparison of the information in the first pair. The relations varied between inclusion (item 4; item 6), opposition (item 8), synonymy (item 2), changing states (item 5; item 7), nationality (item 1), instrumentation (item 9), and blood relationship (item 3) (c.f. Appendix 2). The participants answering percentages are demonstrated in table 29.

	Item 1	**Item 2**	**Item 3**	**Item 4**	**Item 5**	**Item 6**	**Item 7**	**Item 8**	**Item 9**
Correct	46= 67.64 %	37= 54.41 %	34= 50 %	32= 47.05 %	24= 35.29 %	08= 11.76 %	05= 7.35 %	38= 55.88 %	23= 33.82 %
Incorrect	21= 30.88 %	29= 42.64 %	30= 44.11 %	33= 48.52 %	43= 63.23 %	56= 82.35 %	56= 82.35 %	27= 39.70 %	41= 60.29 %
Unanswered	02= 2.94 %	3= 4.1 %	5= 7.35 %	04= 5.88 %	02= 2.94 %	5= 7.35 %	08= 11.76 %	04= 5.88 %	05= 7.35 %

Table 29. Analogies Subtest, Correct Answers+ Percentages

Discussion

The findings of table 29 illustrate the increasing difficulty of the subtest items (regardless of the two last items where the participants were asked to choose a pair sharing a similar relationship). Differences in language proficiency are also quite apparent in this subtest. The participants' failure in choosing the right word that completes the pair is attributed to their non-understanding of the words that make-up the pair (e.g. words like 'niece', 'awful', 'knee', etc. were difficult to recognize by some subjects).

Having analyzed the participants' findings in the different subtests of the three cognitive linguistic measures, it is necessary to explain the distribution of the obtained scores in each subtest as well as each test, to check whether the subtests are related and hence whether the tests are reliable.

6.4. Distribution of scores

In this section, we aim to highlight the distribution of the participants obtained scores in the three administered measures. We have hypothesized that language aptitude, working memory, and verbal reasoning would be correlated and would, subsequently, be factors of an overall dimension that is referred to as 'Linguistic intelligence'. To this end, a distribution of the scores of each measure is required. This distribution provides knowledge about general patterns of associations between language aptitude, working memory and verbal reasoning through demonstrating the mean and the standard deviation of each variable. In addition to aiding the experimenter in establishing relationships between the hypothesized factors, the distribution of scores also illustrate whether or not the scores of the three cognitive linguistic measures correspond to those of IQ tests.

Psychometricians (e.g. Spearman, 1904; Thurstone, 1938; Guilford, 1958; Horn and Cattell, 1967), in their explanation of intelligence, have used a bell-shaped curve. According to them, a normal distribution exists in that the majority of individuals (approximately 68% of the population) are distributed between +1 standard deviation and -1 standard deviation with regard to the mean (i.e. average scores) and 96% of the population should be between +2 standard deviations and -2 standard deviations, while very few (the remaining percentages, i.e. 14% or 4%, symmetrically speaking +7% and -7% or +2% and -2% are situated at the extreme queues of the curve) tend to have exceptionally high or low scores. On the basis of psychometricians view, we predict that the scores of language aptitude, working memory and verbal reasoning also show a normal distribution. A normal distribution is defined, according to Field (2009), as a symmetrical bell-shaped curve in which the highest number of values resides in the centre of the curve and composes the highest point in the curve known as the mean. In a normal distribution, the highest point must be in the centre of the curve and decrease on both sides (left and right). The deviation of the scores should be equal on the positive and negative sides. The distribution of the scores around the mean is calculated using the standard deviation (Field, 2009).

In investigating the distribution of the current measures scores, we have calculated the mean and the standard deviation of each of language aptitude test results, working memory findings and verbal reasoning results. SPSS software was relied on in these calculations. In so doing, we have selected option ‘descriptive statistics’, ‘frequencies’. SPSS findings display the following curves. The subjects’ raw scores in the three tests are presented in Appendix 3 (c.f. Table A. 4, A5, and A6). The following figures demonstrate the distribution of the three measures scores.

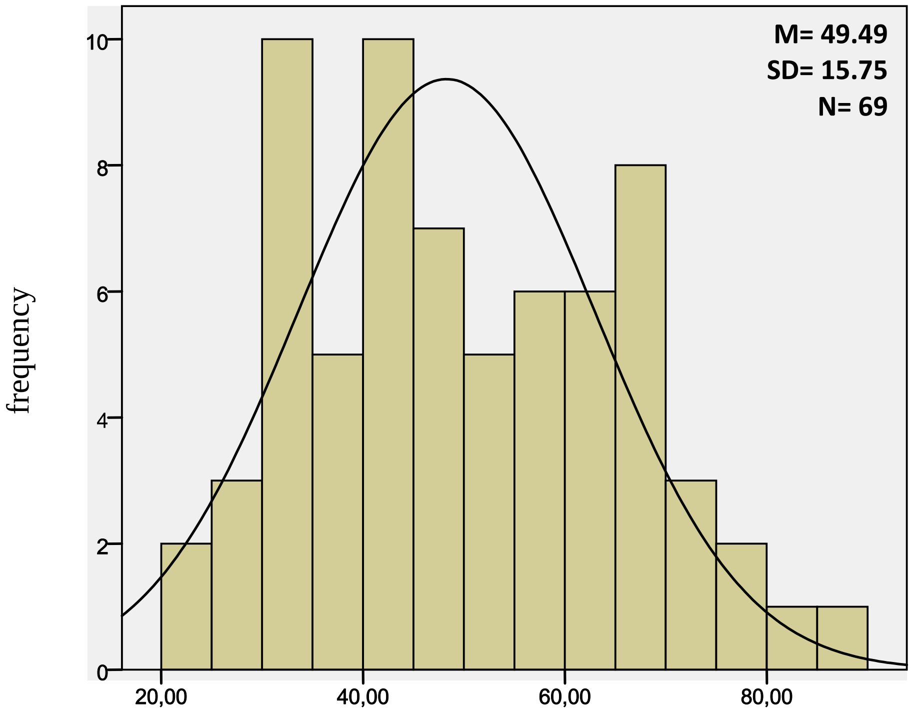

Figure 10. Distribution of Language Aptitude Scores in the Curve

Figure 10 shows that language aptitude scores are normally distributed in the curve with the mean 49.49 and the standard deviation 15.75. Having followed the aforementioned psychologists' distribution of intelligence scores in the bell curve (p. 274), one could notice that there are 68% of the population whose scores are situated between -1 standard deviation (i.e. 33, 74) and +1 standard deviation (i.e. 65.24), and there are 96% of the population whose scores are situated between -2 standard deviations (i.e. 17.99) and +2 standard deviations (80,99). In addition, the figure demonstrates that the subjects' aptitude scores are scattered around the mean, reflecting different ability levels. This means that these scores vary from mediocre ability (<25), to below average ability (25 or >), to average ability (50), to above average ability (<75), and to superior ability (>80), while the majority (frequency 10) are centred between the scores 30 and 45 (reflecting from below average to average capacities). The normal distribution of language aptitude scores directs us to assume that it would be similar to the one of IQ (the mean 49, 49 reflects average ability level).

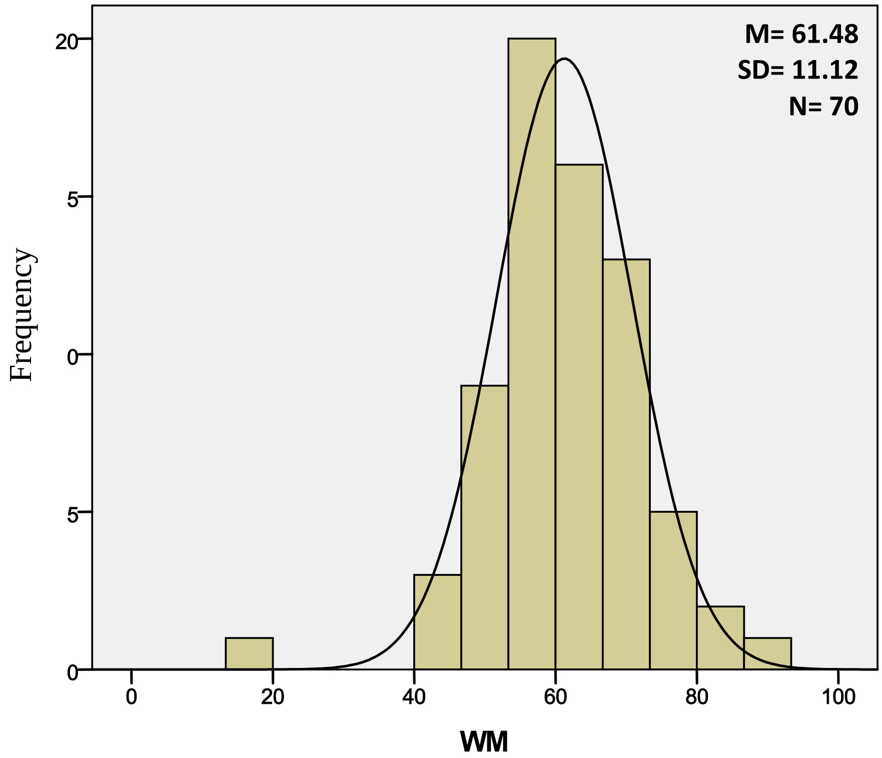

Figure 11. Distribution of Working Memory Scores in the Curve

Figure 11 indicates that working memory results follow a normal distribution as well with the mean 61.48 and the standard deviation 11.12. Having compared with figure10, the above histogram shows that there are approximately 68% of the population with scores situated between -1 standard deviation (i.e. 50.35) and +1 standard deviation (i.e. 72.6), and there are nearly 96% of the population with scores situated between -2 standard deviations (i.e. 39.24) and +2 standard deviations (i.e. 83.72). Besides, unlike the previous figure, figure 10 demonstrates a skewed distribution; that is, the subjects' scores are close to the mean. This reflects relatively similar working memory capacity in the subjects. These results have been confirmed by previous researchers (Cowan, 2000; Miller, 1956, c.f. 3.2.2.2.2). Differences in working memory capacity, however, do exist, in that the participants scores are observed to range between 40 and 80, where the highest number is noticed with average score 50 (frequency 20), which demonstrate higher capacity in comparison to the language aptitude. The distribution of the third administered measure is shown in figure 12.

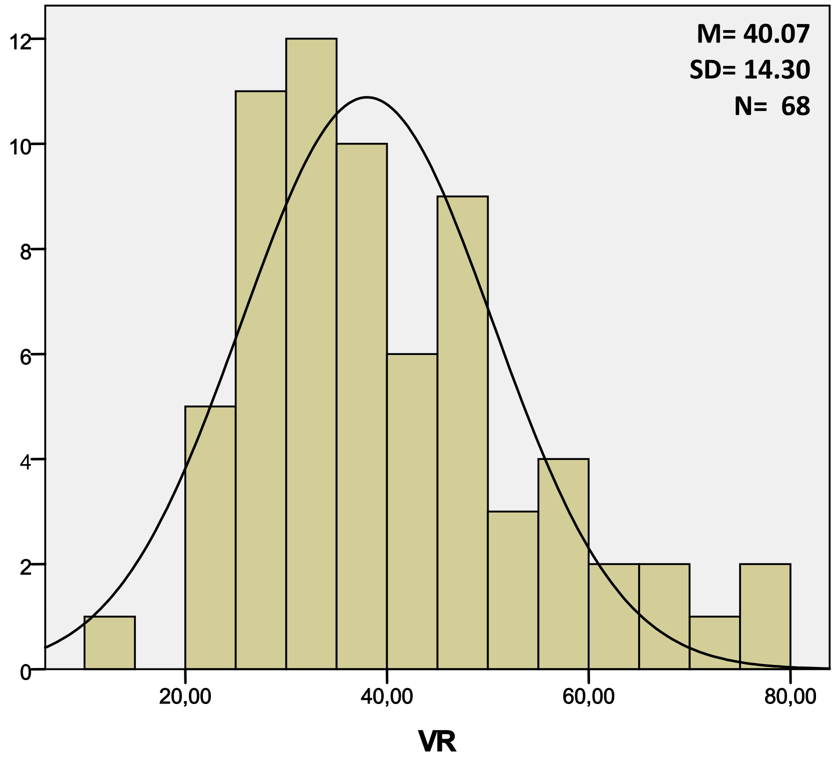

Figure 12. Distribution of Verbal Reasoning Scores in the Curve

Similar to aptitude and working memory, verbal reasoning results are also observed to follow a normal distribution with the mean 40.07 and the standard deviation 14.30. A normal distribution of the third cognitive linguistic measure indicates that there are nearly 68% of the population with scores situated between -1(i.e. 25.77) standard deviation and +1 standard deviation (i.e. 54.37) and that approximately 96% of the population are shown with scores distributed between -2 (i.e. 11.47) standard deviations and +2 standard deviations (i.e. 68.67). Similar to figure 10, the above histogram indicates that there is a dispersion of scores around the mean, which reflects individual differences in verbal reasoning skill (the scores vary from mediocre, i.e. less than 20; to below average, between 20 and 40; to average, around 50; to above average, between 50 and 75; to superior, above

80). Despite these differences, the majority of the subjects are shown with below average, i.e. score 35 (frequency 12), which reflect lower capacity in comparison to working memory and language aptitude. The normal distribution of verbal reasoning directs us to assume also that it would be similar to the one of IQ.

Having presented a distribution of language aptitude scores, working memory scores and verbal reasoning scores in the bell curve, one would notice that the three cognitive linguistic measures share a common normal distribution. We have stated earlier that intelligence (IQ) results also show a normal distribution in the whole population. This might be considered as the initial step to perceive these capacities as the constituent factors of one type of intelligence that we refer to as Linguistic intelligence. The examination of this prediction will be dealt with in the coming chapter (c.f. chapter 7).

6.5. Reliability of the measures

The administration of any test requires checking its reliability and validity. Reliability refers to the consistency in the test scores, while validity refers to whether the test measures what it purports to measure (c.f. chapter four). One technique to check reliability is called internal consistency reliability. This latter is employed through the use of a single administration of a test and splitting it into two halves ‘split-half reliability’; then calculating the correlation between these halves and examining the position of an individual in both of them. If the individual shows a similar position in the two halves, then the test is highly reliable, otherwise, it is not. Assessing the reliability of the administered measures will be done through examining two types of correlations: whole-part correlation, or the degree of association between each test whole score and the score of its subtests; and item-item correlation, or the strength of relationship within each measure subtests.

Before calculating both types of correlations (i.e. whole-part and item-item), the participants obtained scores in all the measures subtests should first be converted into percentages so that the outcome will be identical. This means that the subtests will have an equal value to the overall tests (i.e. the score of perfection in all the subtests will be converted to 100 and all the participants scores in these subtests will be explained in relation to this value).

6.5.1. Checking the reliability of aptitude measure

Similar to the assessment of reliability in aptitude pilot measure, the Pearson Product Moment Correlation Coefficient technique was adopted for the final measure. Having used SPSS software, these are the results displayed in the following tables:

	Phonemic ability subtest	**Grammatical sensitivity subtest**	**Inductive language learning ability subtest**
Whole score	.93	.74	.76

Table 30. Language Aptitude Whole-Part Correlation

	Phonemic ability subtest	**Grammatical sensitivity subtest**	**Inductive language learning subtest**
Phonemic ability subtest	1.00		
Grammatical sensitivity subtest	.59	1.00	
Inductive language learning subtest	.55	.38	1.00

Table 31. Language Aptitude Item-Item Correlation

Discussion

The critical value of *r* for one-tailed test at (0.05) level of significance and with 68 degrees of freedom is (.25). As the obtained value of r for the correlation between aptitude total score and the score of each subtest is very high than the critical value (r= .93, .74, .76), as well as for the correlation between the three subtests (.59, .55, .38), we would say that the results are indeed significant. In other words, the current aptitude final test is proved highly reliable.

Checking the degree of association between aptitude overall score and the score of its subtests is not only helpful in assessing the reliability of the measure but also aids in providing insights on deciding on the component that underlies this capacity. Researchers (e.g. Dörnyei, 2010, c.f. chapter 2.2.1) speculate that phonemic ability predicts aptitude. The data in the table 30 confirm this view through exhibiting the highest correlation between phonemic ability and aptitude total score (.93).

6.5.2. Checking the reliability of working memory measure

The reliability of the second cognitive linguistic measure is also examined using the Pearson correlation. SPSS displays the following findings:

	RSPAN	**OSPAN**	**Anagrams**	**LSPAN**
Whole score	.84	.74	.49	.66

Table 32. Working Memory Whole-Part Correlation

	RSPAN	OSPAN	Anagrams	LSPAN
RSPAN	1			
OSPAN	.56	1		
Anagrams	.23	.45	1	
LSPAN	.320	.18	.21	1

Table 33. Working Memory Item-Item Correlation

Discussion

The critical value for one-tailed test at 0.05 level of significance with 69 degrees of freedom is .19. Table 32 displays significant correlations between working memory total score and its four subtests (.84, .74, .49, and .66>.19). Regarding item-item correlation, only one subtest (OSPAN) does not show a significant correlation (r= .18); all the others show significant correlations. On the basis of these findings, we would come to realize that working memory measure is reliable as well. The non-significant relationship that is shown between one WM subtest directs us to predict that this subtest would measure a different factor of Linguistic intelligence, and that it might show significant associations with the two other measures subtests (i.e. verbal reasoning subtests and aptitude subtests). The investigation of the correlation between the three cognitive linguistic measures subtests will be dealt with in the coming chapter.

Similar to aptitude results, the findings of the correlation between WM whole score and the score of its subtests have aided us in determining the tasks that best measure WMC. Tables 32 and 33 inform us that RSPAN and OSPAN are highly interrelated with the whole score (.84) as well as with the other subtests if compared with the two other subtests. This confirms that these subtests are more useful measures in assessing WMC.

6.5.3. Checking the reliability of verbal reasoning measure

Similar to the two previous measures, the reliability of verbal reasoning test is also assessed through the use of Pearson correlation. SPSS results are presented in tables 34 and 35.

	Analogies	Similarity	Knowledge	Relations	Syllogisms
Whole score	.79	.45	.79	.66	.11

Table 34. Verbal Reasoning Whole-Part Correlation

	Analogies	Similarity	Knowledge	Relations	Syllogisms
Analogies	1				
Similarity	.09	1			
Knowledge	.59	.22	1		
Relations	.30	.21	.43	1	
Syllogisms	.03	-.06	.02	-.02	1

Table 35. Verbal Reasoning Item-Item Correlation

Discussion

The critical value of r for one tailed test at 0.5 level of significance with 67 degrees of freedom is approximately .19. The data in table 34 indicate that the majority of verbal reasoning measure subtests are significantly correlated with the whole score (.79, .45, .79, .66) > .19. One subtest, however, is noticed not to correlate with the total score (Syllogisms: .11). We would come up to say that verbal reasoning measure is also reliable and would, meanwhile, predict that this latter would correlate with WM or aptitude subtests. Concerning item-item correlation, two subtests (i.e. Syllogisms and Similarity) are also observed not to correlate with some other subtests. Similarity subtest shows a non-significant correlation with Analogies subtest (.09), and syllogisms subtest does not show a significant correlation with any other subtest (.03, -.06, .02, -.02). These subtests are also assumed to be linked with other factors of Linguistic intelligence and might, thus, correlate with working memory or language aptitude subtests. The coming chapter is devoted to this investigation.

6.6. General discussions

Having provided a detailed analysis of the findings of each of aptitude measure, working memory measure, and verbal reasoning measure, one would come up to realize that individual differences in the cognitive linguistic aspect do exist. While some subjects were found to struggle with the simplest questions and, hence, obtained unsatisfactory scores; others did excel in the three tests and gained very high scores; and again others were found with average outcomes. The three aforementioned curves (figure 10, 11, and 12) best illustrate these individual differences. Likewise, the analysis of the measures findings indicate that the distribution of the obtained scores is similar to the distribution of IQ scores, in that the highest rate was not far from average (e.g. language aptitude mean $\overline{X}$= 49.49; working memory mean $\overline{X}$= 61.48; verbal reasoning mean $\overline{X}$= 40.07), whereas the lowest rate was observed in exceptionally high or low scores. This has pushed us forward to maintain our investigation of the relationship between the three abilities predicting them to be components of an overall capacity that is referred to as 'Linguistic intelligence'.

Concerning aptitude measure that involved the administration of three subtests assessing respectively phonemic ability, grammatical sensitivity and inductive language learning ability, determining the subjects' areas of strength and weakness requires an observation of the mean of the three subtests. The following table displays the participants' mean score in these subtests. The details are shown in Appendix 3. (c.f.Table A. 4)

	Phonemic ability	Grammatical sensitivity	Inductive language learning ability
Sum of scores	∑= 3211,96	∑=4268,14	∑=2920,17
Mean	$\bar{X}$= 46,55	$\bar{X}$=61,85	$\bar{X}$=42,32

Table 36. Language Aptitude Mean Scores

The data in table 36 indicate that the subjects' area of strength in aptitude is 'grammatical sensitivity', and their area of weakness is 'inductive language learning ability'. We assume that the subjects outperformed in grammatical sensitivity because they had been in contact with the foreign language for several years which made them aware of internalizing the given syntactic structures and grammatical functions. However, the low results which appear in 'inductive language learning ability' might be attributed to their unfamiliarity with the foreign language (i.e. artificial language) which they were exposed to for the first time.

Regarding working memory measure, the decision of the subjects' areas of strength and weakness requires knowledge of the mean score in its four subtests: RSPAN, OSPAN, anagrams, and LSPAN. The following table exhibits these scores. The subjects' findings in working memory measure are presented upon in Appendix 3. (c.f. Table A. 5)

	RSPAN	OSPAN	anagrams	LSPAN
Sum of scores	∑= 5267,07	∑= 3768,16	∑=2161,61	∑=3898,30
Mean	$\bar{X}$= 75,24	$\bar{X}$=53,83	$\bar{X}$=30,88	$\bar{X}$=55,69

Table 37. Working Memory Mean Scores

We observe that the subjects outcome in RSPAN was the best if compared with the three other subtests, whereas their scores in anagrams were the lowest. We would explain that RSPAN was the easiest task, while anagrams was the most demanding. Despite the fact that the subjects activate two processes in answering the four tasks: manipulation of information process and storage process, RSPAN required a passive manipulation of information (reading), but anagrams required active attentional processes in deducing the words.

Determining the subjects areas of strength and weakness in the third cognitive linguistic measure, verbal reasoning, also requires knowledge of the mean score in the five administered subtests. The following table illustrates the subject mean score in these subtests. The subjects' detailed review of verbal reasoning scores is shown in Appendix 3. (c.f. Table A. 6)

	Knowledge	**Similarity**	**syllogisms**	**Understanding relations**	**analogies**
Sum of scores	∑= 3003,33	∑=3193,04	∑=1911,88	∑=3020,57	∑=2138,34
Mean	$\bar{X}$= 44,16	$\bar{X}$=46,95	$\bar{X}$=28,11	$\bar{X}$=44,42	$\bar{X}$=31,44

Table 38. Verbal Reasoning Mean Scores

The observation of table 38 reveal a convergence in some verbal reasoning subtests (e.g. knowledge: $\bar{X}$= 44, 16, similarity: $\bar{X}$=46, 95, and understanding relations: $\bar{X}$=44, 42). This makes it difficult to decide on the areas of strength. However, when it comes to areas of weakness, syllogisms is observed with the lowest score ($\bar{X}$=28, 11). The reason behind obtaining low scores in syllogisms might be attributed to the confusion between what is logical in reality and a logical conclusion that derives from the premises regardless of their relation to reality.

Sex differences is a worthwhile issue within the area of individual differences. This aspect is also prerequisite in psychological testing. In order to determine whether or not there is a difference in performance between girls and boys in the different subtests of the three administered measures, the findings of girls should be compared with those of boys. The following table displays the scores of the two sexes in the different subtests. The mean scores are converted into percentages so that they will all be explained with regard to an equal value.

	Girls	**Boys**
Language aptitude test whole score/ 100	**Mean $\bar{x}$ =** 48.75	**Mean $\bar{x}$ =** 47.96
Phonemic ability subtest	Mean $\bar{x}$ = 45.70	Mean $\bar{x}$ = 46.80
Grammatical sensitivity subtest	Mean $\bar{x}$ = 61.69	Mean $\bar{x}$ = 53.95
Inductive language learning ability subtest	Mean $\bar{x}$ = 40.16	Mean $\bar{x}$ = 49.37
Working memory test whole score	**Mean $\bar{x}$ = 61.07**	**Mean $\bar{x}$ = 63.68**
RSPAN subtest	Mean $\bar{x}$ = 76.12	Mean $\bar{x}$ = 77.32
OSPAN subtest	Mean $\bar{x}$ = 54.2	Mean $\bar{x}$ = 56.72
anagrams subtest	Mean $\bar{x}$ = 30.8	Mean $\bar{x}$ = 33.6
LSPAN subtest	Mean $\bar{x}$ = 55.8	Mean $\bar{x}$ = 60.08
Verbal reasoning test whole score	**Mean $\bar{x}$ = 37.68**	**Mean $\bar{x}$ = 44.87**
Knowledge subtest	Mean $\bar{x}$ = 41.88	Mean $\bar{x}$ = 60
Similarity subtest	Mean $\bar{x}$ = 46.88	Mean $\bar{x}$ = 51.59
Syllogisms subtest	Mean $\bar{x}$ = 28.77	Mean $\bar{x}$ = 27.27
Understanding relations subtest	Mean $\bar{x}$ = 43.24	Mean $\bar{x}$ = 54.54
analogies subtest	Mean $\bar{x}$ = 29.70	Mean $\bar{x}$ = 43.33

Table 39. Sex Differences in Aptitude, Working Memory, and Verbal Reasoning

A comparison of the three tests whole scores reveals that there are almost no substantial differences in the performance of both sexes in aptitude and working memory tests. However, when it comes to verbal reasoning, more performance is observed from the side of boys ($\bar{x}$= 44.87> 37.68). Having taken each test individually, the observation of the findings of aptitude measure indicate that girls outperformed in grammatical sensitivity subtest ($\bar{x}$= 61.69> 53.95), while boys did better in inductive language learning tasks ($\bar{x}$= 49.37>40.16). Concerning working memory measure, there are no apparent differences in the four subtests. Some difference is noticed in LSPAN where boys showed better results than girls ($\bar{x}$= 60.08>55.8). As for verbal reasoning test, better performance is observed from the side of boys in almost all the subtests: knowledge subtest ($\bar{x}$= 60>41.88), similarity subtest ($\bar{x}$= 51.59>46.88), understanding relations subtest ($\bar{x}$= 54.54>43.24), and analogies subtest ($\bar{x}$= 43.33>29.70).

Conclusion

In this chapter we have provided a detailed analysis of each of aptitude measure, working memory measure, and verbal reasoning measure. Many interesting findings emerged, involving the distribution of scores, individual differences in the different aspects of the cognitive linguistic ability, sex differences, and reliability of the measures.

The distribution of scores in the three administered tests was normal which corresponds to the distribution of IQ scores. This means that similar to IQ, the highest rate, and thus the highest point in the distribution curve, is found with approximately average scores (e.g. language aptitude $\bar{x}$= 49.48, working memory $\bar{x}$= 61.48, and verbal reasoning $\bar{x}$= 40.07), while the lowest rate presents exceptionally high and low scores.

Concerning individual differences, our administrated tests revealed different levels of language aptitude, working memory and verbal reasoning. Our sample is proved to be composed of cognitively and linguistically mediocre, average and superior individuals. The distribution of language aptitude scores, working memory scores and verbal reasoning scores illustrate these individual differences.

Similar to individual differences, the obtained scores also revealed substantial sex differences. While boys seemed to outperform in inductive reasoning tasks including knowledge, similarity, understanding relations as well as inductive language learning subtest, girls were better in tasks involving inference of different grammatical functions (i.e. grammatical sensitivity tasks).

As for the reliability of the measures, the high correlations that were found between the three tests whole scores and the different subtests indicate that aptitude measure, working memory measure, and verbal reasoning measure are indeed reliable. On the other hand, the correlations between some subtests (e.g. anagrams, RSPAN, and LSPAN in working memory measure; and similarity and syllogisms in verbal reasoning measure) were far from perfect which lead us to predict that these subtests measure different factors of cognitive linguistic ability. The coming chapter is will investigate these factors.

Chapter Seven

Investigating the Impact of Linguistic intelligence on Language Learning Achievement

Introduction

7.1. Linguistic intelligence test: the correlation between language aptitude, working memory and verbal reasoning

7.1.1. Research hypotheses

a. Part one: Research question and hypothesis

i. Measuring the correlation between language aptitude, working memory and verbal reasoning

1. The correlation between aptitude and working memory

2. The correlation between working memory and verbal reasoning

3. The correlation between aptitude and verbal reasoning

b. Part two: research questions and hypotheses

i. Steps used in exploratory factor analysis

1. Making a correlation matrix

2. Descriptive statistics

3. Factor extraction

4. Loading of variables in factors and their rotation

5. Interpretation of the results

6. Discussion

7.2. The impact of Linguistic intelligence on language learning achievement

7.2.1. Research question and hypotheses

i. The correlation between Linguistic intelligence and language learning achievement

1. Scoring the variables

a. Linguistic intelligence scores

b. Language learning achievement score

2. Assessing the reliability of Linguistic intelligence test

3. Distribution of scores

a. Distribution of Linguistic intelligence scores

b. Distribution of language learning achievement scores

4. Calculating the correlation between Linguistic intelligence and language learning achievement

a. The correlation between Linguistic intelligence total score and language learning achievement

b. The correlation between verbal reasoning and language learning achievement

c. The correlation between working memory and language learning achievement

d. The correlation between grammatical ability and language learning achievement

Conclusion

Investigating the Impact of Linguistic intelligence on Language Learning Achievement

Introduction

This chapter aims at investigating the influence of a cognitive linguistic capacity that is Linguistic intelligence on language learning achievement. Linguistic intelligence is hypothesized to incorporate three main factors, namely language aptitude, working memory, and verbal reasoning. The questions of this investigation are correlational. The examination of the research hypotheses requires the use of different types of correlation.

In this chapter we will examine our first hypothesis which addresses the relationship between the so predicted factors (i.e. aptitude, working memory and verbal reasoning). Multiple correlations will be used to confirm or disconfirm our prediction. Then, Factor analysis will be conducted to determine the final factors of Linguistic intelligence and, accordingly, the ultimate components of Linguistic intelligence measure. Another correlational investigation will be conducted between this latter scores and the scores of language learning achievement in order to assess the relationship between them.

The chapter is divided into two main sections. The first section is entirely devoted to the analysis of the first research hypothesis, and the second section is consecrated to the examination of the second prediction.

7.1. Linguistic intelligence test: the correlation between language aptitude, working memory and verbal reasoning

As have been previously indicated, the questions in this section are primarily correlational in nature. The section involves a set of correlations between the three previously studied measures, i.e. language aptitude measure, working memory measure, and verbal reasoning measure, so as to aid in determining the components of the ultimate Linguistic intelligence measure.

7.1.1. Research hypotheses

Two primary hypotheses will be examined in this section. The first one is that language aptitude, working memory, and verbal reasoning would be significantly interrelated. The second closely related hypothesis is that the three cognitive linguistic measures that attempted to assess these abilities would represent distinct components of the final Linguistic intelligence measure.

The examination of both hypotheses requires from us to divide the section into two parts: the first part will be entirely concerned with the study of the relationship between the above mentioned cognitive linguistic capacities; and the second part will investigate the final components of Linguistic intelligence measure through assessing multiple correlations between the various subtests the three measures encompassed.

a. Part one: Research question and hypothesis

The major question regarding the first part in our investigation is: Are language aptitude, working memory and verbal reasoning related? To answer this question, we have hypothesized that the three capacities would be closely associated. This general statement involves three sub-hypotheses:

- **Sub-hypothesis 1**. Language aptitude would be significantly correlated with working memory capacity.
- **Sub-hypothesis 2**. Working memory would show a strong association with verbal reasoning skill.
- **Sub-hypothesis 3**. Language aptitude and verbal reasoning would be closely linked.

The testing of these hypotheses will be done through a correlational study. A clarification of the term 'correlation' is provided in the review of literature (c.f. chapter 4.3.4.1).

Before calculating the strength of association between aptitude, working memory and verbal reasoning, it is useful to flick through the distribution of the obtained scores in each measure, and the linear relationship the findings share. The following scatter diagram illustrates the distribution of language aptitude scores, working memory scores, and verbal reasoning scores in the plot and the linear relationship they share.

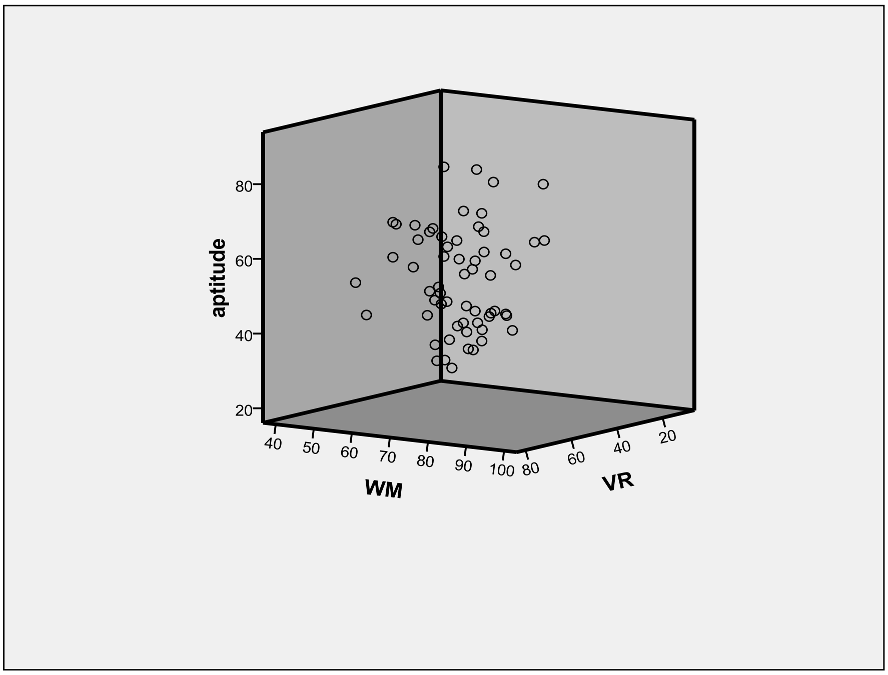

Figure. Findings of Aptitude, Working Memory, and Verbal Reasoning in a Scatter Diagram

The observation of the above scatter plot confirms the existence of a linear relationship between language aptitude, working memory, and verbal reasoning. The participants scores in the three measures are closely distributed, which indicate close interrelationship. Therefore, the Pearson correlation will be calculated to determine the degree of relationship between these variables.

i. **Measuring the correlation between aptitude, working memory and verbal reasoning**

Measuring the strength of relationship between the three hypothesized factors of Linguistic intelligence requires a consideration of the association between each two variables independently: language aptitude and working memory, language aptitude and verbal reasoning, and working memory and verbal reasoning. The Pearson correlation technique will be used to calculate these correlations. The confirmation of these correlations partly confirms the first research hypothesis. One should indicate that the participants' overall scores in the three measures (i.e. aptitude, WM, and verbal reasoning) will be of our concern. The scores of each subtest in these measures will be kept for the examination of the second part of the same hypothesis.

1. The correlation between aptitude and working memory

This part of the section is devoted to examining the first sub-hypothesis which addresses the degree of relationship between aptitude and working memory capacity. In order to test this hypothesis, we have compared the obtained scores in the two measures (c.f. table A. 6). It is necessary to mention that only sixty subjects were kept for this investigation for the reason that some were found to participate in only one of the two measures.

After using SPSS software to calculate the Pearson correlation between aptitude and working memory, the results reveal that r=.53. The critical value of r for one tailed test at (0.05) level of significance with 59 degrees of freedom is (.25). As the obtained value of r is (.53> .25), the correlation is indeed significant. This means that language aptitude and working memory are significantly interrelated.

The confirmation of this hypothesis adds evidence to past research on the relationship between working memory and language aptitude (Carroll, 1993; Miyake and Friedman, 1998; Sawyer and Ranta, 2001; Robinson, 2002; Wen and Skehan, 2011) (c.f. chapter 2.6). Some pedagogical recommendations for the role of working memory in enhancing language aptitude will, thus, be highlighted in the coming chapter (c.f. pedagogical implications and recommendations).

2. The correlation between working memory and verbal reasoning

This part of the section is devoted to the testing of the second sub-hypothesis that is related to the first research prediction. This sub-hypothesis deals with the relationship between working memory and verbal reasoning. The same method of correlation, i.e. Pearson correlation, is used between both measures scores. SPSS findings show that $r=.38>.25$, which indicate significant results. Working memory is, subsequently, linked to verbal reasoning. In spite of the fact that the correlation found between these two cognitive linguistic abilities is small if compared to previous researchers' findings (c.f. chapter 3.4), it supports many experts' views (e.g. Kyllonen and Christal, 1990; Conway et al., 2002; Engle, 2002; Kane, Hambrick and Conway, 2005; Dang et al., 2012) (c.f. chapter 3.4.2). Having confirmed the first two sub-hypotheses, we should examine the third.

3. The correlation between aptitude and verbal reasoning

Regarding the relationship between aptitude and verbal reasoning, the comparison of the participants findings in the two measures indicate approximately convergent scores. The calculation of the correlation between both variables is done through the use of the same statistical technique with the aid of SPSS software. The Pearson Product Moment correlation coefficient results reveal that $r=.58>.25$. Here again significant association is revealed between these cognitive linguistic capacities as well.

The strong established relationships between aptitude, working memory, and verbal reasoning show that the results are in the direction of our first hypothesis. This means that our predicted cognitive linguistic skills would interrelate under one umbrella term "Linguistic intelligence". Investigating the components of this latter will be done in the second part of the section.

b. Part two: Research questions and hypotheses

After the confirmation of significant relationships between language aptitude, working memory capacity, and verbal reasoning ability, we now assume that these variables would represent the main factors of what is known as ‘Linguistic intelligence’. In this part of the section, it is required from us to explore the number of the final factors of this latter. Two main questions are, accordingly, raised:

1. What are the different factors of Linguistic intelligence?
2. Do language aptitude, working memory and verbal reasoning represent the main factors of this ability, or are there other hidden factors?

To answer these questions, we hypothesize that Linguistic intelligence would include three primary factors, namely language aptitude, working memory and verbal reasoning. The examination of this hypothesis will be done through the use of factor analysis and mainly exploratory factor analysis (EFA). A clarification of factor analysis is provided in the literature review (c.f. chapter 4. 3).

i. Steps used in exploratory factor analysis

The steps used for the present study are similar but not identical to those of Urbina (2004) (c.f. chapter 4.3). The first step is conducting a correlation matrix. This latter informs us about the significance of correlation between the different subtests of the cognitive linguistic ability (i.e. Linguistic intelligence) and helps us eliminate the variables that show low correlations (i.e. those which might cause problems when conducting factor analysis). The second step is running descriptive statistics to aid in testing the adequacy of the sample and, hence, the appropriateness of factor analysis. The third step is extracting factors from the variables. The fourth step is loading the variables onto factors and rotating them. The final step is interpreting the results. A discussion of the findings of each step is provided below.

1. Making a correlation matrix

Investigation the number of Linguistic intelligence factors requires first checking the significance of the correlation between the chosen variables. In so doing, two matrices should be evaluated, viz. the one presenting general correlations, and the other one showing specific correlations. In other words, the first matrix informs us about the correlation between the three administered measures, i.e. between aptitude and working memory, between aptitude and verbal reasoning, and between working memory and verbal reasoning, whereas the second one presents the correlations within the twelve subtests (variables) of these measures: phonemic ability,, grammatical sensitivity, inductive learning ability, RSPAN, OSPAN, anagrams, LSPAN, knowledge, similarity, syllogisms, understanding relations, and analogies. The first matrix is already discussed early in the section (c.f. part one), where the results proved significant. The following correlation matrix displays the strength of association between all the subtests intended to measure Linguistic intelligence. It is worth mentioning that we have kept only sixty subjects for this investigation as some participants have engaged in just one or two of the administered tests.

	PCA	GS	ILL	KN	SIM	SYL	UR	ANL	RS	OS	ANG	LS
PCA	1											
GS	0.54	1										
ILL	0.52	0.32	1									
KN	0.53	0.38	0.44	1								
SIM	0.20	0.18	0.19	0.23	1							
SYL	-0.12	-0.09	-0.19	-0.03	-0.13	1						
UR	0.35	0.08	0.30	0.41	0.17	-0.02	1					
ANL	0.52	0.25	0.39	0.61	0.13	0.009	0.34	1				
RS	0.19	0.26	0.20	0.18	0.05	-0.17	0.27	0.11	1			
OS	0.55	0.28	0.36	0.29	0.08	-0.02	0.40	0.28	0.49	1		
ANG	0.46	0.40	0.37	0.42	0.003	-0.23	0.38	0.19	0.27	0.53	1	
LS	0.35	0.29	0.24	0.45	-0.02	-0.08	0.14	0.35	0.36	0.24	0.21	1

Table 40. The Correlation between Language Aptitude Subtests, Working Memory Subtests and Verbal Reasoning Subtests

The observation of table 40 reveals that most of the subtests are significantly correlated with one another. However, two subtests are noticed not to share a significant relationship with all the remaining variables. Syllogisms subtest shows a negative correlation with almost all the subtests (-0.051, -0.033, 0.073, -0.030, -0.010, -0.151, -0.162, -0.105, -0.115, -0.143, -0.152, -0.063), and similarity subtest shows a very weak association (0.20, 0.18, 0.02, 0.19, 0.23, 0.13, 0.17, 0.13, 0.05, 0.08, 0.003). Similarly, as stated previously (chapter 6.5.3), nor do these subtests correlated with other items of the same administered measure (i.e. verbal reasoning measure). Therefore, syllogisms and similarity will be eliminated at this stage as they might cause problems for factor analysis as recommended by Field (2009)[21].

Having excluded these two subtests, ten from twelve variables remain to be considered. Field (2009) also recommends that this method of analysis is also appropriate for factors that correlate fairly well but not perfectly. The observation of table 40 confirms the usefulness of factor analysis as most of the remaining variables share strong associations (e.g. .54, .52, .51, .55, .61, etc.). The correlations in the previous matrix led us to predict that the items that share strong associations with one another intend to measure the same factor, and that these associations will represent components of the same underlying dimension that is known as ‘Linguistic intelligence measure’. Two main questions are, accordingly raised:

- How many components can be extracted to form Linguistic intelligence measure?
- How many factors for Linguistic intelligence the clustering of the components will produce?

In answering these questions, we have relied on SPSS software as a tool of analysis. Many steps are followed after the correlation matrix. An explanation of these steps is provided below.

2. Descriptive statistics

Descriptive statistics is normally the first initial step in factor analysis. It summarizes the chosen data in a clear numerical way. Besides, it gives information about the distribution of data like the mean, median, and mode. This step is kept the second in this investigation after the correlation matrix, as this latter aids in selecting the variables that are acceptable for factor analysis.

[21] Field (2009) suggests that factor analysis can be conducted for correlations over (.30).

This aspect is accessed in checking the option 'Descriptives' in SPSS. After selecting this box, many boxes should be checked as well: 'univariate descriptive', 'initial solution', 'coefficients', 'significance level', 'determinant', and 'KMO and Bartlett's test of sphericity'. 'Coefficients' option gives the correlation matrix (R matrix), while the option of 'significance level' indicates the level of significance for each correlation in this matrix. The 'determinant' option is crucial in checking the multicollinearity (i.e. values close to 1) and singularity (i.e. values close to 0) in the data. Values that indicate muticollinearity and singularity should be omitted from the analysis. (Field, 2009)

The determinant of R matrix is shown in a matrix of squared multiple correlations. A detailed mathematical calculation of R matrix is not of our concern. Rather, the results were automatically obtained in SPSS. Table 41 exhibits the coefficients, the significance level, and the determinant.

		Knowledge	Understanding relations	analogies	Phoemic ability	Grammatical sensitivity	Inductive learning	RSPAN	OSPAN	Anagrams	LSPAN
Correlation	Knowledge	1,000	,419	,619	,531	,382	,443	,186	,295	,427	,454
	Understanfing relations	,419	1,000	,342	,358	,086	,303	,271	,403	,385	,148
	Analogies	,619	,342	1,000	,524	,260	,395	,112	,282	,192	,356
	Phonemic ability	,531	,358	,524	1,000	,546	,528	,192	,558	,470	,354
	Grammatical sensitivity	,382	,086	,260	,546	1,000	,322	,268	,281	,405	,298
	Inductive learning	,443	,303	,395	,528	,322	1,000	,206	,368	,380	,247
	RSPAN	,186	,271	,112	,192	,268	,206	1,000	,496	,273	,369
	OSPAN	,295	,403	,282	,558	,281	,368	,496	1,000	,531	,241
	Anagrams	,427	,385	,192	,470	,405	,380	,273	,531	1,000	,219
	LSPAN	,454	,148	,356	,354	,298	,247	,369	,241	,219	1,000
Significance	Knowledge		,000	,000	,000	,001	,000	,077	,011	,000	,000
	Understanding relations	,000		,004	,002	,257	,009	,018	,001	,001	,130
	Analogies	,000	,004		,000	,023	,001	,197	,014	,071	,003
	Phonemic ability	,000	,002	,000		,000	,000	,071	,000	,000	,003
	Grammatical sensitivity	,001	,257	,023	,000		,006	,019	,015	,001	,010
	Inductive learning	,000	,009	,001	,000	,006		,057	,002	,001	,028
	RSPAN	,077	,018	,197	,071	,019	,057		,000	,017	,002
	OSPAN	,011	,001	,014	,000	,015	,002	,000		,000	,032
	Anagrams	,000	,001	,071	,000	,001	,001	,017	,000		,046
	LSPAN	,000	,130	,003	,003	,010	,028	,002	,032	,046	

Determinant = ,023

Table 41. Correlation Matrix, Significance Level and Determinant

The data in table 41 reveal that some variables share non-significant correlations in comparison to their levels of significance (e.g. grammatical sensitivity and understanding relations: .08<.25, RSPAN and analogies: .11<.19). This implies that the variables might belong to separate factors. The investigation of these factors is discussed upon later in the section. Another observation is that there is neither very low (>.10) nor perfect correlations (more than .90). Regarding the determinant of the R matrix, the value is observed to be higher than the critical value.023 > .0001 (Field, 2009), which means that there are indeed no issues of singularity and multicollinearity in the data. Therefore, no variable should be excluded from the study.

KMO and Bartlett's

The Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) and the Bartlett's test of sphericity are statistical methods used to assess the reliability of factor analysis. KMO values vary between 0 and 1. While values near 0 indicate diffusion in the pattern of correlations, values near 1 indicate a relative strength in the data and, subsequently, the reliability of the produced factors. Kaiser (1974, in Field, 2009) suggests that in order for values to be acceptable, they should be greater than (.50). A detailed calculation of the two methods is not of our concern, as the results are automatically obtained in SPSS. KMO and Bartlett's findings are displayed in the following table:

Kaiser-Meyer-Olkin measure of adequacy		,779
Bartlett's test of sphericity	Approx. Chi square	207,578
DF		45
	Sig	,0001

Table 42. KMO and Bartlett's Test

The data in table 42 show that the value of KMO for 207.57 Chi square of distribution with 45 degrees of freedom and (.0001) level of significance is .77 (>.50). The high obtained value implies that these results fall into the range of being good (i.e. the sample is adequate), and that factor analysis is normally appropriate for these data.

3. Factor extraction

Having provided an overview of descriptive statistics to the current data, extracting factors is the next step. There are different methods for factor extraction in SPSS. The choice of an appropriate method depends on the purpose of the study (Field, 2009). As our main objective is to investigate the number of factors of Linguistic intelligence and the number of the corresponding components of this ability test, the method of 'Principal Components Analysis' has been chosen. Although this method is different from factor analysis, the results are almost similar.

At first, SPSS identified 10 initial eigenvalues[22] (i.e., the same number of variables). Determining the number of factors from eigenvalues can be done in two different ways: first, we would directly select three factors depending on the research hypothesis (i.e. three variables, viz. aptitude, working memory and verbal reasoning, have been predicted to decompose Linguistic intelligence measure); second, we examine the eigenvalues that are greater than 1.00 (Field, 2009). We have opted for the second approach for the belief that some hidden factors might unexpectedly appear in the analysis (Kaiser, in Field, 2009). Table 43 displays the eigenvalues associated with each factor before extraction, after extraction and after rotation[23].

[22] Eigenvalues are calculated in factor analysis to find the number of factors.

[23] Factor rotation is associated with factor analysis. It refers to the transformation of factors mathematically (see step 4)

Componants	Initial eigenvalues			Extraction Sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	% cumulative	Total	% of variance	% cumulative	Total	% of variance	% cumulative
1	4,215	42,154	42,154	4,215	42,154	42,154	2,578	25,780	25,780
2	1,200	11,996	54,150	1,200	11,996	54,150	2,241	22,408	48,189
3	1,012	10,118	64,268	1,012	10,118	64,268	1,608	16,080	64,268
4	,940	9,405	73,673						
5	,639	6,390	80,063						
6	,567	5,672	85,734						
7	,514	5,138	90,872						
8	,413	4,133	95,005						
9	,283	2,826	97,832						
10	,217	2,168	100,000						

Table 43. Total Variance Explained

The data in table 43 demonstrate that there are as many eigenvalues as there are variables in the first column (10 eigenvalues before extraction). We notice that the first three variables represent a large amount of variance[24] (> 10%), especially the first one (42.15%); while the seven other variables represent small amounts of variance. Having extracted values greater than 1, we are left with only three factors. These eigenvalues are displayed again, and the percentage of variance is explained in the column of Extraction: Sums of squared loadings. The values are found the same as those before extraction, what is different is that the values lower than 1.00 are discarded. In the last column (Rotation: Sums of Squared Loadings), the eigenvalues after rotation are also displayed. Here again

[24] Variance in factor analysis refers to the spreading of numbers. If the variance is small, it denotes that the data is close to the mean and to each other; and if it is high it signifies that they are spread out around the mean and around each other.

the same results (the percentages of variance) are found. We would, subsequently, partly confirm the first hypothesis in that three factors exist. However, the hypothesized factors are not confirmed so far. The investigation of the final factors is kept for the coming step.

4. **Loading of variables in factors and their rotation**

After the identification of the number of factors, one should provide an interpretation of each. The interpretation of factors requires first going through the pattern of factor loadings of the variables. In other words, we should examine the factor space that summarizes the relationship between the given variables. This step is accessed in SPSS through the choice of 'rotation' box. The rotation of factors allows us to understand the loading of factors in a simple structure[25] and, accordingly, determines the variables that define these factors easily. Different rotation methods appear in SPSS, and the choice of any method depends on the rotation type[26]. There are three methods for orthogonal rotation, viz. Varimax, Quartimax, and Equamax; and two methods for oblique rotation, viz. Direct Oblimin and Promax (Lee and Ashton, in Robins et al., 2007). Researchers (e.g. Field, 2009) call upon the use of oblique rotation if there is any theoretical assumption on the relationship between variables. On the other hand, orthogonal rotation is used when variables are believed to be completely separate. Researchers add that orthogonal rotation should be avoided in psychological testing for it is impossible that a psychological construct is totally independent from the other constructs. We have selected oblique

[25] In a simple structure the variables load on near 1 or near 0 on a factor. When they load on near 1, they better explain a factor; and when they load on near 0, they are less important for a factor. (Brown, 2009)

[26] There are two types of rotation: orthogonal rotation and oblique rotation. The former is used when one believes that factors are uncorrelated, while the latter is allowed when there is any thought of correlation between factors or when factors are believed to be aspects of a general factor.

rotation and particularly 'promax method' in our analysis due to the fact that our variables correlate.

The next step in the interpretation of factors is checking the participants' scores in each obtained factor. This step is accessed in SPSS through the selection of the box of 'factor scores and options'. Here again different methods appear: Regression, Bartlett and Anderson Rubin. The first method has been chosen as it is the most popular, and since the subjects' scores correlate in the three variables. After the choice of a method to calculate factor scores, SPSS recommends excluding data that seem problematic for our analysis; for this reason, we have checked the box of 'exclude data listwise' so that any participant with missing data for any variable will be excluded from the analysis.

In order to facilitate the interpretation of factors, SPSS involves an option to select how variables are ordered. The box of 'sort by size' places variables that load highly onto a factor together so to increase the clarity of these factors. Similarly, values less than the significance level should be omitted by choosing the option 'suppress absolute values less than a specified value'. Field (2009) recommends that the criterion value should be .40, which necessitates ignoring variables with less value. Tables 44 and 45 exhibit the loading of variables on factors before and after rotation.

	Components (factors)		
	1	2	3
Phonemic ability	,810	-,140	
Knowledge	,752	-,387	
OSPAN	,691	,482	-,147
Anagram	,671	,298	-,165
Inductive learning	,661	-,139	-,137
Analogies	,645	-,523	
Grammatical sensitivity	,596		,445
RSPAN	,481	,621	,306
Understanding relations	,568	,132	-,579
LSPAN	,552	-,111	,555

Table 44. Component Matrix

	Components (factors)		
	1	2	3
Analogies	,820		,156
Knowledge	,783	,176	269
Phonemic ability	,650	,384	,325
Inductive learning	,580	,340	,150
OSPAN	,178	,811	,205
Anagrams	,295	,672	,165
Understanding relations	,448	,636	-,265
RSPAN	-,179	,628	,533
LSPAN	,304	,183	,728
Grammatical sensitivity	,302		,656

Table 45. Rotated Component Matrix

5. Interpretation of the results

The findings of table 44 reveal that all the variables load highly onto the first factor, while the second and the third factors are ignored. However, after rotation, the loading of variables is clarified considerably (table 45). Having chosen the criterion value to be .40 (Field, 2009), the values above it will be considered in explaining the factors. The rotated component matrix demonstrates that four variables load highly onto the first factor (analogies, knowledge, phonemic ability, and inductive language learning ability), four other variables load onto the second factor (OSPAN, Anagrams, understanding relations, and RSPAN), and two variables load onto the third factor (LSPAN and grammatical sensitivity). After the identification of the variables loading onto the three factors, it is required from us to name the factors per se. There is no specific method to name the factors; nonetheless, examining the content of the loaded variables is helpful. This is because the variables loaded onto each factor must share a common theme. The labeling of the three factors is given below.

The four variables loaded onto the first factor (i.e. analogies, knowledge, phonemic ability and inductive learning ability) seem to measure a common ability which we would refer to as ‘verbal reasoning’. All the tasks for these variables intend to measure a specific type of reasoning which is named ‘inductive reasoning’. The subjects’ role in each task is to induce a conclusion from a set of premises. For example, in analogies subtest they were given a set of pairs and were asked to induce the pair with a similar relationship; in knowledge subtest, they induced what the given words represented; in phonemic ability subtest, the majority of the questions required the subjects to induce words with similar sounds (e.g. item 4) or meanings (e.g. item 5) to the given words; and in inductive language learning subtest, the subjects induced similar syntactic structures to the given sentences. It is worth noting that these tasks, in addition to measuring inductive reasoning skills, they also assess knowledge of the vocabulary of the foreign language (mainly analogies tasks, knowledge tasks and phonemic ability tasks). This has directed us to choose the name of ‘verbal reasoning’ as the first factor of Linguistic intelligence and ‘verbal reasoning subtest’ as a corresponding component of this ability measure.

The second four variables (OSPAN, anagrams, understanding relations, and RSPAN) loaded onto the second factor share another common theme which will be called ‘working memory’. Each of these variables assesses two main abilities simultaneously, viz. recall capacity and manipulation of information ability. In addition to remembering the perceived information in the four tasks, the subjects had to:

- perform the given mathematical operations or judge their accuracy in OSPAN;
- read the jumbled letters and arrange them in Anagrams;
- induce the right relationship between people or their arrangement in Understanding relations;
- and read the given sentences and understand the main idea of each in RSPAN.

The second factor of Linguistic intelligence would, hence, be designated as working memory, and the same name will be applied to the second subtest of Linguistic intelligence measure.

As far as the third factor is concerned, the two last variables (LSPAN and grammatical sensitivity) loading onto this factor intend to measure another common theme which will be termed 'grammatical ability'. The items in both tasks assess the participants' sensitivity to the structures of the foreign language. In LSPAN, for example, the participants were instructed to judge the semantic accuracy of the sentences on the basis of the perceived structures. Similarly, in grammatical sensitivity tasks, they induced a similar grammatical function to the underlined words. The third factor would, subsequently, be referred to as "grammatical ability" and the third subtest would take the same name.

6. Discussion

Factor analysis findings confirm the first part of the earlier research hypothesis in that three factors proved to exist for Linguistic intelligence. However, the factors were different from the hypothesized ones. In other words, working memory and verbal reasoning, as predicted, were found two main factors of Linguistic intelligence, yet grammatical ability, unexpectedly, replaced language aptitude. Therefore, working memory, verbal reasoning and grammatical ability are the ultimate factors of the overall dimension that is referred to as ‘Linguistic intelligence’. One should emphasize that the final concepts are but a precise designation of the earlier variables (language aptitude, working memory and verbal reasoning). This means that the three administered measures, excluding syllogisms subtest and similarity subtest, will be kept as the final constituent components of Linguistic intelligence measure.

7.2. The impact of Linguistic intelligence on language learning achievement

We have identified the constituent factors of Linguistic intelligence and the corresponding subtests of this ability measure in the previous section. In this section, we will examine the second major research hypothesis that addresses the degree of relationship between this cognitive linguistic capacity and language learning achievement. We have predicted earlier that the two constructs are closely interrelated and that each factor of Linguistic intelligence would have a noticeable impact on foreign language learning achievement. Since this hypothesis is closely related to the first hypothesis in that the predicted factors of Linguistic intelligence were themselves assumed to affect foreign language learning, and since some alterations have been made to the final factors of this ability (i.e. some variables that were included in the hypothesized factors shifted to the other factors and some variables were totally omitted, which would affect the obtained scores and create bias in the results), it is necessary to adapt the second hypothesis with regard to the findings of the first prediction. Our final hypothesis, thus, becomes as follows: Linguistic intelligence as with its final factors (verbal reasoning, working memory, and grammatical ability) would affect foreign language learning achievement. We will come back to this hypothesis below in the section. In testing this hypothesis, Linguistic intelligence and language learning achievement will be given scores; then correlations will be conducted between these scores. The section provides further analysis of Linguistic intelligence measure and highlights the construct of language learning achievement.

One key issue we should tackle in the analysis of Linguistic intelligence measure is assessing its reliability. The reasons behind doing so are twofold: first, this measure is considered the first trial to assess learners' cognitive linguistic capacity gaining insights from a battery of tests of cognitive linguistic aptitudes; and second, because any test cannot be considered a test unless it proved reliable. In addition to assessing the reliability of this measure, we will deal with the distribution of the subjects' overall scores as well as the scores of each component.

Concerning the analysis of language learning achievement, we will examine the subjects learning outcomes during the whole academic year. The obtained average for the first semester will be added to the one of the second semester, and the total will be divided on two to obtain the final achievement score. Besides, we will present a distribution of this variable scores and compare them with those of Linguistic intelligence to provide an overall view on the association between the two constructs.

7.2.1. Research question and hypotheses

The main question with regard to the impact of Linguistic intelligence on language learning achievement would be as follows: Does Linguistic intelligence predict language learning achievement? In other words, do differences in working memory capacity, verbal reasoning skill and grammatical ability, as the main constituent factors of Linguistic intelligence, underlie differences in language learning achievement?

In answering these questions we have hypothesized that Linguistic intelligence would affect achievement in language learning. A number of sub-hypotheses would be extracted from this prediction:

- Verbal reasoning, that is the first factor of Linguistic intelligence, would have a close association with language learning achievement.
- The second factor of Linguistic intelligence, that is working memory, would correlate highly with language learning achievement.
- Grammatical ability, as the third factor of Linguistic intelligence, would show a strong relationship with language learning achievement.

i. The correlation between Linguistic intelligence and language learning achievement

A number of steps should be followed in assessing the degree of association between Linguistic intelligence and language learning achievement. The first step is scoring the constructs; the second step is assessing the reliability of Linguistic intelligence measure; the third step is examining the distribution of scores for each variable; and the last step is calculating the correlation between the variables. A discussion of these steps is provided below.

1. Scoring the variables

We have stated earlier that Linguistic intelligence measure has been created after proving significant correlations between a battery of cognitive linguistic tests. It has been indicated also that some items were omitted from this measure for sharing non-significant relationships. In addition, a new factor emerged for this measure to replace a hypothesized one. All these reasons call for an application of new scoring procedures. These procedures will be discussed upon in the section.

a. Linguistic intelligence score

Linguistic intelligence is just a theoretical concept so far. The term has been created after proving strong correlations between three cognitive linguistic capacities (verbal reasoning, working memory, and grammatical ability). To make the term practical, it is required from us to adopt a score for this ability naming it ‘the score of Linguistic intelligence’.

The score of Linguistic intelligence will be divided on the number of items that were administered to assess this ability. Since only ten from twelve items were found with significant relationships (c.f. table 40), this score will be divided on them. We should indicate that we have chosen the value 100 as the score of perfection for this variable. After dividing this score equally on the ten items, we would get the value 10 as a threshold for each individual item. The scores of perfection in each subtest (i.e. analogies subtest, knowledge subtest, phonemic ability subtest, inductive learning subtest, OSPAN subtest, anagrams subtest, understanding relations subtest, RSPAN subtest, LSPAN subtest, and grammatical sensitivity subtest) should, subsequently, be converted into 10, and the subjects’ scores will be explained according to this value. Table 46 presents the subjects’ reproduced scores in the ten items as with Linguistic intelligence total score. The participants’ raw scores are shown in Appendix 3 (c.f. Table A. 4, A5, and A6).

Participants	Analogies / 10	Knowledge/ 10	Phonetic coding bility / 10	Inductive learning/ 10	OSPAN/ 10	ANAGRAMS/ 10	relations/ 10	RSPA N/ 10	LSPA N/ 10	Grammatical sensitivity/ 10	Final Linguistic intelligence score
1	6,83	10	7,66	4,5	5,7	4,5	6,5	7,81	5,7	8,25	67,45
2	2,66	5,5	6	9,25	4,8	6	8,5	5,81	3,9	5,75	58,17
3	2,83	5,75	5,75	6,5	6,8	4,75	5	8,37	6,1	6,25	58,1
4	3,66	5,5	7,91	6,5	5,9	5,5	5,75	8,12	6,4	8,5	63,74
5	2,16	3,75	5,25	7	5,9	5,25	1,25	9,31	7,8	8	45,67
6	1,83	7,5	5,41	6,5	5,2	2,25	7	7,81	6,6	7,75	58,02
7	1,33	3,75	5,5	7	5,6	3,25	4	8,75	9,6	7,25	56,03
8	6,5	10	8,41	8,25	6,7	6,5	6,25	9,12	7,6	9,25	78,58
9	3,33	4,25	3,25	8	3,5	2,25	3,75	7,87	4,5	6	46,7
10	2	5,5	6	3	5,6	4	7,5	8,81	5,6	8,25	56,26
11	2,16	2,5	4,33	4,5	4,5	1,75	2,5	7,68	4,2	7,25	41,37
12	3,16	5,5	7,08	8,5	4,8	1,75	00	5,93	6,7	10	53,42
13	1,83	2,5	5	7,5	7,2	5,5	8,5	8,87	2,7	5,75	55,35
14	2,33	3	6,5	7	6,5	3,5	6,75	6,81	5,2	7,75	53,04
15	1,5	4	3	8	5,6	5,75	4,25	8,06	6,8	3,75	50,71
16	5	6	3,41	3	5,5	3,25	6,5	7,56	6,8	4,25	51,27
17	3,83	5,5	3,91	0	5	1	6	8,06	6,5	3,5	43,3
18	3,66	5,5	5,58	7,5	5	1,5	2,25	8,56	8,4	8,25	56,2
19	2,83	7,5	5,5	5,5	7,6	7,5	7,5	9,31	7,7	7,5	68,44
20	00	1	3	3	3,3	1	3,75	7	6,8	6,25	35,1
21	5	3,75	3,91	2,5	5,3	3,5	4,5	7,25	7,4	7	50,11
22	2,83	2,25	4,33	1,5	5,1	2	4,25	8,68	6,4	4,25	41,49
23	3,83	4	3,66	00	4,1	1,5	4	8,12	7,2	4,75	41,16
24	6,66	1,75	6,08	1,5	3,9	1	4,25	5,43	4,7	5,5	40,77
25	5	4,25	4,16	2	5,5	3,25	6	9,12	9	8,25	56,53
26	5	4	4,33	3,5	5,6	1	1,25	7,06	6,8	1,5	40,04
27	1,33	5,75	3,5	4,5	4,1	2,75	3,75	6,87	4,4	5	41,95
28	2,5	2,5	4,16	1,5	4,3	1,75	2,5	7,93	4,1	9	40,24
29	6,5	10	6,5	7	7,9	3,75	8,5	9,31	8,6	8	76,06
30	6	10	6	7	4,4	3	7,5	6,87	7,3	5,25	63,32
31	4,66	2,25	5	4,5	6,5	5	4,25	7,5	4,8	7,25	51,71
32	3	3,25	4,83	5,5	6,4	4	5,75	9,31	5,5	6,75	54,29
33	4,83	8	6,25	7,25	5,3	5,25	5,5	7,37	6,5	7,25	63,5
34	6	5,5	6,25	5,5	5,3	3,75	4	6,68	6,5	7,25	56,73
35	3,16	2,25	4,16	2	5,2	4	2,5	7,56	4,9	4,25	39,98
36	1	4	6,83	4,5	7,7	3	2,75	8	5,8	8,25	51,83
37	1,66	5,75	3,25	2	4,4	4,25	4,25	5,18	8	5	43,74
38	00	1	4,08	2	5	2,25	5,5	7,43	4,1	6,25	37,61
39	8,16	10	6,25	8	7	4	10	9,12	6,7	7,75	76,98
40	1,83	5,75	3,08	3,5	5,8	1,5	2,75	8,37	5,4	7,5	45,48
41	1,5	7	3,83	1	5,5	5,25	1,5	8,56	4,7	7,75	46,59
42	00	4,25	6,16	0,5	6,8	4,75	3,75	7,56	5	9	47,77

43	1,33	2,5	2,75	5,75	5,1	2,25	4,25	6,68	4,2	7,25	42,06
44	00	2	2,75	1	5	1	4,5	7,43	3,6	5	30,53
45	7,83	7,5	6,41	8,5	7,3	2,75	7,5	8,25	7,1	7,25	70,39
46	0.16	1,5	3,53	3	4,3	1	1	8,56	5,1	2,75	30,9
47	00	1,25	2,91	0	4,5	3	4,75	8,25	4,5	7,25	36,41
48	6,33	6	8,08	7	8,4	4	5,5	9,68	9,4	9,5	73,89
49	3,16	4,25	7,25	4,5	7,1	5,5	7	7,62	6,7	9	62,08
50	0,5	3,75	3,08	0	4,6	1	3,75	6,12	5,2	4	32
51	5,5	5,5	3,75	4	4,9	1,25	3,75	6,06	4,1	6	44,81
52	4,66	7	3,16	5	5,2	4,5	2,75	7,5	4,5	8,5	52,77
53	00	1	3,5	0	6	1,75	3,75	6,62	2	1	25,62
54	5,16	2,25	5,16	6	6,3	2,75	1	6,5	3,9	6,25	45,27
55	4,83	4,25	4,5	6	4	0,75	4,25	8,5	3,7	7,75	48,53
56	1,83	00	3,41	5,5	7,1	2,25	5,5	8,81	4,4	4,25	43,05
57	3,83	3,75	5,16	5	5,7	3	8,5	7,93	4,2	4	51,07
58	0,16	3	4,33	5	5	1	3,25	6,81	3,8	2,75	35,1
59	6	7,5	6,83	5	6,4	5,25	4,5	6,87	4,2	8,25	60,8
60	0,66	2	3,16	0	3,5	3	2	6,56	4,8	7,75	33,43

Table 46. Subjects Scores Vis-à-Vis The Score 10

b. Language learning achievement score

Regarding the scoring of language learning achievement, we should note that since there was no administered test to assess this construct, the value (100) will be put as a threshold, and the participants averages will be explained according to it. In other words, the value (20) which represents the score of perfection and which is considered a threshold in the traditional calculation of the average will be converted into the value (100), and all the outcomes will be scored vis-à-vis this value. The participants' achievement raw scores and their conversion are displayed in Appendix 5 (c.f. table A.9).

2. Assessing the reliability of Linguistic intelligence test

The second step after scoring both constructs is assessing the reliability of the final Linguistic intelligence measure. In psychological testing or any other discipline, a test is not considered a test unless it proved reliable. Linguistic intelligence test is an outcome of a set of correlational studies, including factor analysis. This means that a number of tasks have been taken from a variety of measures (e.g. working memory tests, reasoning tests, language aptitude tests) to assess different aspects of this cognitive linguistic capacity. Due to the fact that Linguistic intelligence test is not a standardized test and because it is the first attempt to measure this ability, we should assess its reliability before we proceed in the analysis.

In assessing the consistency of the measure, the same technique that was adopted earlier (c.f. chapter 6.5) will be used. In other words, two types of correlation, viz. whole-part correlation (i.e. the correlation between the test total score and the score of its three components) and item-item correlation (i.e. the correlation between the test components) will be studied to determine whether the test is reliable. For example, an individual with average Linguistic intelligence should show average ability level in its three factors (i.e. working memory, verbal reasoning and grammatical ability). An observation of the subjects' obtained scores in this measure indicates equivalence between Linguistic intelligence total score and the score of its three components from the part of the majority (c.f. appendix 7). This has urged us to calculate the degree of association between the three components of Linguistic intelligence and the total score using the Pearson Product Moment Correlation Coefficient. The following tables display the results of both types of correlations after the use of SPSS software.

	Verbal reasoning	**Working memory**	**Grammatical ability**
Linguistic intelligence	.91	.74	.63

Table 47. The Correlation between Linguistic intelligence test and its Three Components

	Verbal reasoning	Working memory	Grammatical ability
Verbal reasoning	1		
Working memory	.50	1	
Grammatical ability	.52	.37	1

Table 48. The Correlation between the Three Components of Linguistic intelligence Test

Discussion

The critical value of r for one tailed test with (0.05) level of significance and with 59 degrees of freedom is (.25). Concerning the relationship between the overall Linguistic intelligence score and its three components, very strong correlations have been found, e.g. nearly a perfect correlation between the total score and verbal reasoning (.91), very high correlation between the total score and working memory (.74) and between the total score and grammatical ability (.63). As far as item-item correlation is concerned, table 48 reveals that the obtained value for r is also higher than the critical value (>.25), i.e. verbal reasoning and working memory (.50), verbal reasoning and grammatical ability (.52), and working memory and grammatical ability (.37). Therefore, the results prove that the test is highly reliable. This allows us to carry out the analysis of the correlation between Linguistic intelligence measure scores and language learning achievement scores.

Another worthwhile issue one could notice from table 47 is that in addition to assessing the reliability of the measure, the analysis of whole-part correlation gives us insights to determine the predictor of Linguistic intelligence. Verbal reasoning proved to be a better predictor for this ability in comparison to working memory and grammatical ability.

3. Distribution of scores

In assessing the correlation between two variables, it is useful to compare the distribution of scores for these variables. Two variables showing a significant correlation must show approximately similar distribution of scores. The distribution of Linguistic intelligence scores and language learning achievement scores is discussed further below.

a. Distribution of Linguistic intelligence scores

The distribution of Linguistic intelligence scores is not only important in measuring its correlation with achievement but also informative about the cognitive linguistic level of the participants. Intelligence tests (IQ tests) (e.g. Binet and Wechsler scales) reveal that the majority of individuals intend to have average ability level, while very few show exceptionally high or low scores. This study will reveal whether or not the distribution of the subjects' Linguistic intelligence scores corresponds to the one of IQ scores.

In examining the distribution of Linguistic intelligence scores, we should assess whether these scores follow a normal distribution (c.f. chapter 6.4). In doing so, we have first to classify the obtained scores into different ability levels (four quartiles). As the score of perfection is 100, the score 50 will be made as the mean score indicating average ability level. All the scores surrounding the mean, i.e. lying between 25 and 75, would reveal average ability level. Scores at or above 75 would reveal above average ability, whereas scores that lie at or below 25 would indicate below average ability. Exceptional scores, i.e. those that lie at or above the score 95 or those lying at or below the score 5, would indicate exceptional ability levels while the former scores indicate superior linguistic ability, the latter ones show a deficit.

The following figures exhibit SPSS findings of the distribution of Linguistic intelligence total scores as well as the scores of its final components (working memory, verbal reasoning and grammatical ability). The subjects' raw scores and their conversion into percentages are presented in Appendix 4 (c.f. Table A. 8).

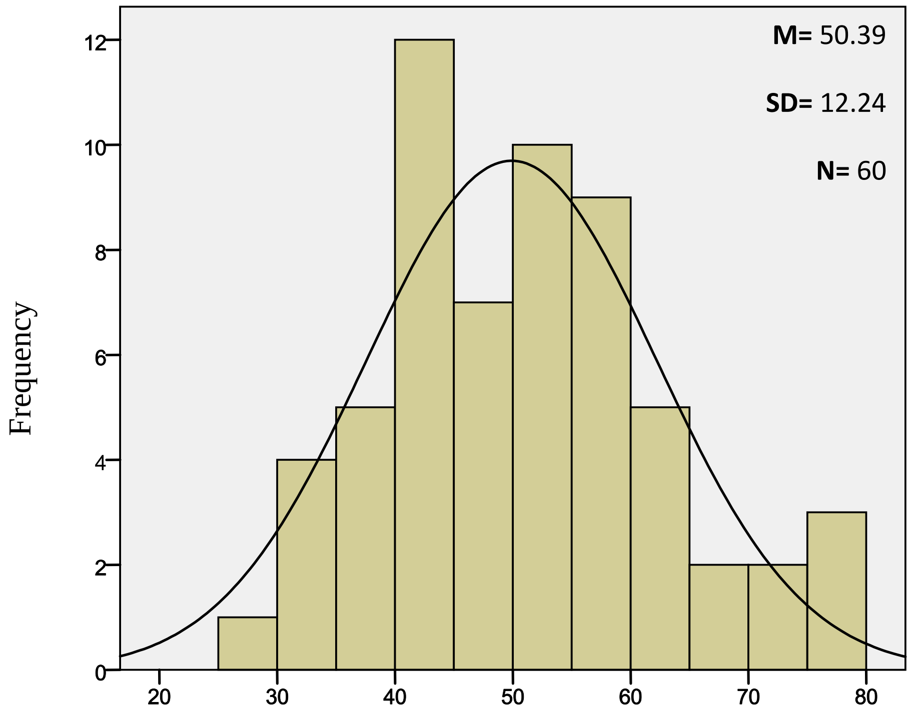

Figure 13. Distribution of Linguistic intelligence Total Scores

Figure 13 confirms the normal distribution of Linguistic intelligence scores with the mean 50.39 and Standard deviation 12.24. The figure shows also that the scores correspond to those of IQ, as approximately 68% of the population are situated between +1 standard deviation (65.24) and -1 standard deviation (33.74), and that 96% of the population are situated between +2 standard deviations (74.87) and -2 standard deviations (25.91). Similar to the previous distribution of scores (c.f. figure 10, 11, and 12), the scores are scattered around the mean, reflecting different ability levels. This means that these scores vary from mediocre ability (<25), to below average ability (25 or >), to average ability (50), to above average ability (<75), and to superior ability (>80), while the majority (frequency 12) are centred in the score 40 (reflecting near average capacity).

- **Distribution of verbal reasoning reproduced scores**

Verbal reasoning scores are first converted into percentages before their distribution. This is because these scores will be explained according to the score of perfection 100. The subjects' reproduced verbal reasoning scores and their conversion are presented in Appendix 4 (c.f. Table A. 8). The following figure displays the distribution of the first component of Linguistic intelligence measure.

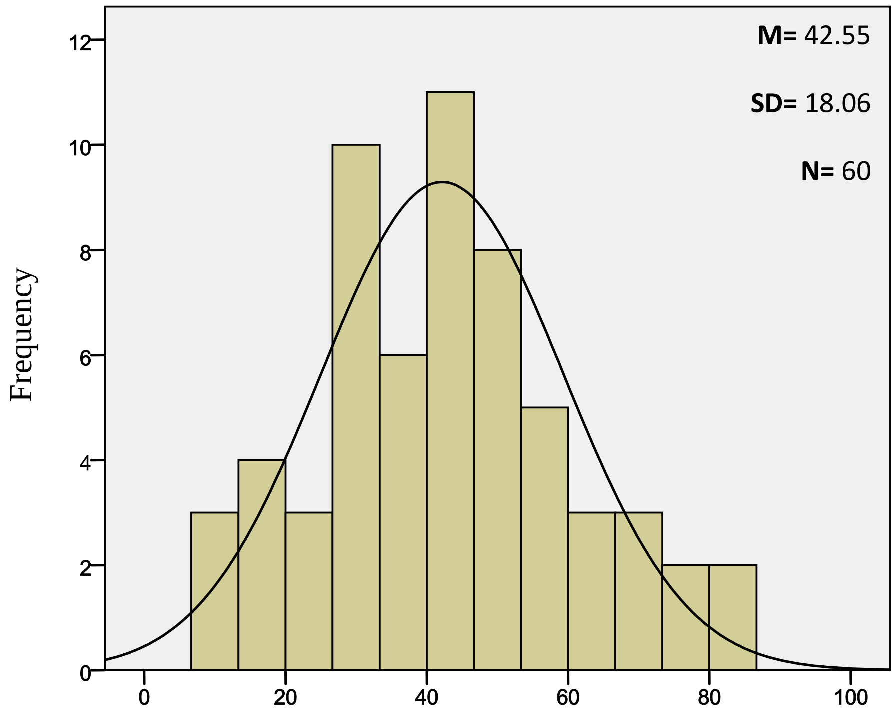

Figure 14. Distribution of Verbal Reasoning Reproduced Scores

Verbal reasoning scores are also observed to follow a normal distribution with the mean 42.55 and the standard deviation 18.06. While most of the participants (approximately 68 % of the population) are distributed between +1 (60.61) standard deviation and -1 (24.49) standard deviation, and 96% are situated between +2 standard deviations (78.67) and -2 standard deviations (6.43). The score are also noticed to be scattered around the mean, showing different levels of reasoning skill (they vary from below average ability to above average ability), while the majority of the subjects (frequency 11) lie on the score 40, reflecting near average level

- **Distribution of working memory reproduced scores**

Similar to the two previous variables, working memory scores are also converted into percentages so that they will be explained according to the same score of perfection. The participants working memory reproduced scores and their conversion into percentages are exhibited in Appendix 4 (c.f. Table A. 8). The following figure illustrates the distribution of working memory scores on the curve.

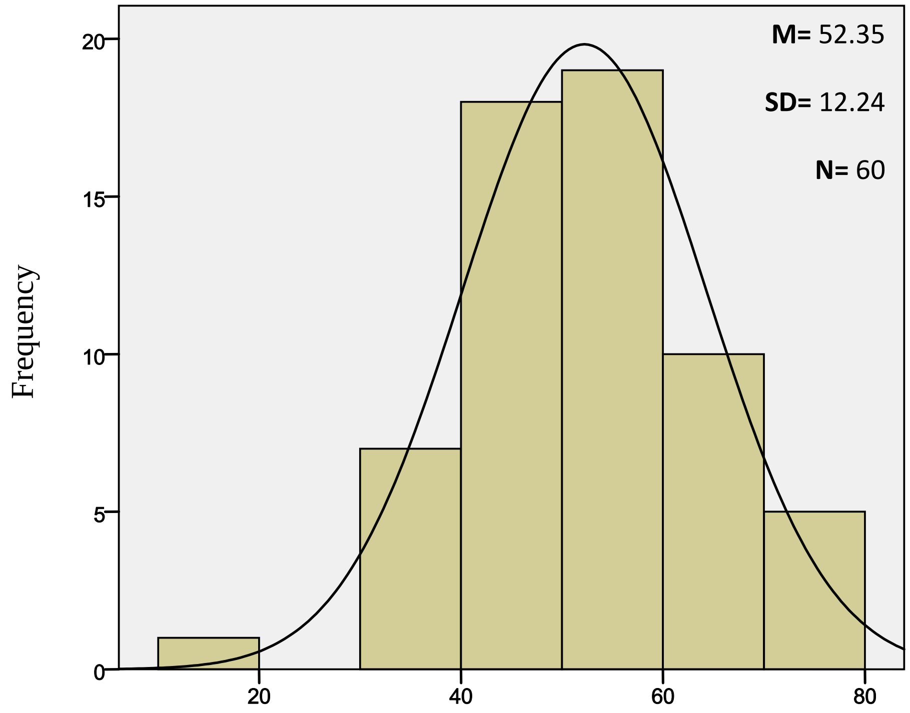

Figure 15. Distribution of Working Memory Reproduced Scores

The above curve reveals that the distribution of working memory sores is also similar to the two previous variables (i.e. verbal reasoning and the overall Linguistic intelligence) as well as IQ scores with the mean 52.35 and the standard deviation 12.24. The majority of the participants' scores (approximately 68% of the population) are situated between +1 standard deviation (64.59) and -1 standard deviation (40.11), and that 96% are situated between +2 standard deviations (76.83) and -2 standard deviations (27.87). Similar to the previous distribution of working memory test (c.f. figure 11), the scores are narrowly distributed around the mean, reflecting approximately similar working memory capacity, i.e. the majority of the scores (frequency 18) reside between 40 and 60. Similarly, there is an observation of very low working memory capacity (i.e. scores less than 20).

- **Distribution of grammatical ability reproduced scores**

The scores of the third component of Linguistic intelligence measure are also converted into percentages before their distribution. The results are exhibited in the following figure. Grammatical ability raw and reproduced scores are presented in Appendix 4 (c.f. Table A. 8).

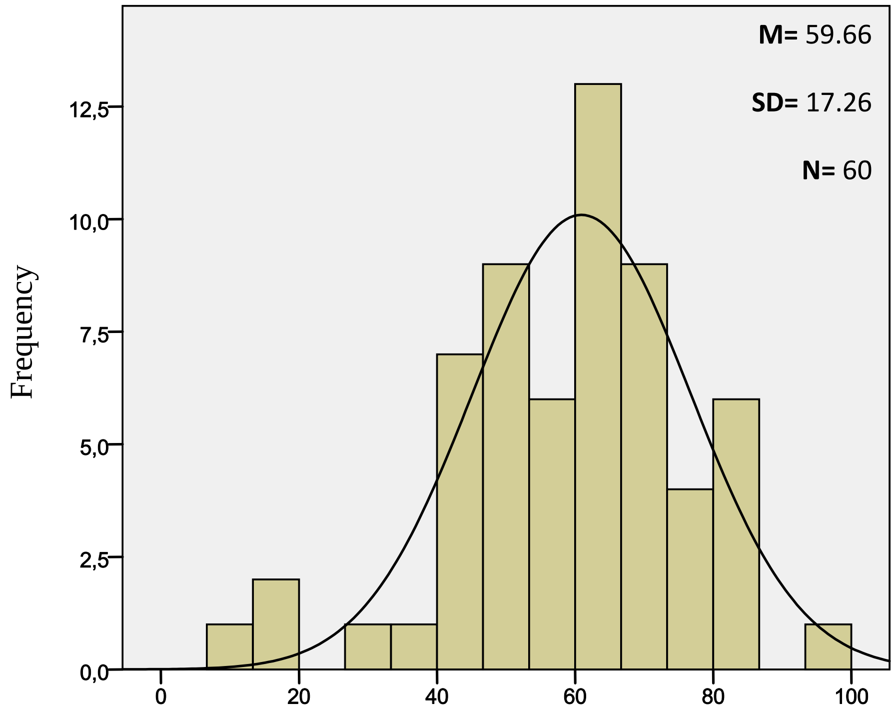

Figure 16. Distribution of Grammatical Ability Scores

Grammatical ability scores follow a normal distribution as well with the mean 59.66 and the standard deviation 17.26. Figure 16 indicate that 68% of the population are situated between +1 standard deviation (76.92) and -1 standard deviation (42.4), and that 96% are situated between +2 standard deviations (94.18) and -2 standard deviations (25.14). In addition, the figure demonstrates that the subjects' grammatical ability scores are scattered around the mean, reflecting different ability levels, while the majority (frequency 13) are centred approximately on the score 60, reflecting nearly above average capacity.

The observation of figures 14, 15, and 16 indicate that the distribution of Linguistic intelligence final components is somehow similar to the one of the predicted components (c.f. figures 10, 11, and 12). This means that both the predicted components (language aptitude, working memory and verbal reasoning) and the final components (verbal reasoning, working memory and grammatical ability) reveal different ability levels where the majority of the subjects reside in average scores. Therefore, we do confirm that the distribution of Linguistic intelligence scores is similar to the one of IQ scores.

b. Distribution of language learning achievement scores

In order to place our subjects in different levels of achievement, it is necessary to convert their language learning outcomes into scores (c.f. Table A. 6 for the participants' raw and reproduced achievement scores). Similar to Linguistic intelligence, language learning achievement score of perfection (100) is also divided into different ability levels. While the score 50 and the scores surrounding it (from 25 to 75) indicate average ability level, the scores below 25 indicate below average ability and the scores above 75 indicate above average ability. The scores below 5 reveal exceptionally low ability, whereas the scores above 95 indicate exceptionally high ability. The following figure exhibits the distribution of this variable scores.

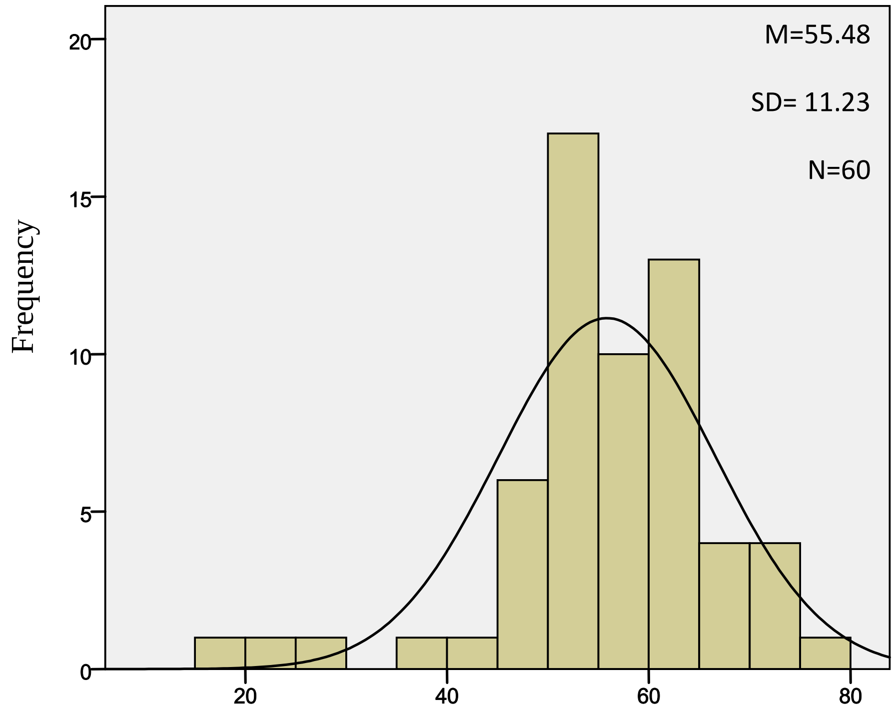

Figure 17. Distribution of Language Learning Achievement Scores

The observation of figure 17 indicates that language learning achievement shows a normal distribution of scores as well with the mean 55.46 and the standard deviation 11.23. The aforementioned figure also indicates that 68% of the population are situated between +1 standard deviation (66.71) and -1 standard deviation (44.25), and that 96% are situated between +2 standard deviations (77.94) and -2 standard deviations (33.02). Similarly, the figure demonstrates that the subjects' scores are scattered around the mean, reflecting individual differences in language learning achievementt, with the majority of scores centering between 55 and 65 (frequency 17) to show average level.

The comparison of the distribution of Linguistic intelligence and language learning achievement scores reveals a kind of linear relationship between the two constructs. The degree of this relationship will be calculated using the statistical technique correlation[27].

4. **Calculating the correlation between Linguistic intelligence and language learning achievement**

This part of the section addresses the strength of the relationship between Linguistic intelligence global scores and language learning achievement, as well as the association between each factor of the former ability and foreign language learning achievement. All these correlations are discussed further below.

a. **The correlation between Linguistic intelligence total score and language learning achievement**

The first question with regard to the second research hypothesis was: Does Linguistic intelligence predict language learning achievement? In order to determine the degree of relationship between Linguistic intelligence and language learning achievement we use the Pearson Product Moment Correlation Coefficient. This type of correlation is useful to examine the linear relationship between variables.

Significant results in the Pearson correlation output were obtained in SPSS software. Linguistic intelligence is proved to have significantly positive correlation with language learning achievement ($r = .40 > .25$). The moderate relationship between the two constructs suggests that the students who have a better linguistic ability would be more successful in foreign language learning than those with less Linguistic intelligence scores.

[27] For further details on correlation see chapter 4.3.4.1

The findings of the present study might add evidence to the influence of the cognitive aspect and particularly the cognitive linguistic aspect on foreign language learning achievement. While pioneers in human intelligence (e.g. Spearman, 1905; Thurstone, 1938; Cattell, 1967; Gardner, 1985; Sternberg, 1985, etc., c.f. chapter 1.1.4) emphasize the crucial role of intelligence in learning in general and language learning in particular, and working memory experts (e.g. Carroll, 1993; Baddeley, 2000, etc., c.f. chapter 3.4.1) underline the importance of working memory capacity in language learning, and language aptitude researchers (e.g. Dörnyei, 2005, c.f. chapter 2) highlight the impact of this ability on language learning, the current study assembles between all these views through extracting a common ability 'Linguistic intelligence' and proving its role in success in foreign language learning.

The significant association that is proved between Linguistic intelligence test and language learning achievement might open the way to researchers in maintaining the investigation of the relationship between the two constructs and examining whether significant results remain to be found. It might further urge teachers to apply the current test of Linguistic intelligence to learners who engage into a tertiary language instruction for the first time as a selection procedure to ensure success.

After proving a significant relationship between Linguistic intelligence and language learning achievement, it is required from us to investigate which factor shows the highest correlation and would, hence, predict success in foreign language learning. The prediction that the overall dimension Linguistic intelligence would correlate with achievement involves that each factor of the former ability would also be interrelated with the latter construct. In other words, the final factors of Linguistic intelligence (i.e. verbal reasoning, working memory, and grammatical ability) would show a significant association with achievement. The results of the correlation between Linguistic intelligence factors and language learning achievement are discussed below.

b. The correlation between verbal reasoning and language learning achievement

This part of the section tackles the degree of association between the first factor of Linguistic intelligence and language learning achievement. We have hypothesized that differences in achievement would be due to differences in verbal reasoning skill. Pearson correlation is opted for as a statistical method to calculate the degree of association between these variables. SPSS software displays significant results ($r= .36>.25$). Consequently, this moderate positive relationship might suggest that more skilful verbal reasoners are better foreign language learners.

c. The correlation between working memory and language learning achievement

To address the strength of association between the second factor of Linguistic intelligence and language learning achievement, we have hypothesized that the students with higher working memory capacity would have better achievement results. The same statistical technique of Pearson correlation is used to calculate the strength of association between these variables. The results, unexpectedly, reveal a non-significant relationship ($r= .19<.25$). These results, subsequently, disconfirm our second sub-hypothesis. We would attribute the inconvenience in the results to either the items used to measure this construct or to the physical conditions of this test, since most if not all researchers in the field of working memory and learning prove very close interrelationship (e.g. Baddeley and Hitch, 1974; Baddeley, 1999; 2000; 2003; Baddeley and Gathercole, 1990; Baddeley et al., 1998) (c.f. chapter 3.4.1).

d. The correlation between grammatical ability and language learning achievement

Our third sub-hypothesis that deals with the relationship between the third factor of Linguistic intelligence and language learning achievement is that grammatical ability would be strongly linked with language learning achievement. Again the Pearson Product Moment Correlation Coefficient is calculated to determine the degree of linear association between these constructs. Significant results are proved (r= .45>.25), which confirm this prediction. The results might add evidence to previous research findings on the relationship between grammatical ability and foreign language learning achievement (e.g. grammatical sensitivity for Carroll and Sapon, 1959; and inductive language learning ability for Skehan, 1998, c.f. chapter 2.2.1).

Conclusion

In this chapter we investigated the main study hypotheses that tackle the degree of relationship between Linguistic intelligence and language learning achievement. In doing so, we went through a number of steps.

The first required step in our investigation was to determine the different factors of Linguistic intelligence. As predicted, the results proved the existence of three factors. However, there was an alteration in the designation of some factors. While working memory and verbal reasoning remained intact, the concept of language aptitude turned to be addressed as grammatical ability.

Since Linguistic intelligence measure was considered the first attempt to assess this ability, it was necessary to check its consistency. The significant correlations indicated that the test was indeed reliable and, thus, allowed us to maintain the analysis.

Regarding the association between the overall Linguistic intelligence and language learning achievement, the Pearson correlation findings proved significant relationships. As for the link between this latter and the different factors of Linguistic intelligence, i.e. verbal reasoning, working memory, and grammatical ability, it varied from weak to moderate. Verbal reasoning showed a positively moderate significant association, working memory indicated a low correlation, and grammatical ability revealed the highest degree of relationship. This latter was found to be better predictor of success in foreign language learning. This leads to the confirmation of our major research hypothesis in that individual differences in Linguistic intelligence underlie individual differences in language learning achievement. From these results, we would conclude the following:

The cognitive linguistic aspect plays an important role in foreign language learning. Teachers would, hence, consider individual differences in the cognitive linguistic capacity in their teaching to improve language learning outcomes (c.f. the section on suggestions and recommendations).

Grammatical ability, as an aspect of Linguistic intelligence, also plays an important role in underlying success in foreign language learning. This implies that learning a foreign language requires the ability to learn its syntactic structures.

General conclusion and recommendations

1. **Summary and conclusion**
2. **Limitations of the study**
3. **Recommendations**
4. **Suggestions for future investigations**

General Conclusion and Recommendations

Having developed the issue of Linguistic intelligence throughout seven whole chapters, this chapter is mainly concerned with a general conclusion and a presentation of some key elements germane to the current study. The chapter starts with a summary of the focal points and the major results of the thesis. Then some limitations this work was confronted with are highlighted. A number of recommendations that spring out from the results of this investigation are also proposed. The chapter concludes with a presentation of some suggestions for future investigations.

1. Summary and conclusion

Second language acquisition is influenced by a variety of factors in which cognition plays a crucial role. Intelligence is an important cognitive factor that contributes to success in foreign language learning. The present study has highlighted one type of intelligence that is referred to as 'Linguistic intelligence', through examining its effects on foreign language learning achievement. The term 'Linguistic intelligence' has been introduced in the history of intelligence almost three decades now (Gardner, 1983); nevertheless, the concept per se has remained theoretical as there has been no true empirical evidence (i.e. most measures of Linguistic intelligence rely on Gardner's Multiple Intelligences theory, e.g. Armstrong MI Checklist, 1999; Walter McKenzie MI Inventory, 1999). Therefore, the current study has come out as an attempt to provide more empirical evidence to the concept through hypothesizing a set of skills as different factors of this ability. In this inquiry, we have considered the linguistic and psychological aspects of Linguistic intelligence and, hence, come to predict language aptitude, working memory capacity and verbal reasoning skill as its principal factors.

The major purpose of the current investigation is to design a Linguistic intelligence test and implement it in foreign language learning. The test purports to be an entry test for holders of Baccalaureate who engage into a tertiary language instruction (i.e. learning English as a foreign language at university). Unlike intelligence tests that are required in many universities all over the world, urging all entrants to take them before having access to any field, the current test does not deprive learners from learning what they wish. It rather seeks to reveal their areas of strength and weakness so to overcome the areas of weakness. The test aims also to indentify learners with language problems so to orient them to choose alternative fields. In addition, the test results might give insights in placing learners with equal abilities, and direct teachers to choose corresponding courses. Linguistic intelligence test might receive strong support, especially that it is carefully designed with the consideration of the psychological and the linguistic perspectives of linguistic ability. In order to fulfill these objectives, the present work sought to answer three major questions underlying two main hypotheses:

- What is Linguistic intelligence?
- Do working memory, language aptitude and verbal reasoning constitute the main factors of this ability?
- Does Linguistic intelligence affect foreign language learning achievement?

In answering the first question, a battery of tests including working memory test, language aptitude test, and verbal reasoning test have been administered at the beginning of the academic year to approximately seventy subjects from the population of first year students at the department of Letters and the English language, University of Mentouri

Brothers- Constantine. The results of the three tests have been correlated and factor analysis has been conducted to determine the ultimate factors of Linguistic intelligence. As for answering the second question, Linguistic intelligence final test results were correlated with those of language learning achievement, using the Pearson Product Moment Coefficient of Correlation to measure the degree of association between the two constructs. The results, globally, do confirm our hypotheses.

The concept of Linguistic intelligence has been thoroughly discussed throughout the study. Seven chapters have been devoted to provide theoretical and practical explanations of this ability. The first four chapters have highlighted the hypothesized factors of Linguistic intelligence as with presenting theoretical implications of the relationship between each hypothesized ability and language learning achievement.

The first chapter has been the gateway of the study. It has provided an overview of the concept of 'intelligence'. The various reviewed theories of this ability with regard to its nature, structure and measurement revealed the controversy of the issue of intelligence. In addition, the wide theoretical evidence that has been provided with the consideration of the role of intelligence in general and reasoning in particular, as an indistinguishable aspect of this ability, in foreign language learning has proved a close relationship. Concerning the second chapter that has introduced the concept of language aptitude- the second predicted ability of Linguistic intelligence-, many studies (c.f. chapter 2.5) have revealed a significant association between this ability and the general cognitive ability termed 'intelligence', as well as the essential role of language aptitude in the acquisition of foreign language sounds, words, and structures (c.f. chapter 2.4). As for the third chapter that has shed light on the third predicted factor of Linguistic intelligence that is referred to as 'working memory', previous findings (c.f. chapter 3.4.1) stressed the important role of this active process, basically in primary levels of acquisition when attention is highly required;

furthermore, the strong reviewed interrelationships between working memory and intelligence, on one hand, and working memory and language aptitude, on the other hand, have been considered the point of departure for our present investigation.

As far as empirical evidence is concerned, the findings of the first practical chapter have confirmed the consistency of language aptitude pilot test, working memory pilot test, and verbal reasoning pilot test, and suggested some adaptations to the final measures. The results of the second empirical chapter confirmed existing individual differences in language aptitude, working memory capacity and verbal reasoning skill. Besides, since some adaptations have also been made to the three final administered measures, it was necessary to reassess the reliability of these measures, and again, significant results have been shown and have, thus, encouraged us to maintain the analysis of the final Linguistic intelligence test. Within the same chapter, the results of the obtained scores in the three measures have indicated similar distribution of these scores which has given us insights that significant correlations would be found between the three abilities, and directs us to carry out the investigation of the main factors of Linguistic intelligence. As far as the final empirical chapter is concerned, factor analysis results have confirmed the existence of three different factors with a precision in the designation of the hypothesized factors. Language aptitude turned to be addressed as grammatical ability while the concepts of working memory and verbal reasoning kept the same appellations. Concerning the findings of the relationship between Linguistic intelligence and language learning achievement, significant correlations have been revealed. However, the correlations between language learning achievement and the final factors of Linguistic intelligence have not all been significant. More explicitly, grammatical ability and verbal reasoning have shown significantly moderate correlation, while working memory has revealed a weak relationship. We would attribute the non-significant correlation between working memory and language learning achievement to a number of imperfections that we were confronted by throughout our investigation.

2. Limitations of the study

A number of drawbacks and limitations have been encountered in the present study, mainly with regard to data collection, data analysis and physical conditions. Concerning data collection, the main problem that might affect the final results is the use of non-standardized tests in measuring language aptitude, working memory capacity and verbal reasoning skill. Stronger correlations would be obtained between the different factors of Linguistic intelligence and language learning achievement if these tests were standardized (with making some adaptations to fit the participants cognitive and linguistic abilities as well as their socio-cultural context) so that more accurate scoring procedures would be given. Besides, the small number of tasks in these tests and even in standardized tests can never be informative about the participants' real cognitive and linguistic skills.

As for data analysis, the period of four years is never sufficient in designing a test, assessing its reliability, and maintaining the examination of its influence on language learning achievement, so to implement it as an entry test to all universities for learners who intend to learn English as a foreign language. If we were given more time, we would adopt long-term reliability assessments (e.g. test-retest reliability, split-half reliability; alternate form reliability, or inter-rater reliability: c.f. chapter 4.3.3.1); and we would also provide a longitudinal research on the impact of this Linguistic intelligence on language learning achievement (for example, conducting an experiment on developing Linguistic intelligence and examining its effects on foreign language learning).

Furthermore, the physical conditions (laboratory materials not available) in the administration of the tests have not been very helpful. Taking the tests in small groups in the classroom and not individually in a lab might affect the subjects' outcomes in the administered tests and, subsequently, the results of the correlations, providing knowledge that the lab offers better physical conditions that are of paramount importance in psychological testing especially in assessing working memory capacity.

Despite these drawbacks, we have endeavored to make standard-like tests through carefully examining a sample of language aptitude tasks, verbal reasoning tasks and working memory tasks. We have also sought to warrant more reliable conditions by bringing an additional supervisor to enhance the supervision of the subjects and increase the reliability of the results.

3. Recommendations

The significant results of the relationship between Linguistic intelligence and language learning achievement might be of valuable assistance to the departments of the English Language, teachers and syllabus designers. These are some pedagogical recommendations the present work might offer:

We would highly recommend the implementation of Linguistic intelligence test in foreign language learning, through making it an entry test for students who register in a department of Letters and the English Language. This test might be "a ticket for access" that allows learners without cognitive and linguistic problems to have access to learning English as a foreign language, especially that it is carefully designed from the psychological and linguistic perspectives, i.e. it measures the learners' cognitive and linguistic abilities, and does not only center their proficiency with the language. At the beginning of 1980s (between 1984 and 1985) a test of proficiency was given by the Ministry of Higher Education as a selection basis for learners who opt to engage in a language program and led to very successful results; however, the test was no longer administered after a couple of years for unknown reasons. The current test of Linguistic intelligence comes to resurrect this test but with the consideration of the cognitive abilities in addition to linguistic proficiency.

The test results might not only be useful in allowing learners to have access to foreign language learning but also in revealing different levels of cognitive and linguistic abilities. This gives insights in placing learners with equal abilities and designing corresponding lessons, which opens the gate to future investigations on syllabus design. In addition, the test uncovers the students' areas of strength and weakness in the different aspects of this ability, i.e. working memory, verbal reasoning and grammatical ability and might, consequently, be more informative about the students needs, so that teachers will make intensive teaching to overcome the areas of weakness to enhance their Linguistic intelligence and subsequently their language learning achievement.

Having stated some pedagogical recommendations the general Linguistic intelligence test might provide, the following are additional recommendations the administered measures could offer:

As far as language aptitude test is concerned, the obtained results indicating individual differences in language aptitude might urge teachers to focus their attention on the learners' cognitive processing needs rather than seeking real life goals. In other words, learners might learn the foreign language better if there is more focus on their cognitive demands rather than teaching the language in real life contexts. In addition, language aptitude findings uncover the learners' areas of strength and weakness, in the different aspects of language aptitude (i.e. phonetic ability, grammatical sensitivity, and inductive language learning ability), which might direct teachers to place students with equal abilities and design corresponding lessons to overcome their areas of weakness. Insightful suggestions of how to cover the different aspects of language aptitude are provided in Skehan (1998).

The analysis of working memory findings has led us to provide a number of (insightful) suggestions which might be of beneficial support in language pedagogy. The results call for a careful consideration of individual differences in working memory capacity in a language instruction. The limited capacity of working memory urges teachers to select the number of words to teach with caution so to appropriately develop the learners' vocabulary repertoire and avoid distraction. For example, the new words that teachers intend to present in each session should not exceed the number Five (c.f. chapter 6.3), a combination of Miller's view (7 ± 2) and Cowan's view (4 ± 1). Similarly, the limited capacity system of WM that was proved from the test results would urge teachers to consider learners limited attention when presenting lessons, that is, for better memory storage and, hence, better learning, the material to be presented should not exceed this capacity. To this end, refreshing learners' attention would enhance learning. This can be done through making constant pauses when presenting materials to ensure the learners encoding.

In addition to attention, interference is a further aspect that is quite noticeable in WM test results. Teachers should, therefore, consider this aspect in their teaching practices. They should bear in mind that positive transfer that comes from their long term memory (from their mother tongue or from French) is but an outcome of interference of these languages, and the same way is true when it comes to negative transfer. Teachers are, hence, recommended to benefit from positive transfer when presenting new vocabulary.

For example they would refer to learners' mother tongue when presenting words like sugar, table, cake, etc. however, when teaching some language rules (e.g. prepositions), they should draw learners attention to the difference between their first language and English.

Besides, the test findings highlight the role of deep processing in storing information and, subsequently, encourage meaningful learning. For instance, teachers should present new vocabulary through the use of pictures, mimes or gestures to ensure long-term storage and, hence, long-term learning. In addition, examples of chunking (i.e. putting similar items together) and semantic associations (e.g. linking a new presented item with items that are stored in LTM) that the findings of this study have revealed might call attention to implementing memory strategies in enhancing working memory capacity and, thus, foreign language learning.

Furthermore, the significant results of the relationship between verbal reasoning and foreign language learning achievement might give suggestions to the teaching of foreign language structures. Individual differences in both types of verbal reasoning (deductive and inductive) affect the degree of internalizing these structures. Some might learn better inductively, i.e. through presenting examples first, whereas for some others, following the deductive approach, i.e. presenting the rule first, can bring better results. Teachers should, thus, be aware of these individual differences through varying the methods of teaching so to satisfy all the learners' needs. Besides, the interrelationship between verbal reasoning and foreign language learning achievement might give teachers insights to follow certain strategies to develop reasoning skills, which would result in enhancing foreign language learning achievement.

Last but not of least importance, the significant relationship between the cognitive linguistic constructs (working memory, verbal reasoning and language aptitude) might suggest that developing one of the abilities leads to the development of the others. More explicitly, concerning the relationship between working memory and verbal reasoning and working memory and language aptitude, the study advocates that practice on working memory tasks enhances working memory capacity and might result in improving verbal reasoning skills, and increasing language aptitude as well. As for the relationship between verbal reasoning and language aptitude, there is another suggestion that developing verbal reasoning through different strategies might increase aptitude for learning foreign languages.

4. Suggestions for future investigations

The present work might open the door to some possible avenues to be explored in the future. It would be very interesting if our Linguistic intelligence test was associated with one of Multiple Intelligences inventories (for example, Armstrong Multiple Intelligences checklist, or Walter McKenzie's Multiple Intelligences inventory), making both measures university entrance tests. The findings of the second measure (i.e. Multiple Intelligences inventory) might be a supportive mean to Linguistic intelligence test as they would confirm the participants' results in the administered test. Multiple Intelligences questionnaire would also give insights to better orient learners according to their areas of strength, especially that it measures a variety of abilities in addition to linguistic skills which are not investigated in the current Linguistic intelligence test. The administration of multiple intelligences questionnaire and the examination of the degree of its relationship with the test are our major concern for future studies.

Linguistic intelligence test might receive wide popularity in Algerian universities if more accurate assessments of reliability were adopted. This is considered another area of interest for future research. Test-retest reliability which requires the administration of Linguistic intelligence test to the same sample, at different points in time and the examination of the degree of association between the findings, would need to be explored in future works.

Another open door for future investigation is the design of experimental study to explore to what extent working memory and verbal reasoning, which are considered important factors of linguistic intelligence, affect foreign language learning achievement. Implementing memory and reasoning strategies in foreign language learning, and studying their effects would also need to be highlighted for future work.

As one goal of Linguistic intelligence test is to place learners with equal abilities and design corresponding courses, this latter might be considered a further area of future inquiry. The different areas of strength and weakness in the different aspects of linguistic skills would open the way to researchers to design courses so to overcome language problems and, hence, improve learning outcomes.

Hypothesizing language aptitude, working memory and verbal reasoning as the major factors of Linguistic intelligence does not only indicate that these are the only factors but also opens the way to hypothesizing further cognitive linguistic abilities that would be additional factors of Linguistic intelligence and would have an impact on foreign language learning.

Last but not of least importance, owing to the striking development in the use of technology, in general, in language teaching classrooms and computer-based language testing techniques in particular, a shift from paper and pencil Linguistic intelligence test to an automated test are to be investigated in future research.

We would conclude that the present work is just an attempt to revive the importance of the cognitive aspect in second language acquisition, when this issue is increasingly fading away especially that current theories shift attention to alternative factors, e.g. linguistic, affective and social factors. The current Linguistic intelligence test would, hopefully, be a very helpful means that enhances success in foreign language learning for emphasizing both cognitive and linguistic aptitudes.

References

AllIQtests.com. (2008-2013). Analogies Test (Online Test). Retrieved, October 21st, 2013. From <http://alliqtests.com/error.php>.

Alloway, T. P. & Alloway, R. G. (2009). The efficacy of working memory training in improving crystallized intelligence. *Nature Precedings*. Htl: 1010/npre.2009.3697.1.

Altarriba J. & Isurin, L. (Eds.). (2012). *Memory, language, and bilingualism: Theoretical and applied approaches*. Cambridge: CUP.

Alvarado, D.G., Ruef, M.L., & Schrank, F.A. (2005). Comprehensive Manual. *Woodcock-Muñoz Language Survey-Revised*. Itasca, IL: Riverside Publishing.

Analogies-Examples and Types. (2011). Fibonicci. Retrieved, September 17th, 2013. From <http://www.fibonicci.com/verbal-reasoning/word-analogies/examples-types>.

Anderson, M. & Reid, C. (2005). Intelligence. In M. Hewstone, F. Fincham & J. Foster (Eds.), *Psychology* (pp. 268-290). USA : Blackwell Publishing.

Aptitude. (2014). In *Merriam-Webster.com. Retrieved, November 16th, 2014.* From http://www.merriam webster.com/dictionary/aptitude/.

Armstrong, T. (1999). *7 Kinds of Smart: Identifying and Developing Your Many Intelligences.* New York: Plume.

Ary, D., Jacobs, L. C., Sorensen, C & Razavieh, A. (2010). *Introduction to Research in Education*. (8th Ed.). Belmont: Wadsworth, Cengage Learning.

Atkinson, R. C., & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. In K. W. Spence (Ed.), *The psychology of learning and motivation: Advances in research and theory* (pp. 89–195). New York: Academic Press.

Avery, M. B., Chun, A., Downing, B., Maynard, M., Ruschke, K., Bidar-Sielaff, S. & Roat, C. (April, 2001). Language Testing Options. *The National Council on Interpretation in Health Care Working Paper Series.* Claremont, CA : Robert Wood Johnson Foundation.

Axelrod, B. N. (2001). Administration duration for the Wechsler Adult Intelligence Scale-III and Wechsler Memory Scale-III. *Archives of Clinical Neuropsychology*, 16, pp. 293-301.

Baddeley, A. D. (1986). *Working Memory*. New York: OUP

Baddeley, A. D. (1996). Exploring the central executive. *The Quarterly Journal of Experimental Psychology*, 49A, pp. 5–28.

Baddeley, A. D. (2000). The Episodic Buffer: A New Component of Working Memory? *Trends in Cognitive Sciences*, 4 (11), pp. 417-423.

Baddeley, A. D. (2003a). Working memory: Looking back and looking forward. *Nature Reviews: Neuroscience*, 4, pp. 829–839.

Baddeley, A. D. (2003b). Working memory and language: An overview. *Journal of Communication Disorders*, 36, pp. 189–208.

Baddeley, A. D. (2004). The Psychology of Memory . *The Essential Handbook of Memory Disorders and Clinicians*. In A. D. Baddeley, M. D. Kopelman & B.A. Wilson (Eds.) (pp. 01-14). Chinchester: John Wiley and Sons Ltd.

Baddeley, A. D. (2012). Working Memory: Theories, Models, and Controversies. *Annual Review of Psychology*, 63, pp. 1-29.

Baddeley A. D. & Hitch, G. (2000). Development of Working Memory: Should the Pascual-Leone and the Baddeley and Hitch Models Be Merged? *Journal of Experimental Child Psychology 77* , pp. 128-137.

Baddeley, A. D. & Repovš G. (2006). The Multi-Component Model of Working Memory: Explorations in Experimental Ccognitive Psychology. *Neuroscience* 139, pp.5-21.

Baecher, R. E. (Jan, 1982). *Bilingualism, Language Proficiency, and Language Learning: Issues and Definitions.* Speeches/Conference Papers. pp. 01-25.

Bailey, H. (2012). Computer-paced versus experimenter-paced working memory span tasks: Are they equally reliable and valid? *Learning and Individual Differences* 22, pp. 875–881

Bain, S. K., McCallum, R. S., Bell, S. M., Cochran, J. L., & Sawyer, S. C. (2010). Foreign language learning aptitudes, attitudes, attributions, and achievement of postsecondary students identified as gifted. *Journal of Advanced Academics, 22*, pp. 130–156.

BankersALgo.com. (2013). Banker's Algo Preparation Tools. Retrieved, October 21st, 2013. From <http://bankersalgo.com/Prep_Tool_Question.php?13>.

Becker, K. A. (2003). *History of the Stanford-Binet intelligence scales: Content and psychometrics.* (Stanford-Binet Intelligence Scales, Fifth Edition Assessment Service Bulletin No. 1). Itasca, IL: Riverside Publishing.

Beiera, M. E., & Ackerman P. L. (2004). A reappraisal of the relationship between span memory and intelligence via best evidence synthesis. *Intelligence,* 32, pp. 607–619.

Bowden, H.W., Sanz, C. & Stafford, C. (2005). Individual differences: Age, sex, working memory, and prior knowledge. *Mind and Context in Adult Second Language Acquisition: methods, theory, and practice.* In C. Sanz (Ed.) (pp. 105-140). Washington: Georgetown University.

Brown, D. (2007). *Principles of Language Learning and Teaching* (5th ed.). NY: Pearson Education.

Brown, J.D. (November, 2009). Choosing the Right Type of Rotation in PCA and EFA. *Shiken: JALT Testing & Evaluation SIG Newsletter. 13* (3), pp. 20 – 25.

Carroll, J. B. (1993). *Human cognitive abilities: A survey of factor analytic studies*. New York: Cambridge University Press.

Carter, P. (2005). *The Complete Book of Intelligence Tests*. England: John Willey and Sons.

Carter, R. & Nunan, D. (2001). (Eds.) *The Cambridge Guide to Teaching English to Speakers of Other Languages.* Cambridge: CUP.

Chan E., Skehan, P. & Gong, G. (2011). Working memory, phonemic coding ability and foreign language aptitude: Potential for construction of specific language aptitude tests – the case of Cantonese. *Ilha Do Desterro: A Journal of English language, literatures and cultural studies*, 60, pp. 45-73.

Child, J. R. (1998). Language aptitude testing. In L. Woytak (Ed.). *Applied Language Learning*, 9 (1 & 2), pp. 1-10.

Cognitive Fun. (2012). Cognitive tests: Reading Span Test (Online test). Retrieved, October 8th, 2013. From <http://cogpsy.info/language/reading-span-test>.

Cohen, L., Manion, L. & Morrison, K. (2000). *Research Methods in Education.* (5th Ed.). London: Routledge.

Comrey, K. (2000). GUILFORD, JOY PAUL. In A.E. Kazdin (Ed.) *Encyclopedia of Psychology*, (pp. 38-39) New York: OUP.

Conway, A., Cowan, N., Bunting, M.., Therriaul, D., Minkoff, S. (2002). A latent variable analysis of working memory capacity, short-term memory capacity, processing speed, and general fluid intelligence. *Intelligence*, 30, pp. 163-183.

Copeland, D. & Radvansky, G. (2004). Working memory and syllogistic reasoning. *The Quarterly Journal of Experimental Psychology Section A: Human Experimental Psychology*, 57 (8), pp. 1437-1457.

Cowan, N. (2000). The magical number 4 in short-term memory: A reconsideration of mental storage capacity. *Behavioural and Brain Sciences*, *24* , pp. 87-185.

Cowan, N. (2010). The magical mystery four: How is working memory capacity limited, and why? *Current Directions in Psychological Science,* 19, pp. 51-57.

Craik, M. & Lokhart R. S. (1990). Levels of processing: A retrospective commentary on a framework for memory research. *Canadian Journal of Psychology,* 44 (1), pp. 87-112.

Craik, M. &Tulving, E. (1975). Depth of processing and the retention of words in episodic memory. *Journal ol Experimental Psychology: General*, 104 (3), pp. 268-294.

Cronbach, L.J. (1984). *Essentials of Psychological Testing*. (4^{th} edition.). New York: Harper and Row publishers

Cummins, J. (1979). Cognitive/academic language proficiency, linguistic interdependence, the optimum age question and some other matters. *Working Papers on Bilingualism,* 19, pp. 121–129.

Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior,* 19, pp. 450–466.

Dang, C. P., Braeken, J., Ferrer, E. & Liu, C. (2012). Unitary or non-unitary nature of working memory? Evidence from its relation to general fluid and crystallized intelligence. *Intelligence*, 40 (5), pp. 499-508.

Dehn, M. (2008). *Working Memory and Academic Learning Assessment and Intervention*. New Jersey: John Willey and Sons.

Del Vecchio, A., & Guerrero, M. (1995). *Handbook of Language Proficiency Tests.* Albuquerque, NM: Evaluation Assistance Center.

Dörnyei, Z. (2005). *The psychology of the language learner: Individual differences in second language acquisition*. Mahwah , NJ : Lawrence Erlbaum.

Dörnyei, Z. (2006). Individual differences in second language acquisition. in K. Bardovi-Harlig & Z. Dörnyei (Eds.). *Themes in SLA Research. AILA Review*, 19, pp. 42–68. Amsterdam: John Benjamins.

Dörnyei, Z. (2010). The relationship between language aptitude and language learning motivation: Individual differences from a dynamic systems perspective. In E. Macaro (Ed.) *Continuum companion to second language acquisition* (pp. 247-267). London: Continuum Books.

Ehrman, M. (1998). The modern language aptitude test for predicting learning success and advising students. In L. Woytak (Ed.). *Applied Language Learning*, 9 (1 & 2), pp. 31-70.

Ellis, R. (2003). *Second Language Acquisition*. Oxford : OUP.

Engle, R. W. (2002). Working memory capacity as executive attention. *Current Directions in Psychological Science,* 11, pp. 19-23.

Evans, J. B.T. (Ed.). (2004). *Thinking & Reasoning. Special Issue: Development and Reasoning*, 10 (2), pp. 113–240.

Fibonicci (2011) Analogies Aptitude Test (Online test). Retrieved, October 21st, 2013 from <http://www.fibonicci.com/verbal-reasoning/analogies-test/>.

Field, L. P. (2009). *Discoving Statistics using SPSS* (2nd edition). London, Sage.

Gallagher, J. M., & Reid, D. K. (1981). *The learning theory of Piaget and Inhelder*. Monterey, Calif.: Brooks/Cole Pub.

Gardner, H. (1983). *Frames of Mind: The Theory of Multiple Intelligences*. New York: Basic Books.

Gardner, H. (2011). *Fames of Mind: The Theory of Multiple Intelligences*. (2nd Ed., 10th Anniversary). New York: Basic Books.

Gass, S. & Selinker, L. (2008). *Second Language Acquisition: An Introductory Course*. New York, NY: Routledge.

Gray, J. R., Chabris, C. F. & Braver, T. S. (2003). Neural mechanisms of general fluid intelligence. *Nature Neuroscience*, pp. 1-7.

Grégoire, J. (2004). Factor structure of the French version of the Wechsler Adult Intelligence Scale-III. *Educational and Psychological Measurement,* 64, pp. 463-474.

Grigorenko, E.L. & Sternberg, R. J. (2001). Analytical, creative, and practical intelligence as predictors of self-reported adaptive functioning: a case study in Russia. *Intelligence,* 29, pp. 57-73.

Grigorenko, E. L., Sternberg, R. J. & Ehrman, M. (2000). A theory-based approach to the measurement of foreign language learning ability. The CANAL-F theory and test. *The Modern Language Journal,* 84 (4), pp. 390–405.

Guilford, J. P., & Fruchter, B. (1978). *Fundamental statistics in psychology and education* (6th ed.). New York: McGraw-Hill.

Holyoak, K. J. & Morrison, R. G. (Eds.). (2005*). The Cambridge Handbook of Thinking and Reasoning.* Cambridge: CUP.

Horn, J. L. & Cattell, J. B. (1967). Age differences in fluid and crystallized intelligence. *Acta Psychologica*, 26, pp. 107-129.

Hummel, K. M. (2009). Aptitude, phonological memory, and second language proficiency in nonnovice adult learners. *Applied Psycholinguistics*, 30 (2), pp. 225-49.

IndiaBix. (2008-2013). Online Verbal Reasoning Test. Retrieved, October 21st , 2013). From <http://www.indiabix.com/online-test/verbal-reasoning-test/51>.

Jaeggi, S.M., Buschkuehl, M., Jonides, J. & Perrig, W. (2008). Improving fluid intelligence with training on working memory. *Psychology*, 105 (19), pp. 6829–6833.

Jarrold, C., Towse, J. N. (2006). Individual differences in working memory. *Neuroscience,* 139, pp. 39–50.

Juffs, A. (2006). Working Memory, Second Language Acquisition and Low-Educated Second Language and Literacy Learners. In I. V. de Craats, J. Kurvers & M.Y.Scholten (Eds.), *Low-Educated Second Language and Literacy Acquisition*. (pp. 89-100). The Netherlands: Tilburg University.

Kane, M. J., & Engle, R.W. (2002). The role of prefrontal cortex in working-memory capacity, executive attention, and general fluid intelligence: An individual-differences perspective. *Psychonomic Bulletin and Review*, *9*, pp. 637-671.

Kane, M. J. and Engle, R. W. (2003). Working-memory capacity and the control of attention: the contributions of goal neglect, response competition, and task set to stroop interference. *Journal of Experimental Psychology: General*, 132 (1), pp. 47–70.

Kane, M. J., Hambrick, D.Z., & Conway, A. R. A. (2005). Working memory capacity and fluid intelligence are strongly related constructs: Comment on Ackerman, Beier, and Boyle. *Psychological Bulletin*, 131, pp. 66-71.

Kelly, C. (1998). Activities for ESL Students a4esl.org. *Interactive JavaScript Quizzes for ESL Students.* Retrieved, October 8th, 2013. From <http://a4esl.org/q/j/ck/mc-spelling.html>.

Kemerling, G. (2011). Categorical syllogisms. *Britannica : Philosophy*. Retrieved, October 8th, 2013. From <http://www.philosophypages.com/lg/e08a.htm>.

Kempen, G. (1992). Second language acquisition as a hybrid learning process. In F. Engel, D. Bouwhuis, T. Bösser, & G. d'Ydewalle (Eds.), *Cognitive modeling and interactive environments in language learning* (pp. 139-144). Berlin: Springer.

Kormos, J. & Sáfár, A. (2008). Phonological short-term memory, working memory and foreign language performance in intensive language learning. *Bilingualism: Language and Cognition,* 11 (2), pp. 261-271.

Kothari, C. R. (2004). *Research Methodology: Methods and Techniques*. New Delhi: New Age International.

Krashen, S. (1981). *Second language acquisition and second language learning.* South California: Pergamon.

Krashen, S. D. & Terrell, T. D. (1983). *The natural approach: Language acquisition in the classroom*. London: Prentice Hall Europe.

Kyllonen, P. C. & Christal, R. E. (1990). Reasoning ability is (little more than) working-memory capacity?! *Intelligence,* 14, pp. 389-433.

Language. (2014). In *Merriam-Webster.com. Retrieved, December 8th, 2014. From* <http://www.merriam-webster.com/dictionary/language>.

Learning. (2014). In *Merriam-Webster.com. Retrieved, December 8th, 2014.* From <http://www.merriam-webster.com/dictionary/learning>.

Leighton, J. P., & Sternberg, R.J. (Eds.). (2004). *The nature of reasoning*. New York, NY: CUP.

Llurda, E. (2000). On competence, proficiency and communicative language ability. *International Journal of Applied Linguistics,* 10, pp. 85-96.

Lowe, Jr. (1998). Zero-Based Language Aptitude Test Design Where's the Focus for the Test? In L. Woytak (Ed.). *Applied Language Learning*, 9 (1 & 2), pp. 11-30.

Lutz, S., & Huitt, W. (2003). Information processing and memory: Theory and applications. *Educational Psychology Interactive*. Valdosta, GA: Valdosta State University. Retrieved, (October 8th, 2014), from <http://www.edpsycinteractive.org/papers/infoproc.pdf>.

Lynch, R. (2003). Authentic, performance-based assessment in ESL/EFL reading instruction. *Asian EFL Journal*, pp. 1-28.

Macleod, C.M. (1979). Individual differences in learning and memory: A unitary information processing approach. *Journal of Research in Personality*, 13, pp. 530-545.

Maehara, Y. & Saito, S. (2007). The relationship between processing and storage in working memory span: Not two sides of the same coin. *Journal of Memory and Language, 56 (2)*, pp. 212-228.

Manktelow, K. (1999). *Reasoning and Thinking*. UK: Psychology Press.

Marczyk, G., DeMatteo, D., Festinger, D. (2005). *Essentials of Research Design and Methodology*. New Jersey: John Willey & Sons.

Massaro, D.W., & Cowan, N. (1993). Information processing models: Microscopes of the mind. *Annual Review of Psychology*, 44, pp. 383-425.

McKenzie, W. (1999). Multiple Intelligences Inventory. Retrieved, October 8th, 2013, from <http://surfaquarium.com/MI/inventory.htm>.

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, 63, pp. 81–97.

Miller, M. D. (2008). Reliability. In N.J. Salkind (Ed.), *Encyclopedia of Educational Psychology* (pp. 846-852). Los Angelos: Sage Publictions

Millisecond. (2013). Automated OSPAN (Measurement Instrument). Retrieved, October 21st ,2013. From <http://www.millisecond.com/download/library/OSPAN/>.

Miyake, A. & Shah, P. (1999). *Models of Working Memory: Mechanisms of Active Maintenance and Executive Control.* Cambridge : CUP.

Neisser, U., Boodoo, G, Bouchard, T., Boykin, A., Brody,N., Ceci,S., Halpern, D., Loehlin,J., Perloff, R., Sternberg, R. & Urbina, S. (1996). Intelligence: Knowns and Unknowns. *American Psychologist, 51 (2)*, pp. 77-101.

Nyberg, L., Forkstam C., Petersson K, Cabeza, R. & Ingvar, M. (2002). Brain Imaging of Human Memory Systems: Between-Systems Similarities and Within-System Differences. *Cognitive Brain Research, 13*, pp. 281-292.

Oller, J. W., Kim, Jr., K. & Choe, Y. (2000). Testing verbal (language) and nonverbal abilities in language minorities: a socio-educational problem in historical perspective. *Language Testing,* 17 (3), pp. 341-360.

Online adult Wechsler intelligence scale test. (2013). Retrieved, October 10th, 2013. From: <http://wechsleradultintelligencescale.com>.

Pellegrino, J. W. & Kail, R. (1985). *Human Intelligence.* NewYork: Freeman.

Piaget, J. (1950). *The Psychology of Intelligence*. London: Routledge and Kegan Paul.

Psychometric success. (2013). Verbal ability spelling test. Retrieved, October 8th, 2013. From <http://www.psychometric-success.com/downloads/download-verbal-spelling-practice-tests.htm>.

Ranta, R. (2008). Aptitude and good language learners. *In* C. Griffiths (Ed.). *Lessons from Good Language Learners*.(pp. 142-158*).* Cambridge: CUP.

Raven, J. (2000). The Raven's Progressive Matrices: Change and Stability over Culture and Time. *Cognitive Psychology,* 41, pp. 1–48.

Reed, D. J. & Stansfield, C.W. (May 16 – May 18, 2002). *The Use of the Modern Language Aptitude Test in the Assessment of Foreign Language Learning Disability*. Presented at the Language Assessment Ethics Conference, Pasadena, CA.

Richards, J. C., & Rodgers, T.S. (1986). *Approaches and Methods in Language Teaching*. New York: CUP.

Riccio, C. A., Rodriguez, O.& Valle, M. (2005). Contemporary measures of intelligence. In S.W. Lee (Ed.), *Encyclopedia of School Psychology* (pp. 271-272). London: Sage Publications.

Rips, L. J. (1990). Reasoning. *Annual Review of Psychology*, 41, pp. 321-53.

Robins, R. W., Fraley, R. C., & Krueger, R. F. (Eds.). (2007). *Handbook of research methods in personality psychology*. New York: Guilford Press.

Robinson, P. (2005). Aptitude and second language acquisition. *Annual Review of Applied Linguistics*, 25, pp. 45-73.

Roid, G.H. (2003). *Stanford-Binet Intelligence Scales*, *Fifth Edition* (SB:V). Itaska, IL: Riverside Publishing.

Sáfár, A. & Kormos, J. (2008). Revisiting problems with foreign language aptitude. *International Review of Applied Linguistics in Language Teaching*, 46 (2), pp. 113-136.

Sanchez , C. A. , Wiley, J., Miura, T. K., Colflesh, G. J. H., Ricks, T., R., Jensen, M. S. and Conway, A. R. A. (2010). Assessing working memory capacity in a non-native language. *Learning and Individual Differences*, 20, pp. 488–493.

Sasaki, M. (2012). The Modern Language Aptitude Test (Paper-and-Pencil Version). *Language Testing*, 29, pp. 315-321.

Schacter, D. L. (1987). Implicit Memory: History and Current Status. *Journal of Experimental Psychology*, 13 (3), pp. 501-518.

Schrank, F. A. (2010). Woodcock-Johnson III Tests of Cognitive Abilities. In A. Davis (Ed.). *Handbook of Pediatric Neuropsychology*. New York, NY: Springer Publishing Company.

Schunk, D.H. (2012). *Learning Theories: An Educational Perspective*. (6th edition). Boston, Pearson Education .

Schweizer, K. & Moosbrugger, H. (2004). Attention and working memory as predictors of intelligence. *Intelligence,* 32, pp. 329–347.

Skehan, P. (1998). *A Cognitive Approach to Language Learning.* Oxford: Oxford University Press.

Slavin, R. E. (2006). *Educational Psychology: theory and practice*. (8th ed.). USA: Pearson Education.

Sparks, R., & Ganschow, L. (1993). The impact of native language learning problems on foreign language learning: Case study illustrations of the linguistic coding deficit hypothesis. *Modern Language Journal*, 77, pp. 58-74.

Sparks, R., & Ganschow, L. (2001). Aptitude for learning a foreign language. *Annual Review of Applied Linguistics,* 21, pp. 90-111.

Sparks, R. L., Javorsky, J., Patton, J., and Ganschow, L. (1998). Factors in the Prediction of Achievement and Proficiency in a Foreign Language. In L. Woytak (ed.). *Applied Language Learning*. 9 (1&2), pp. 71-105.

Sparks, R., Patton, J., Ganschow, L., Humbach, N. (2011). Subcomponents of Second-Language Aptitude and Second-Language Proficiency. *The Modern Language Journal*, 95 (2), pp. 253-73.

Spearman, C. (1904). General Intelligence Objectively Determined and Measured. *The American Journal of Psychology*, 15 (2), pp. 201-299.

Spearman, C. (1927). *The Abilities of Man: Their Nature and Measurement*. London, Macmillan and Co.

Stansfield, C. (2013). Modern Language Aptitude Test. Language learning and testing foundation. Retrieved, October 8th, 2013. From <http://lltf.net/aptitude-tests/language-aptitude-tests/modern-language-aptitude-test-2/>.

Stern, H.H. (1983). *Fundamental Concepts of Language Teaching*. Oxford: OUP.

Sternberg, J. R. (1985). *Beyond IQ: A Triarchic Theory of Human Intelligence.* Cambridge: CUP.

Sternberg, R. J. & Grigorenko, E. L. (Eds.). (2002). *The general factor of intelligence. How general is it?* New Jersey: Lawrence Erlbaum Associates.

Sternberg, R. J., & Kaufman, J.C. (1998). Human Abilities. *Annual Review of Psychology*. 49, pp. 479-502.

Sternberg, R. J & Kaufman, J.C. (2011). *The Cambridge Handbook of Intelligence*. New York: CUP.

Stevick, E. W. (1976). *Memory, Meaning and Method.* USA: Newburry House.

Squire, L. R. (2004). Memory systems of the brain: A Brief History and Current Perspective. *Neurobiology of Learning and Memory*, *82,* pp. 171-177.

Team examsbook. (2013). Verbal reasoning classification questions and answers. Retrieved, October 21st, 2013. From <http://www.examsbook.com/verbal-reasoning-classification-questions-answers/>.

Test. (2014). In *Merriam-Webster.com. Retrieved, December 8th , 2014. From* <http://www.merriam-webster.com/dictionary/test>.

The Colleges of Oxford University. (1996). Language Aptitude Test. Retrieved, October 8th, 2013. From < https://www.royalholloway.ac.uk/classics/cucd/test.html>.

Tulving, E. (2002). Episodic Memory: From Mind to Brain. *Annual Review of Psychology*, 53, pp. 1 -25.

Thinking. (2014). In *Merriam-Webster.com. Retrieved, December 8th, 2014.* From <http://www.merriam-webster.com/dictionary/thinking>.

Troike, M. S. (2006). *Introducing second language acquisition*. Cambridge: CUP.

Turner, M. L., & Engle, R. W. (1989). Is working memory capacity task dependent? *Journal of Memory and Language*, 28, pp. 127–154.

Urbina, S. (2004). *Essentials of Psychological Testing.* New Jersey: John Wiley & Sons.

Vernon, P. E. (1961). *The structure of human abilities* (2nd ed.). London: Methuen.

Wen, Z. & Skehan, P. (2011). A new perspective on foreign language aptitude: Building and supporting a case for “working memory as language aptitude”. *Ilha Do Desterro: A Journal of English language, literatures and cultural studies, 60, pp. 15-44.*

Wesche, M., Edwards, H., & Wells, W. (1982). Foreign language aptitude and intelligence. *Applied Psycholinguistics*, 3 (2), pp. 127-40.

White, J. (2004). *Howard Gardner : the Myth of Multiple Intelligences*. Lecture at Institute of Education, University of London. Retrieved, October 2nd, 2013. From <http://www.google.dz/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CC

EQFjAA&url=http%3A%2F%2Fwww.nottingham.ac.uk%2F~ttzelrn%2Fmtl%2Fmodule-1%2Fdocuments%2FHowardGardner_lecture.pdf&ei=uhOLVLD8BMftaue0gbAD&usg=AFQjCNHHnIOvZKcHCW-lJlfXNpCxC4hQFg>.

Yam,P. (Ed.). (1998). Intelligence Considered. *Exploring Intelligence*. 9 (4), pp. 1-100.

Yuan, K. Steedle J. , Shavelson R., Alonzo, A., & Oppezzo, M. (2006). Working Memory, Fluid Intelligence, and Science Learning. *Educational Research Review 1*, pp. 83–98.

APPENDICES

APPENDIX 1: pilot tests

1. Language aptitude pilot test

Name:
Group:
Age:

Part One

A. Read the following words silently and put a cross (×) on the one that is pronounced differently:

1. Worked, watched, wanted, walked
2. neighbours, blackboards, bridges, accessions
3. Clear, dear, gear, break, fear
4. ought, thought, aught, cough, caught

B. In the following sentences, choose the correct spelling of the missing word. Put a cross (×) next to the correct answer

1. His _______________ of the situation was incorrect

    b. annalysis
    c. analysis
    d. anallysys

2. She did not actually ______________ the stolen goods.

    a. receive
    b. recieve
    c. receve
    d. recive

3. It was not ______________ who committed the crime.

    a. apparent
    b. apperant
    c. aparent
    d. aperant

4. There was only one witness to the boy's _______________.

    a. abducton
    b. abducsion
    c. abduction
    d. abduckion

5. She was a _____________ worker.

    a. conscienteous
    b. consceintious
    c. consceinteous
    d. conscientious

6. Choose the pair of words that best completes the sentence. Put a cross (×) near the correct answer for the first line and the second cross (×) for the right word in the second

The -------- of the timetable caused some ----------.

a rivision b. revision c. revission d. revition

a. inconvenience b. inconvenince c. inconveneince d. inconvinience

7. He has a -------- in his pocket

a. handkerchief b. handkachief c. hankachief d. hankerchief

8. This box is very ----------

a. hevy b. heavy c. haevy d. havy

9. What’s your -------name

a. daughter's b. doughter's c. doghter's d. dauter’s

C. Look at the following transcriptions of the and write corresponding words, phrases or sentences:

1. /pɪk.tʃə/ …………………………………………….
2. /streŋθ/…………………..
3. /ˈbʌt.ə.flaɪ/………………………………………….
4. /ˈɡrɑːsˌhɒp.ər/………………………………………
5. /ˈwɔː.təˌmel.ən/…………………………………….
6. /ɪtsʌptəˈjuː/…………………………………………
7. /ɪteɪkstutumeɪkəkwɔrəl/……………………………………………………
8. /greɪtmaɪndzrʌnɪnðəseɪmtʃænəlz/……………………………………………………

D. Here is a list of some made up words, read them and given an example for each word having the same pronunciation, if you don’t find write their phonetic transcription

1. Pote
2. Nool
3. Snitting
4. Suspex
5. Undases
6. Renules
7. overcouched
8. rebenderable

E. Here is a list of words spelled approximately as they are pronounced. Choose from the list those which have similar meaning to the given words. Put a cross (×) next to the correct answer

1. kloz
    a. clothes
    b. nearby
    c. stick
    d. important
    e. relatives
2. prezns
    a. kings
    b. explanations
    c. dates
    d. gifts
    e. news
3. klen
    a. brave
    b. group of people
    c. a person who rules
    d. not dirty
4. grbj
    a. garage
    b. seize
    c. boat
    d. exaggeration
    e. waste

5. restrnt
    a. food
    b. self-control
    c. sleep
    d. space
    e. drug

6. othntc

    a. great
    b. big
    c. real
    d. fake

7. preoccpd

    a. busy
    b. absent
    c. thoughtful

d. employed

F. Listen to the following sentences and write them out. (the sentences are given in an audiotape)

1. ………………………………………………………………………………………
2. ……………………………………………………………………………………..
3. ………………………………………………………………………………………
4. ………………………………………………………………………………………
5. ………………………………………………………………………………………

Part Two

A. Examine the following pairs of sentences; the first sentence of each pair contains one word underlined. Select one word which has the same grammatical function. Here is an example:

<u>MARY</u> is happy.
From the <u>look</u> on your <u>face</u>, <u>I</u> can tell that you <u>must</u> have had a bad <u>day</u>.
A B C D E
Answer: **C**

1. Amy <u>SANG</u> a pretty song to her class.
<u>James</u> <u>throws</u> <u>big</u> <u>rocks</u> <u>into</u> the lake.
A B C D E

2. The officer gave me a <u>TICKET</u>!
When she went away to <u>college</u>, the young man's <u>daughter</u> wrote <u>him</u> the most beautiful <u>letter</u>
A B C
D
that <u>he</u> had ever received.
E

3. We wanted to go out, <u>BUT</u> we were too tired.

<u>Because</u> of our extensive training, <u>we</u> were confident <u>when</u> we were out sailing, <u>yet</u> we were
A B C D
always aware <u>of</u> the potential dangers of being on the lake.
E

4. John said <u>THAT</u> Jill liked chocolate.

In <u>our</u> class, <u>that</u> professor claimed <u>that</u> he knew <u>that</u> girl on <u>the</u> television news show.
A B C D E

5. Diaries and memoirs have not caused <u>ME</u> much interest.

Her look made you first freeze and then move as fast as you could.
A B C D E

6. But these farms and bits of ground had gone again BEFORE our time.

It was not easy to resettle in lands supposedly fit for heroes to live in after over twenty million
A B C D E
souls had perished.

7. I knew the day would EVENTUALLY arrive when I could sit down and take stock.

Naturally, conditions in 1960 were still a far cry from those we enjoy today.
A B C D E

B. Choose the right answer to fill in the blank. Put a (×) next to the correct answer

1. "Susan ___ me that her nationality was British. I thought she had said earlier that she was Canadian."
   - Tell
   - Told
   - Say
   - Said
2. "She isn't going to the conference in Madrid, ___? " "No, I don't think she is."
   - She is
   - Is she
   - Will she
   - Would she
3. "I haven't seen you for so long! It's ___ ages!" "Yes, it has, but you look just the same!"
   - Been
   - Being
   - Had been
   - Be
4. "Would you mind if I ___ early?" "I wouldn't mind at all, but the boss would be upset."
   - Am leaving
   - Had left
   - Left
   - Will leave
5. "How long do you plan on ___ in the U.S.?" "It depends on when the convention finishes."
   - Staying
   - Will stay
   - stay
   - to stay
6. "Mike told me _______to the meeting without preparing first and being ready for their questions."
   - Not go
   - Not to go
   - To go not

- Not going

7. _____ pen drives are these? They've been lying here for over a week."
    - Who's
    - Who is
    - Whom
    - whose

C. Identify the mistake in the following sentences

1. "I've already told you that he's have the situation completely under control and doesn't need additional help."
- I've already told
- He's have
- Completely
- Doesn't need

2. "Could we to have dinner together sometime?" "Yes, that's a wonderful suggestion. Why don't we?"
    - Could we to have
    - Sometime
    - That's
    - Why don't we
3. The boss asked to Ted and Mary to set up the display for the new computer.
    - asked
    - To Ted and Mary
    - To set up
    - For the new computer

4. "Tom really shouldn't had missed the meeting because now he won't have any idea of what to expect from our new client."

    - Shouldn't had missed
    - Because now
    - Won't have
    - What to expect

Part Three

A. The following sentences are in the foreign language (an invented language). Each sentence in the foreign language is translated into a one in English. Try to guess the individual words in English from the previous sentences
    a. hi-tiacumya-? 'Is a cat listening carefully?'
    b. hi-tisno-sist? 'Is the little girl listening sleepily?'
    c. mya-tsno-hi-ti. 'The cat is listening sleepily.'
    d. sisacuhi-ti. 'A little girl is listening carefully.'

How does one express the following in this Language?

Example
« cat » is expressed as « mya »
1. 'little girl'?_________

2. 'carefully'?__________
3. 'sleepily'?__________
4. 'a'?__________
5. 'the'?__________
6. 'is listening'?__________

B. The list below contains words from a foreign language and the English equivalents of these words.

Gade ………………… father, a father
Shi …………………... horse, a horse
Gade shir le ………… Father sees a horse.
Gade shir la ………… Father saw a horse.
be …………………... carries

Using the above list, select the best statement in the foreign language that best translates the following statement in English

A horse carried Father

a. gade shir be
b. gade shir ba
c. shi gader be
d. shi gader ba

C. The list below contains words from a foreign language and the English equivalents of these words.

jiban………………boy, a boy
jojo………………..dog, a dog
jiban njojo za…….A boy likes a dog.

By referring to the above list, try to guess how the following statement should be expressed in this language.

A dog likes a boy.

…………………………………………………………………………….

2. Working memory pilot test

Sub-test One

1. Read the following sentences silently and try to remember the letter next to each sentence:

a. The girl bought a dress. **K**
b. The mechanic fixed the broken car. **R**

Now try to recall the letters in their order of presentation.

2. Read the following sentences silently and try to remember the number next to each sentence:

   a. The dishes disliked by people were removed by the waiter. **5**
   b. The greatest minds are capable of the greatest faults as well as of the greatest virtues. **7**

Now try to recall the numbers in their order of presentation.

3. Read the following sentences silently and try to remember the word next to each sentence:

a. It was the woman that the fur coat desired. **DOG**
b. The routine that the dancer performed amazed the audience. **PEOPLE**

Now try to recall the words as they appeared.

4. Read the following sentences silently and try to remember the letter next to each sentence:

   a. Our family inherited a big house in Algiers. **R**
   b. Our people are fascinated with romantic series than scientific documentaries. **W**
   c. The girl was dissatisfied with the dress she bought yesterday. **X**

Now try to recall the letters in their order of presentation.

5. Read the following sentences silently and try to remember the number next to each sentence:

   1. Ice-cream is highly demanded in this period of the year. **10**
   2. The poor and weak are often made to suffer for the madness of the great. **15**
   3. she was in the habit of waking them early in the morning, at sunrise.**20**

Now try to recall the numbers in their order of presentation

6. Read the following sentences silently and try to remember the word next to each sentence:

1. It was the woman that the gift delighted. **BABY**
2. He who listens to daily praise is not wise, for it has no good purpose. **FAMILY**
3. When he came up to them, he saluted them and passed on without stopping. **TICKET**

Now try to recall the final words as they appeared.

7. Read the following sentences silently and try to remember the letter next to each sentence:

a. The station is crowded with people going away. **B**
b. The candles started the fire. **R**
c. The child enjoyed the hot chocolate. **Y**
d. We like horror movies better than action movies. **X**

Now try to recall the letters in their order of presentation

8. Read the following sentences silently and try to remember the number next to each sentence:

a. The boy was thrilled by the coming of the airplane. **45**
b. Sometimes a man stands out and waves a little flag, and sometimes a woman. **54**
c. They all requested him say what he liked, for they would listen to him willingly. **64**
d. After they had gone he felt lonely, and started to be tired of his lady-love. **75**

Now try to recall the numbers in their order.

9. Read the sentences and examine the final words carefully.
1. It was the bone that the dog fetched.
2. It was the disc jockey that the tape broke
3. It was the ocean that the boat swallowed up
4. sometimes one prince fights with another for fear the other should fight with him

Now try to recall the final word of each sentence in its order of presentation.

10. Look at the following words or sentences and try to remember the letters that appear at the end of each set.
a. Undetermined. **Z**
b. Undetermined. **L**
c. Undetermined. **M**
d. Love yourself. **N**
e. I feel delighted. **S**

Now try to remember the letters in their order of presentation.

11. Read the following sentences and remember the words at the end of each sentence
   a. The girl was pleased with the bracelet. **GIRL**
   b. I polish the furniture every weekend. **GOAST**
   c. The lines guided the swimmer. **CAGE**
   d. The gangsters attacked the store. **BONE**
   e. The dollhouse amazed the baby. **BIRD**

Now try to recall the words in their order of presentation

12. Read the following sentences silently and examine the last word of each sentence.
   a. The drivers were frustrated by the endless traffic.
   b. The wife was shocked by finding her husband thrown dead in the chamber.
   c. It was the mirror that the cat felt excited.
   d. It was the dog that found the victim in their investigation.
   e. It was the air conditioner that the man was installing all morning.

Try to recall the final words in their order of presentation.

13. Read the following sentences and remember the numbers that appear at the end
   a. Be happy. **5**
   b. Be self confident. **9**
   c. Be enthusiastic. **12**
   d. Be curious. **7**
   e. Be satisfied. **9**
   f. Live your life. **4**

Now recall the previous numbers in their order.

14. Read the following sentences and examine the words next to each sentence:
   a. The play will start in few minutes. **TABLE**
   b. Our house was filled with quests. **BOOK**
   c. The football game was amazing. **PEN**
   d. I cannot read what you have written. **DESK**
   e. The bomb killed fifty people. **BALL**
   f. The shopkeeper is a nice girl. **GAME**

Now try to recall the words in their order.

15. Read the following sentences and examine the final words.
   a. It was the police officer that found the drugs.
   b. It was the ship that transported the food to our country.
   c. I would rather have a store of chocolate than all the jewels in the world.
   d. A wooden ticket containing Japanese characters is given to me in exchange for a few tiny coins.
   e. I never said that they have to, replied the teacher; I said that you might.
   f. Impossible things we cannot hope to achieve and they are no use to try.

Now try to recall the final words in their order of appearance.

16. Read the following words and sentence and examine the letters and numbers that appear at the end

a. Undefined. **U**
b. Undefined. **2**
c. Undefined. **K**
d. Undefined. **5**
e. Undefined. **Z**
f. Undefined. **3**
g. The elephant knocked over the gate. **Y**

Now try to recall the letters and numbers as they appeared

17. Read the following phrases and examine the words next to them

a. A brave man. **KEY**
b. A little girl. **DOOR**
c. Unhealthy country. **COAT**
d. An easy test. **FURNITURE**
e. Severe teachers. **BELL**
f. Serious students. **ENTER**
g. Extended courses. **RING**

Try to recall the words as they appeared

18. Read the following sentences and examine the final words

a. It was the psychologist who scored the test
b. It was the ship that transported the food
c. It was the bone that the dog fetched.
d. It was the gangster who attacked the store
e. It was the woman that the gift delighted.
f. It was the telephone that woke up the tired girl
g. It was the noise that woke up the sleepy dog

Now try to remember the final words as they appeared

19. Read the following sentences silently and try to remember the letter next to each sentence:

a. I have a dream. **L**
b. I have to attain it. **B**
c. I should be serious. **S**
d. I should be active. **P**
e. I should be curious. **Z**
f. I have to work hard. **D**
g. I should learn from my mistakes. **G**
h. The mistakes should make me stronger. **R**

Now try to recall the letters as they appeared

20. Read the following sentences silently and try to remember the number next to each sentence:

a. This test makes me curious to know my score. **7**
b. I wonder if I have good memory ability.**3**
c. If my memory score doesn't satisfy me I've to search for tips to improve my memory. **2**
d. There are a number of strategies for improving memory ability. **4**
e. Organizing information in the mind makes it easy to remember. **5**
f. Associating words with words I know makes them easy to recall. **6**
g. Regular practicing of cognitive tests strengthens my memory ability. **1**
h. Eating fish is also helpful. **0**

Try to recall the numbers in their order of presentation

21. Read the following sentences and examine the final words
   a. It was the professor who scored the test.
   b. The bomb killed fifty people.
   c. The victim was her husband.
   d. She needs an urgent surgery.
   e. The accident was extremely awful.
   f. Almost all the passengers were killed.
   g. The quality of the road and bad weather conditions cause this disaster.
   h. The majority of the passengers could not be known because of the damage caused.

Now try to remember the words in their order of presentation

Subtest Two

1. The following are equalities you should judge. Next to each equation there is a letter you should remember.
   a. Is (8+2)-5= 5? **P**
   b. Is (1*4)-4=0? **J**

Now recall the letters in their order of presentation

2. Judge the following equalities and remember the last word that appears in each equation
   a. Is (9/9)-1=2?
   b. Is (2*2)-0=3?

Try to recall the numbers that appear at the end of each equation in order.

3. Solve the following equalities and remember the results
   a. What is the result of (3/3) +3?

b. What is the result of (6/3) +4?

Now try to recall the obtained results in their order.

4. Judge the following equalities and remember the letter next to each equation
   a. Is (8-1)+1=6? **L**
   b. Is (5/5)+5=6? **J**
   c. Is (9/3)-1=2? **S**

Try to recall the letters as they appear in their order

5. Solve the following equations and remember the results
   a. What is the result of (15*2)+7?
   b. What is the result of (20-7)+5?
   c. What is the result of (35/5)-9?

Try to recall the results you obtained in their order

6. Judge the following equations and remember the last word
   a. Is (1*5)+7= 15? **DRESS**
   b. Is (7/1)-5= 2? **CLOCK**
   c. Is (3*4)-9=3? **HAT**

Now try to recall the words that appear next to each equation in their order.

7. Judge the following equations and remember the letters next to each equation
   a. Is (2*6)-2=15? **K**
   b. Is (6*2)-7=5? **Y**
   c. Is (2*2)-4=1? **N**
   d. Is (2/1)+5=7? **P**

Now recall the letters as they appear.

8. Judge the following equations and remember the final numbers
   a. Is (4*2)-1=7?
   b. Is (3*3)-1=8?
   c. Is (6/3)+3= 5?
   d. Is (7*2)-9= 5?

Now try to recall the numbers that appear at the end of the equations in their order.

9. Solve the following equations and remember the last words
   a. What is the result of (15*2)-10? **THUMB**
   b. What is the result of (8*9)+5? **INK**
   c. What is the result of (6+4)*5? **PEN**
   d. What is the result of (4/2)*6? **PAPER**

Now recall the words that appear at the end f each equation in their order of presentation

10. Judge the following equations and remember the final letters

a. Is (4*3)+9=20? **S**
b. Is (6/2)-3=5?**T**
c. Is (9/1)-3=6? **P**
d. Is (5*2)+7=16? **J**
e. Is (1*4)-3=3? **F**

Try to recall the letters that appear at the end of each equation in their order of presentation

11. Solve the following equations and remember the results

a. What is the result of (4/1)-3?
b. What is the result of (4*3)-1?
c. What is the result of(8/4)+6?
d. What is the result of (7*7)+3?
e. What is the result of (1*7)-5?

Now try to recall the obtained results in their order

12. Judge the following equations and remember the words that appear at the end

a. Is (7*3)+3=30? **STONE**
b. Is (4*10)-4=45? **BRAIN**
c. Is (6/3)+10=13? **BIRD**
d. Is (12*3)-1=35? **CAGE**
e. Is (20*9)/9=10? **HUNT**

Now try to recall the words that appear next to each equation in their order

13. Judge the following equations and remember the last letters

a. Is (5*3)+2=17? **S**
b. Is (2*3)-6=2? **J**
c. Is (8/8)+7=16? **P**
d. Is (1*8)-3=0? **H**
e. Is (9/9)+8=9? **F**
f. Is (2*2)+5=13? **Y**

Now try to recall the letters as they appeared in their order

14. Solve the following equations and remember the results

a. What is the result of (2/2)-1?
b. What is the result of (4/4)+6?
c. What is the result of(2*3)-3?
d. What is the result of(3*2)+6?
e. What is the result of (3*5)-2?
f. What is the result of (1*6)-5?

Now try to recall the obtained results as they appeared in their order

15. Judge the following equations and remember the words

a. Is (2*15)+4=40? **PIE**
b. Is (7*6)-5=30? **COOKIES**
c. Is (6/6)*6=6? **DESSERT**
d. Is (8*4)+6=35? **CHEESE**
e. Is (2*9)-4=14? **MEAL**
f. Is (8*2)/2=8? **FORK**

Now try to recall the words in their order of presentation

16. Judge the following equations and remember the final letters

a. Is (3/3)+1=1? **F**
b. Is (8/2)-4=14? **S**
c. Is (8/8)+6=7? **Q**
d. Is (9/9)+7=3? **P**
e. Is (3*4)+5=17? **R**
f. Is (7*2)-1=13? **T**
g. Is (2*7)+5=19? **K**

Now try to recall the letters as they appeared in their order of presentation

17. Judge the following equations and remember the last numbers

a. Is (1/1)+8=9?
b. Is (1*8)+3=11?
c. Is (4*2)-1=13?
d. Is (8/1)+2=18?
e. Is (3*3)-5=8?
f. Is (5*3)-7=8?
g. Is (2*5)-9=8?

Now try to recall the results in their order of presentation

18. Judge the following equations and remember the words

a. Is (10*3)-4=26? **TUNNEL**
b. Is (6/6)+9=8? **TUBE**
c. Is (8/4)*4=16? **TRAFFIC**
d. Is (7*5)+5=20? **RAILWAY**
e. Is (6*2)+7=20? **EMERGENCY**
f. Is (8/4)*2=10? **STAIRS**
g. Is (9*1)/3=3? **CALL**

Now try to recall the words in their order of presentation

Subtest Three

A list of jumbled letters will appear on the screen, try to remember these letters and make meaningful words out of them

ATE
TAC
AIDE
DAER
LOMEN
TIGHN
SLATE
SIDEASE
CHENKIT
ANULTRA

3. Verbal reasoning pilot test

Part One

Look at the first pair, it holds a kind of relation. Understand the relation and circle the word from the list to complete the second pair

1. Brother : sister
   Niece : ?

A. Mother B. Daughter C. Aunt D. Uncle E. Nephew

2. Milk : glass
   Letter : ?

A.Stamp B. Pen C. Envelope D. Book E. Mail

3. Finger : hand
   Leaf : ?

A.Tree B. Branch C. fruit D. flower E. Bark

4. Awful : bad
   marvelous :?

A.Delicious B. good C. sunny D. angry E. happy

5. Foot : knee
   Hand : ?

A.Finger B. Elbow C. Toe D. Leg E. Arm

6. Water : ice
   Milk : ?

A.Honey B. Cheese C. Cereal D. coffee E. Cookie

7. Ice : Liquid
   Water : ?

A. steam B. gas C. solid D. pool E. watery

8. Chinese : China
   Farsi :?

A. Japan B. Okinawa C. Korea D. Israel E. Iran

9. Tree : ground
   Chimney : ?

A.Smoke B. stone C. Sky D. Garage E. House

Now Circle the pair that has similar relation to the following pairs:

10. Optimism : pessimism

A. Success : failure B. Food : hunger

C.Motivation : dedication

D. Maturity : youth

11. Chalk : blackboard

A. Type : point

B. table : chair

C. Door: handle

D. Paper: ink

Part Two

Read the following lists of words, four words are similar in some way, cross the word that seems least like the other four?

1.
    - Sister
    - Friend
    - Brother
    - Father
    - Mother
2.
    - Bear
    - Snake
    - Cow
    - Dog
    - Tiger
3.
    - Potato
    - Corn
    - Apple
    - Carrot
    - Bean
4.
    - Touch
    - Taste
    - Hear
    - Smile
    - See
5.
    - Stocking
    - Dress
    - Shoe
    - Purse
    - Hat
6.
    - A
    - D
    - G
    - I
    - J
    - M
    - P
    - S
7.
    - Bottle

- Cup
- Tub
- Funnel
- Bowl

8.
   - Horse
   - Kangaroo
   - Zebra
   - Deer
   - Donkey

9.
   - Calendar
   - Date
   - Day
   - Month
   - Year
   -

10.
   - Moon
   - Sun
   - Universe
   - Star
   - Planets

Part Three

1. If you rearrange the letters "BARBIT", you would have the name of a:
   - Ocean
   - Country
   - State
   - City
   - animal
2. If you rearrange the letters "RAPIS", you would have the name of a:
   - Ocean
   - Country
   - State
   - City
   - Animal
3. If you rearrange the letters "MANGERY", you would have the name of a:
   - Ocean
   - Country
   - State
   - City
   - animal
4. If you rearrange the letters "CIFAIPC" you would have the name of :

- Country
- City
- River
- Ocean
- Animal

5. If you rearrange the letters “SEOMU” you would have the name of
    - Country
    - City
    - Animal
    - Ocean

Part Four

Read the following statements and choose the right answer

1. Jack is taller than Peter, and Bill is shorter than Jack. Which of the following statements would be most accurate?

B. It is impossible to tell whether Bill or Peter is taller
C. Bill is as tall as Peter.
D. Bill is shorter than Peter.
E. Bill is taller than Peter.

2. Sandy is taller than Sharon and shorter than Megan. If Martin is taller than Megan then

A. Martin is the tallest
B. The answer cannot be determined with the data given
C. Sandy is shorter than Sharon
D. Sharon is taller than Martin.

3. There are five friends: Mary, Linda, Lisa, Sara and Maria. Mary is shorter than Linda but taller than Maria. Lisa is the tallest. Sara is a little shorter than Linda and a little taller than Mary.

Who is the shortest?

A. Maria B. Mary
C. Sara D. Linda

4. Five girls are sitting on a bench to be photographed. Seema is to the left of Rani and to the right of Bindu. Mary is to the right of Rani. Reeta is between Rani and Mary. Who is sitting immediately right to Reeta ?

A. Bindu B. Rani
C. Mary D. Reeta

5. Pointing to a photograph Lata says, « he is the son of the only son of my grandfather ». How is the man in the photograph related to Lata ?

A. Brother B. Uncle
C. Cousin D. information is incorrect

6. There are 8 houses in a line and in each house only one boy lives with the following conditions: Jack is not the neighbor Simon; Harry is just next to the left of Larry ; There is at least one to the left of Larry ; Paul lives in one of the two houses in the middle ; Mike lives in between Paul and Larry. If at least one lives to the right of Robert and Harry is not between Taud and Larry, then which one of the following statement is not correct?

A. Robert is not at the left end
B. Robert is in between
C. Taud is in between Paul and Jack
D. There are three persons to the right of Paul

Part Five

Examine the following statements carefully and choose the right answer:

1. If all men are fathers and all fathers are brothers, then all men are brothers
   - True
   - False
   - Neither

2. If all instruments are pianos and no instruments are guitars, then some guitars are no pianos
   - True
   - False
   - Neither

3. If all schools are buildings, and some houses are buildings, then some schools are houses

   - True
   - False
   - Neither

Here are some statements. Understand them and try to draw the right conclusion

4.

a. No trousers are clothing
b. No jackets are trousers

- Some jackets are clothing
- Some clothing are jackets
- All jackets are clothing
- None of the above

5.

a. Some woman are mothers
a. All mothers are blonds

- No blonds are mothers
- Some mothers are no blonds
- Some women are blonds
- Some women are no blonds

6.

a. No computers are televisions
b. All radios are televisions.

- All radios are computers
- No radios are computers
- All computers are radios
- None of the above

Appendix 2: final tests

Language Aptitude Test

Part One

1. Read the following words silently and put a cross (×) on the one that is pronounced differently:
1. ought, thought, aught, cough, caught
2. Clear, dear, gear, break, fear
3. Worked, watched, wanted, walked
4. neighbours, blackboards, bridges, accessions

2. In the following sentences, choose the correct spelling of the missing word. Put a cross (×) next to the correct answer

1. There was only one witness to the boy's ………………………
a. abducshion b. abducsion c. abduction d. abduckion

2. This box is very ……………………
a. hevy b. heavy c. haevy d. havy

3. His ………………………of the situation was incorrect.
a. analisys b. annalysis c. analysis d. anallysys

4. What's your …………….name
a. daughter's b. doughter's c. doghter's d. dauter's

5. He has a ……………. in his pocket.
a. handkerchief b. handkachief c. hankachief d. hankerchief

6. She was a ………………… worker.
a. conscienteous b. consceintious c. consceinteous d. conscientious

7. She did not actually …………………… the stolen goods.

a. recieve b. receive c. receve d. recive

8. It was not ………………….who committed the crime.
a. apparent b. apperant c. aparent d. aperant

9. Choose the pair of words that best completes the sentence. Put a cross (×) near the correct answer for the first line and the second cross (×) to the right answer in the second line

The……………… of the timetable caused some ……………...

a rivision b. revision c. revission d. revition

a. inconvenience b. inconvenince c. inconveneince d. inconvinience

3. Look at the following transcriptions and write corresponding words for each
   1. /ˈbʌt.ə.flaɪ/…………………………………………
   2. /pɪk.tʃə/ ……………………………………………
   3. /streŋθ/…………………..
   4. /ˈwɔː.təˌmel.ən/……………………………………
   5. /ˈɡrɑːsˌhɒp.ər/………………………………………

4. Here is a list of some made up words (i.e. they resemble english words), read them and give a similarly pronounced word having the same sound of the underlined sounds

   1. Pote ………………………………
   2. Nool ………………………………
   3. Snitting ………………………………
   4. Suspex ………………………………
   5. Undases ………………………………
   6. Renules ………………………………
   7. Overcrouched ………………………………
   8. Rebenderable ………………………………

5. Here is a list of words spelled approximately as they are pronounced (i.e. the pronunciation is not wrong but misses other sounds). Choose from the list those which have similar meaning to the given pronunciations. Put a cross (×) next to the correct answer

1. klen
   a. brave
   b. group of people
   c. a person who rules
   d. not dirty

2. restrnt
   a. food
   b. self-control
   c. sleep
   d. space
   e. drug

3. grbj
   a. garage
   b. seize
   c. boat
   d. exaggeration
   e. waste

4. prezns
    a. kings
    b. explanations
    c. dates
    d. gifts
    e. news
5. kloz
    a. clothes
    b. nearby
    c. stick
    d. important
    e. relatives

6. preoccpd

    a. busy
    b. absent
    c. thoughtful
    d. employed

7. othntc

    a. great
    b. big
    c. real
    d. fake

6. Listen to the following sentences and write them out. (cf. the sentences were given in an audiotape)

1.…………………………………………………………………………………………

2.……………………………………………………………………………………………

3.……………………………………………………………………………………………

4.……………………………………………………………………………………………

5.…………………………………………………………………………………………

Part Two

A. Examine the following pairs of sentences, the first sentence of each pair contains one word underlined. Select one word which has the same grammatical function. Here is an example

Example:
<u>MARY</u> is happy.
From the <u>look</u> on your <u>face</u>, <u>I</u> can tell that you <u>must</u> have had a bad <u>day</u>.
A B C D E

Answer: **C**

1. Amy SANG a pretty song to her class.

James throws big rocks into the lake.
A B C D E

2. John said THAT Jill liked chocolate.

In our class, that professor claimed that he knew that girl on the television news show.
A B C D E

3. But these farms and bits of ground had gone again BEFORE our time.

It was not easy to resettle in lands supposedly fit for heroes to live in after over twenty million
A B C D E
souls had perished.

4. The officer gave me a TICKET!

When she went away to college, the young man's daughter wrote him the most beautiful letter
A B C
D
that he had ever received.
E

5. I knew the day would EVENTUALLY arrive when I could sit down and take stock.

Naturally, conditions in 1960 were still a far cry from those we enjoy today.
A B C D E

6. Diaries and memoirs have not caused ME much interest.

Her look made you first freeze and then move as fast as you could.
A B C D E

7. We wanted to go out, BUT we were too tired.

Because of our extensive training, we were confident when we were out sailing, yet we were
A B C D
always aware of the potential dangers of being on the lake.
E

B. Choose the right answer to fill in the blank. Put a (×) next to the correct answer

1. "Susan ___ me that her nationality was British. I thought she had said earlier that she was Canadian."
   - Tell
   - Told
   - Say
   - Said
2. "She isn't going to the conference in Madrid, ___? " "No, I don't think she is."
   - She is
   - Is she

- Will she
- Would she

3. “How long do you plan on ___ in the U.S.?” “It depends on when the convention finishes.”
   - Staying
   - Will stay
   - stay
   - to stay
4. “Mike told me _______to the meeting without preparing first and being ready for their questions.”
   - Not go
   - Not to go
   - To go not
   - Not going
5. “I haven’t seen you for so long! It’s ___ ages!” “Yes, it has, but you look just the same!”
   - Been
   - Being
   - Had been
   - Be
6. “Would you mind if I ___ early?“ “I wouldn’t mind at all, but the boss would be upset.”
   - Am leaving
   - Had left
   - Left
   - Will leave
7. _____ pen drives are these? They’ve been lying here for over a week.”
   - Who’s
   - Who is
   - Whom
   - whose

C. Identify the mistake in the following sentences. Put a cross (×) next to the mistake

1. “<u>I’ve already told</u> you that <u>he’s have</u> the situation <u>completely</u> under control and <u>doesn’t need</u> additional help.”
   - I’ve already told
   - He’s have
   - Completely
   - Doesn’t need

2. “<u>Could we to have</u> dinner together <u>sometime</u>?” “Yes, <u>that’s</u> a wonderful suggestion. <u>Why don’t we</u>?”
   - Could we to have
   - Sometime
   - That’s
   - Why don’t we
3. The boss <u>asked</u> <u>to Ted and Mary</u> <u>to set up</u> the display <u>for the new computer</u>.
   - asked
   - To Ted and Mary
   - To set up

- For the new computer

4. "Tom really <u>shouldn't had missed</u> the meeting <u>because now</u> he <u>won't have</u> any idea of <u>what to expect</u> from our new client."

   - Shouldn't had missed
   - Because now
   - Won't have
   - What to expect

Part Three

A. The following sentences are in the foreign language (an invented language). Each sentence in the foreign language is translated into a one in English. Try to guess the individual words in English from the following translations and example

   a. hi-tiacumya-? 'Is a cat listening carefully?'
   b. hi-tisno-sist? 'Is the little girl listening sleepily?'
   c. mya-tsno-hi-ti. 'The cat is listening sleepily.'
   d. sisacuhi-ti. 'A little girl is listening carefully.'

Example
« cat » is expressed as « mya »

How does one express the following in this language?

D. 'little girl'?........................
E. 'sleepily'? ....
F. 'the'? ....
G. 'is listening'? ....
H. 'carefully'? ....
I. 'a'? ....

B. The list below contains words from a foreign language (an invented language) and their English equivalents

Gade ………………… father, a father
Shi …………………... horse, a horse
Gade shir le ………… Father sees a horse.
Gade shir la ………… Father saw a horse.
be …………………... carries

Using the above list, select the best statement in the foreign language that best translates the following statement in English. Put a cross next to the right answer

A horse carried a Father

a. gade shir be	b. gade shir ba
c. shi gader be	d. shi gader ba

C. The list below contains words from a foreign language (an invented language) and the English equivalents of these words.

jiban………………boy, a boy
jojo………………..dog, a dog
jiban njojo za…….A boy likes a dog.

By referring to the above list, try to guess how the following statement should be expressed in this language.

A dog likes a boy.
…………………………………………………………………………….

D. The following sentences are in the foreign language (an invented language). Each sentence in the foreign language is translated into a one in English

a. **cunmati kid.** 'A child is coming.'
b. **go-ti kid't.** 'The child is going.'
c. **mu- kid'n go-pi.** 'A cow and a child are going.'
d. **cunmapi ben mu-'t'n, la-pi'n.** 'A boy and the cow are coming and singing.'

By referring to the above list, try to guess how the following statement should be expressed in this foreign language.

kid't mu-'n cunmapi 'n go-pi.

……………………………………………………………

Working memory test

Part One

1. Read the following sentences silently and try to remember the letter next to each sentence
   - The girl bought a dress. **K**
   - The mechanic fixed the broken car. **R**

Now try to recall the letters in their order of presentation

2. Read the following sentences silently and try to remember the number next to each sentence

1. Ice-cream is highly demanded in this period of the year. **5**
2. The poor and weak are often made to suffer for the madness of the great. **7**
3. She was in the habit of waking them early in the morning, at sunrise.**9**

Now try to recall the numbers in their order of presentation

3. Read the following sentences silently and try to remember the letter next to each sentence

1. The station is crowded with people going away. **Doll**
2. The candles started the fire. **House**
3. The child enjoyed the hot chocolate. **Sweet**
4. We like horror movies better than action movies. **Television**

Now try to recall the words in their order of presentation

4. Read the sentences and examine the final words carefully

1. It was the bone that the dog **fetched**.
2. It was the disc jockey that broke the **tape.**
3. It was the ocean that swallowed up the **boat.**
4. Sometimes one prince fights with another for fear the other should fight with **him .**

Now try to recall the last words as they appeared

5. Look at the following words or sentences and try to remember the letters that appear at the end of each

1. Undetermined. 2
2. Undetermined. 8
3. Undetermined. 4
4. Love yourself. 6
5. I feel delighted. 6

Now try to recall the numbers in their order of presentation

6. Read the following sentences and remember the words at the end of each sentence

1. The girl was pleased with the bracelet. **GIRL**
2. I polish the furniture every weekend. **GOAST**
3. The lines guided the swimmer. **CAGE**
4. The gangsters attacked the store. **BONE**
5. The dollhouse amazed the baby. **BIRD**

Now try to recall the words in their order of presentation

7. Read the following sentences silently and examine the last word of each sentence

1. The drivers were frustrated by the endless **traffic**.
2. The wife was shocked by finding her husband thrown dead in the **chamber**.
3. It was the mirror that makes the cat **excited**.
4. It was the dog that found the victim in their **investigation**.
5. It was the air conditioner that the man was installing all **morning**.

Now try to recall the last words in their order of presentation

8. Read the following sentences and remember the numbers that appear at the end

1. Be happy. **L**
2. Be self confident. **S**
3. Be enthusiastic. **R**
4. Be curious. **X**
5. Be satisfied. **M**
6. Live your life. **Y**

Now try to recall the letters in their order of presentation

9. Read the following sentences and examine the final words

1. It was the police officer that found the **drugs.**
2. It was the ship that transported the food to our **country.**
3. I would rather have a store of chocolate than all the jewels in the **world.**
4. A wooden ticket containing Japanese characters is given to me in exchange for a few tiny **coins**.
5. “I never said that you have to”, replied the teacher; I said that you **might**.
6. Impossible things we cannot hope to achieve and they are no use to **try.**

Now try to recall the last words in their order of presentation

10. Read the following words and sentence and examine the letters and numbers that appear at the end of each

1. Undefined**. U**
2. Undefined**. 2**
3. Undefined**. K**
4. Undefined**. 5**
5. Undefined**. Z**

6. Undefined**. 3**
7. The elephant knocked over the gate. **Y**

Now try to recall the letters and numbers in their order of presentation

11. Read the following phrases and examine the words next to each

1. A brave man. **KEY**
2. A little girl. **DOOR**
3. Unhealthy country. **COAT**
4. An easy test. **FURNITURE**
5. Severe teachers. **BELL**
6. Serious students. **ENTER**
7. Extended courses. **RING**

Now try to recall the words in their order of presentation

12. Read the following sentences and examine the final words

1. It was the psychologist who scored the **test.**
2. It was the ship that transported the **food.**
3. It was the bone that the dog **fetched**.
4. It was the gangster who attacked the **store.**
5. It was the woman that the gift **delighted**.
6. It was the telephone that woke up the tired **girl.**
7. It was the noise that woke up the sleepy **dog**

Now try to recall the last words in their order of presentation

13. Read the following sentences and examine the final words

1. I have a dream. **L**
2. I have to attain it. **B**
3. I should be serious. **S**
4. I should be active. **P**
5. I should be curious. **Z**
6. I have to work hard. **D**
7. I should learn from my mistakes. **G**
8. The mistakes should make me stronger. **R**

Now try to recall the letters in their order of presentation

14. Read the following sentences silently and try to remember the word next to each sentence

1. This test makes me curious to know my score. **Test**
2. I wonder if I have good memory ability. **Memory**

3. If my memory score doesn't satisfy me I have to search for tips to improve my memory. **Improve**
4. There are a number of strategies for improving memory ability. **Number**
5. Organizing information in the mind makes it easy to remember. **Information**
6. Associating words with words I know makes them easy to recall. **Word**
7. Regular practicing of cognitive tests strengthens my memory ability. **Able**
8. Eating fish is also helpful. **Fish**

Now try to recall the words in their order of presentation

15. Read the following sentences and examine the final words

1. It was the professor who scored the **test**.
2. The bomb killed fifty **people**.
3. The victim was her **husband**.
4. She needs an urgent **surgery**.
5. The accident was extremely **awful**.
6. Almost all the passengers were **killed**.
7. The quality of the road and bad weather conditions cause this **disaster**.
8. The majority of the passengers could not be known because of the damage **caused**.

Now try to recall the last words in their order of presentation

Part Two

1. The following are equalities you should judge. Try to remember the letters that appear at the end of each equality.

1. Is (8+2)-5= 5? **P**
2. Is (1*4)-4=0? **J**

Now try to recall the letters in their order of presentation

2. Judge the following equalities and remember the last number

1. Is (8-1)+1=6?
2. Is (5/5)+5=6?
3. Is (9/3)-1=2?

Now try to recall the last numbers in their order of presentation

3. Solve the following equalities and remember the results

1. What is the result of (6*2)-10?
2. What is the result of (2*9)+5?
3. What is the result of (3+4)*5?
4. What is the result of (4/2)*6?

Now try to recall the obtained results in their order

4. Judge the following equalities and remember the words

1. Is (4*2)-1=**7**? **THUMB**

2. Is (3*3)-1=**8**? **INK**
3. Is (6/3)+3= **5**? **PEN**
4. Is (7*2)-9= **5**? **PAPER**

Now try to recall the words in their order of presentation

5. Solve the following equalities and remember the results

1. What is the result of (4/1)-3?
2. What is the result of (4*3)-1?
3. What is the result of(8/4)+6?
4. What is the result of (2*7)+3?
5. What is the result of (1*7)-5?

Now try to recall the obtained results in their order

6. Judge the following equalities and remember the words that appear at the end

1. Is (6*3)+3=20? **STONE**
2. Is (4*2)-4=4? **BRAIN**
3. Is (6/3)+10=13? **BIRD**
4. Is (6*3)-1=10? **CAGE**
5. Is (7*5)/5=20? **HUNT**

Now try to recall the words in their order of presentation

7. Judge the following equalities and remember the last letter next to each

1. Is (5*3)+2=17? **S**
2. Is (2*3)-6=2? **J**
3. Is (8/8)+7=16? **P**
4. Is (1*8)-3=0? **H**
5. Is (9/9)+8=9? **F**
6. Is (2*2)+5=13? **Y**

Now try to recall the letters in their order of presentation

8. Solve the following equalities and remember the results

1. What is the result of (2/2)-1?
2. What is the result of (4/4)+6?
3. What is the result of(2*3)-3?
4. What is the result of(3*2)+6?
5. What is the result of (3*5)-2?
6. What is the result of (1*6)-5?

Now try to recall the obtained results in their order

9. Judge the following equalities and remember the word next to each

1. Is (2*5)+4=20? **PIE**
2. Is (2*6)-5=30? **COOKIES**

3. Is (6/6)*6=6? **DESSERT**
4. Is (8*4)+6=35? **CHEESE**
5. Is (2*9)-4=14? **MEAL**
6. Is (8*2)/2=8? **FORK**

Now try to recall the words in their order of presentation

10. Solve the following equations and remember the results

1. What is the result of (1/1)+8?
2. What is the result of (1*8)+3?
3. What is the result of (4*2)-1?
4. What is the result of (8/1)+2?
5. What is the results of (3*3)-5?
6. What is the result of (4*3)-6?
7. What is the result of (2*5)-9?

Now try to recall the obtained results in their order

11. Judge the following equations and remember the word next to each

1. Is (10*3)-4=26? **TUNNEL**
2. Is (6/6)+9=8? **TUBE**
3. Is (8/4)*4=16? **TRAFFIC**
4. Is (7*5)+5=20? **RAILWAY**
5. Is (6*2)+7=20? **EMERGENCY**
6. Is (8/4)*2=10? **STAIRS**
7. Is (9*1)/3=3? **CALL**

Now try to recall the words in their order of presentation

Part three

1. Listen to the following sentence and say they are meaningful or know and remember the last elements :

1. It was the telephone that woke up the tired **girl.**
2. It was the furniture that cleaned the **woman.**

Now try to recall the last words in their order of presentation

1. It was the bone that searched the **dog.**
2. It was the driver that frustrated the **road.**
3. It was the girl that bought the **dress.**
4. Now try to recall the obtained results in their order

Now try to recall the last words in their order of presentation

1. It was the spectators that watched the **play.**
2. It was the pizza that ate the **boy.**

3. It was the woman that inherited the **house.**
4. It was the puzzle that the child **solved.**

Now try to recall the last words in their order of presentation

1. It was the ocean that swallowed up the **boat.**
2. It was the puzzle that solved the **girl.**
3. It was the woman that delighted the **gift.**
4. It was the cookie that the girl **made.**

Now try to recall the last words in their order of presentation

1. It was the thief that stole the **house.**
2. It was the elephant that knocked over the **gate.**
3. It was the radio that annoyed the **class.**
4. It was the critic that disappointed the **play.**
5. It was the souvenir that impressed the **man.**

Now try to recall the last words in their order of presentation

1. It was the candles that started the **fire.**
2. It was the girl that nourished the **milk.**
3. It was the hot chocolate that enjoyed the **child.**
4. It was the dollhouse that amazed the **baby.**
5. It was the furniture that polished the **wife.**

Now try to recall the last words in their order of presentation

1. It was the painting that inspired **us.**
2. It was the policeman that provoked the **gun.**
3. It was the mirror that excited the **cat.**
4. It was the man that annoyed the **light.**
5. It was the inspector that rejected the **place.**
6. It was the mess that bothered the **cleaner.**

Now try to recall the last words in their order of presentation

1. It was the man that pleased the **tie.**
2. It was the housewife that lost the **key.**
3. It was the director that began the **play.**
4. It was the bride that terrified the **dress.**
5. It was the student that took the **test.**
6. It was the people that hurt the **bomb.**

Now try to recall the last words in their order of presentation

1. It was the fog that crashed the **plane.**
2. It was the ship that transported the **food.**
3. It was the woman that chose the **dress.**
4. It was the administration that posted the **note.**
5. It was the tailor that displeased the **cloth.**
6. It was the mouse that ate the **cheese.**
7. It was the chair that sat on the **woman.**

Now try to recall the last words in their order of presentation

1. It was the heat that melts the **ice.**
2. It was the passengers that hold the **bus.**
3. It was the professor that scored the **test.**
4. It was the swimmer that guided the **lines.**
5. It was the bracelet that pleased the **wife.**
6. It was the DJ that broke the **tape.**
7. It was the test that takes the **students.**

Now try to recall the last words in their order of presentation

Part four

A list of jumbled letters will appear on the screen, try to remember these letters and make meaningful words out of them

1. ATE

2. TAC

3. AIDE

4. DAER

5. LOMEN

6. TIGHN

7. SLATE

8. SIDEASE

9. CHENKIT

10. ANULTRA

Verbal Reasoning Test

Part One

1. If you rearrange the letters "**MANGERY**", you would have the name of:
   - An ocean
   - A country
   - A state
   - A city
   - An animal
2. If you rearrange the letters "**BARBIT**", you would have the name of:
   - An ocean
   - A country
   - A state
   - A city
   - An animal

3. If you rearrange the letters "**RAPIS**", you would have the name of:
   - An ocean
   - A country
   - A state
   - A city
   - An animal
4. If you rearrange the letters **"CIFAIPC"** you would have the name of :
   - A country
   - A city
   - A river
   - An ocean
   - An animal

5. If you rearrange the letters **“AZNULENIF”** you would have the name of:
   - A disease
   - A vegetable
   - An ocean
   - An animal
   - A sport

F. If you rearrange the letters “**TANOTANI”** you would have the name of vegetable
   - An animal
   - A sport
   - A disease
   - A fruit

Part Two

Read the following lists of words, four words are similar in some way, cross the word that seems least like the other four?

1.
    - Sister
    - Friend
    - Brother
    - Father
    - Mother
2.
    - Calendar
    - Date
    - Day
    - Month
    - Year
3.
    - Stocking
    - Dress
    - Shoe
    - Purse
    - Hat
4.
    - Bottle
    - Cup
    - Tub
    - Funnel
    - Bowl
5.
    - A
    - D
    - G
    - I
    - J
    - M
    - P
    - S
6.
    - Horse
    - Kangaroo
    - Zebra
    - Deer
    - Donkey

Part Three

Examine the following statements carefully and choose the right answer:

1. If all men are fathers and all fathers are brothers, then all men are brothers
    - True
    - False
    - Neither

2. If all instruments are pianos and no instruments are guitars, then some guitars are no pianos
    - True
    - False
    - Neither

3. If all schools are buildings, and some houses are buildings, then some schools are houses
    - True
    - False
    - Neither

4. If no trousers are clothing and no jackets are trousers, then:
    - Some jackets are clothing
    - Some clothing are jackets
    - All jackets are clothing
    - None of the above

Part Four

Read the following statements and choose the right answer

1. Sandy is taller than Sharon and shorter than Megan. If Martin is taller than Megan, then:

    A. Martin is the tallest.
    B. The answer cannot be determined with the data given.
    C. Sandy is shorter than Sharon
    D. Sharon is taller than Martin.

2. There are five friends: Mary, Linda, Lisa, Sara and Maria. Mary is shorter than Linda but taller than Maria. Lisa is the tallest. Sara is a little shorter than Linda and a little taller than Mary.

   Who is the shortest?

    A. Maria B. Mary
    C. Sara D. Linda

3. Jack is taller than Peter, and Bill is shorter than Jack. Which of the following statements would be most accurate?

    A. It is impossible to tell whether Bill or Peter is taller.
    B. Bill is as tall as Peter.
    C. Bill is shorter than Peter.
    D. Bill is taller than Peter.

4. Five girls are sitting on a bench to be photographed. Seema is to the left of Rani and to the right of Bindu. Mary is to the right of Rani. Reeta is between Rani and Mary. Who is sitting immediately right to Reeta ?

A. Bindu B. Rani
C. Mary D. Reeta

5. Pointing to a photograph Lata says, « He is the son of the only son of my grandfather ». How is the man in the photograph related to Lata?

A. Brother B. Uncle
C. Cousin D. Information is incorrect

6. There are 8 houses in a line and in each house only one boy lives with the conditions as given below:

Jack is not the neighbor of Simon; Harry is just next to the left of Larry; There is at least one to the left of Larry; Paul lives in one of the two houses in the middle; and Mike lives in between Paul and Larry.

If at least one lives to the right of Robert, and Harry is not between Taud and Larry, then which one of the following statements is not correct?

E. Robert is not at the left end.
F. Robert is in between .
G. Taud is in between Paul and Jack.
H. There are three persons to the right of Paul.

Part Five

Look at the first pair; it holds a kind of relation. Understand the relation and circle the word or the pair from the list to complete the second pair

1. Chinese : China
   Farsi :?

A. Japan B. Okinawa C. Korea D. Israel E. Iran

2. Awful : bad
   Marvelous :?

A.Delicious B. good C. sunny D. angry E. happy

3. Brother : sister
   Niece : ?

A. Mother B. Daughter C. Aunt D. Uncle E. Nephew

4. Milk : glass
   Letter : ?

A.Stamp B. Pen C. Envelope D. Book E. Mail

5. Water : ice
   Milk : ?

A.Honey B. Cheese C. Cereal D. Coffee E. Cookie

6. Foot : knee
   Hand : ?

A.Finger B. Elbow C. Toe D. Leg E. Arm

7. Ice : Liquid
   Water : ?

A. Steam B. Gas C. Solid D. Pool
E. Watery

- Now you will be given a pair to choose instead of a word, choose the pair that holds the same relation to the given pairs :

8. Optimism : pessimism

B. Success : failure
B. Food : hunger
C.Motivation : dedication
D. Maturity : youth

9. Chalk : blackboard

B. Type : point
B. Table : chair
C. Door : handle
D. Paper : ink

Appendix 3: the participants obtained scores in the three cognitive linguistic tests

Table A.1. The Participants' Raw and Reproduced Scores in Language Aptitude Pilot Test

subjects	Language aptitude score/100	Phonetic abillity subtest /50+ %	Grammatical sensitivity subtest score/30+%	Inductive learning ability subtest score/20+%
1	23.5	12= 24	9.5= 31	2= 10
2	45	19= 38	18= 60	8= 40
3	66	27.5= 55	28.5=95	10= 50
4	50	22.55= 45	17.5= 58	10= 50
5	54	24= 48	20= 66	10= 50
6	38	24= 48	5= 16	9= 45
7	35	16= 32	15= 50	4= 20
8	63.5	33.5= 67	26= 86	4= 20
9	48	22.5= 45	20= 66	5.5= 27
10	41.5	22= 44	14= 46	5.5= 27
11	39.5	14= 28	17.5= 58	8= 40
12	32	13= 26	11= 36	8= 40
13	42	18.5= 37	18.5= 61	5= 25
14	20	8.5= 17	11.5= 38	00= 00
15	51	24.5= 49	15= 50	11.5= 57
16	46.5	21= 42	14= 46	11.5= 57
17	50	23= 46	14= 46	13= 65
18	69	32.5= 65	21.5= 77	15= 75
19	38	12= 24	14= 46	02= 10
20	34.5	15.5= 31	11= 36	8= 40
21	36	16.5= 33	18= 60	11= 55
22	35.5	16= 32	11.5= 38	8= 40
23	53.5	25= 50	23.5= 78	6= 30
Mean	X= 44	X= 40.26	X= 54.08	X= 37.95

Table A.2. The Participants' Raw and Reproduced Scores in Working Memory Pilot Test

Subjects	WM score/96+ %	RSPAN/41+%	OSPAN/35+%	ANAGRAMS/20+%
1	65=67	34.5= 84	23= 65	7.5= 37
2	67=69	34.5= 84	24.5= 70	8= 40
3	76= 79	37= 90	30= 85	9= 45
4	61.5= 64	34.5= 84	19.5= 55	7.5= 37
5	67= 69	34.5=84	29.5= 84	3= 15
6	50= 52	29=70	15.5= 44	5.5=27
7	63= 65	33=80	24.5= 70	5.5= 27
8	77= 80	30= 73	27= 77	20= 100
9	59= 61	34.5= 84	20.5= 58	4= 20
10	69= 71	36.5=89	24= 68	8.5=42
11	59.5= 61	36.5= 89	23= 65	00=00
12	33= 43	13= 31	20= 57	00=00
13	29= 30	19= 46	8= 22	2= 10
14	70= 72	36=87	17= 48	17=85
15	65.5= 68	34=82	16.5= 47	15=75
16	46.5= 48	30=73	16.5=47	00=00
17	73.5= 76	36.5=89	23.5=67	13.5=67
18	75= 78	34=82	28= 80	13= 65
19	78= 81	37= 90	29= 82	12=60
20	77.5= 80	37.5= 91	31= 88	9= 45
21	66.5=69	37=90	22.5= 64	7= 35
22	86= 89	38.5= 93	29.5=84	18= 90
23	80.5= 83	35.5= 86	28= 80	17=85
24	54.5= 56	31=75	19.5=55	4= 20
25	55= 57	34=82	21= 60	00=00
26	52= 54	30.5=74	15=42	6.5=32
27	60= 62	35=85	21.5= 61	3.5= 17
Mean	X= 66.07	X=80.25	X= 63.88	X=39.85

Table A.3. The Participants' Raw and Reproduced Scores in Verbal Reasoning Pilot Test

Subje-cts	Total score/100	analogies/30+ %	similarity/20+ %	knowledge/20+ %	relations/20+ %	syllogisms/10+ %
1	35.5	04=13	08=40	09=45	11=55	03.5=35
2	39	05=16	12.5=62	12=60	09.5=47	00
3	19.5	06=20	04.5=22	02.5=12	00=00	06.5=65
4	31.5	07.5=25	15=75	03.5=17	02=10	03.5=35
5	19.5	03.5=11	08=40	05.5=27	02.5=12	00
6	75.5	15.5=51	17.5=87	20=100	12.5=62	10=100
7	20	08.5=28	02=10	09.5=47	00	00
8	26	03.5=11	04.5=22	06=30	08.5=42	03.5=35
9	44	12=40	17.5=87	02.5=12	08.5=42	3.5=35
10	22.5	00=00	04.5=22	06=30	08.5=42	03.5=35
11	45	19=63	07.5=37	08=40	07.5=37	03=30
12	57	11=36	17.5=87	14.5=72	07.5=37	06.5=65
13	35.5	08.5=28	12=60	10=50	02.5=12	02.5=25
14	34.5	08.5=28	07.5=37	09=45	08.5=42	01=10
15	53.5	08.5=28	12=60	20=100	10.5=52	02.5=25
16	61	16.5=55	11=55	15.5=77	17=85	01=10
17	24	00=00	08=40	07=35	02=10	07=70
18	46.5	11=36	07.5=37	13=65	11.5=57	03.5=35
19	46.5	06=20	15=75	20=100	00	05.5=55
20	53.5	14.5=48	13=65	10=50	16=80	00
21	33	04=12	05=25	15.5=77	02.5=12	1=10
22	48.5	15.5=51	17=85	06.5=32	06=30	3.5=35
23	55.5	19=63	04.5=22	13.5=67	14.5=72	04=40
24	70	15.5=51	12.5=62	20=100	15=75	07=70
25	60	13=43	07.5=37	20=100	13=65	06.5=65
26	61	08=26	12=60	20=100	17.5=87	03.5=35
27	46	08=26	08=40	08.5=42	15=75	06.5=65
28	26	13.5=45	05=25	04=20	00	3.5=35
29	55.5	14.5=48	16.5=82	10.5=52	07.5=37	06.5=65
Mean	X=42.94	X=31.79	X= 50.27	X= 55.31	X= 36.31	X= 37.41

Table A. 4. The Participants' Raw and Reproduced Language Aptitude Scores

Subjects	whole score/100	Phonetic ability/60+ %	grammatical sensitivity/20+%	Inductive learning/20+%
1	71,5	46= 76,66	16.5= 82,5=	9= 45
2	60	34.5= 57,5	12.5= 62,5	13= 65
3	77,5	47.5= 79,16	17= 85	13= 65
4	41,5	18= 30	7.5= 37,5	16= 80
5	30,5	23,5= 39,16	7= 35	0
6	36	26= 43,33	3= 15	7= 35
7	60,5	36= 60	10.5= 52,5	14= 70
8	53,5	29= 48,33	13.5= 67,5	11= 55
9	69	37.5= 62,5	15.5= 77,5	16= 80
10	42,5	16.5= 27,5	14.5= 72,5	11.5= 57,5
11	42,5	22.5= 37,5	12= 60	8= 40
12	90	60=100	11.5= 57,5	18.5= 92,5
13	61,5	31.5= 52,5	16= 80	17= 70
14	61	32.5= 54,16	15.5= 77,5	13= 65
15	61,5	33= 55	14.5= 72,5	14= 70
16	31	15.5= 25,83	7= 35	8.5= 42,5
17	85,5	50.5= 84,16	18.5= 92,5	16.5= 82,5
18	47,5	19.5= 32,5	12= 60	16= 80
19	58,5	60= 36	16.5= 82,5	6= 30
20	47	28.5= 47,5	10.5= 52,5	8= 40
21	32	16.5= 27,5	8.5= 42,5	7= 35
22	49,5	26= 43,33	14.5= 72,5	9= 45
23	79.5	42.5= 70.83	20= 100	17= 85
24	56.5	30= 50	11.5= 57.5	15= 75
25	68.5	39= 65	15.5= 77.5	14= 70
26	36	20.5= 34.16	8.5= 42.5	06= 30
27	65	33.5= 55.83	16.5= 82.5	15= 75
28	59	33= 55	15= 75	11= 55
29	30.5	21.5= 35.83	09= 45	00
30	36.5	18= 30	12.5= 62.5	06= 30
31	42.5	23.5= 39.16	14= 70	05= 25
32	37.5	26= 43.33	8.5= 42.5	03= 15
33	31.5	22= 36.66	9.5= 47.5	00= 00
34	50.5	36.5=60.83	11= 55	03= 15
35	45.5	25= 41.66	16.5= 82.5	04= 20
36	40	21= 35	10= 50	09= 45
37	51.5	26= 43.33	16.5= 82.5	09= 45
38	46	25=41.66	18= 90	03= 15
39	69	39= 65	16= 80	14= 70
40	20,5	16.5= 27,5	4= 20	0

41	53.5	30= 50	14.5= 72.5	09= 45
42	66.5	37.5= 62.5	14.5= 72.5	14.5= 72.5
43	63	37.5= 62.5	14.5= 72.5	11= 55
44	37.5	25= 41.66	8.5= 42.5	4=20
45	66.5	41= 68.33	16.5= 82.5	09= 45
46	33.5	19.5= 32.5	10=50	04=20
47	41	24.5=40.83	12.5= 62.5	04=20
48	40.5	18.5=30.83	15=75	07=35
49	40.5	23=38.33	15.5=77.5	02=10
50	56	37=61.66	18=90	01=05
51	26	12.5= 20,83	8.5= 42,5	4.5= 25
52	28.5	16.5=27.5	10=50	02=10
53	70	38.5=64.16	14.5=72.5	17=85
54	33	21.5=35.38	05.5=27.5	06=30
55	32	17.5=29.16	14.5=72.5	00=00
56	81.5	48.5=80.83	19=95	14=70
57	70.5	43.5=72.5	18=90	09=45
58	26.5	18.5=30.83	08=40	00
59	30	19.5= 32,5	6.5=32,5	4=20
60	46	19=31.66	17=85	10=50
61	23	21=35	02=10	00
62	55.5	31=51.66	12.5=62.5	12=60
63	54.5	27=45	15.5=77.5	12=60
64	40	20.5=34.16	08.5=42.5	11=55
65	49	31=51.66	08=40	10=50
66	34.5	19=31.66	15.5=77.5	00
67	41.5	26=43.33	05.5=27.5	10=50
68	67.5	41=68.33	16.5=82.5	10=50
69	55	29= 48,33	14= 70	12= 60
Mean	$\overline{X}$= 49.49	$\overline{X}$= 46.55	$\overline{X}$= 61.85	$\overline{X}$= 42.32

Table A. 5. The Participants WM Raw and Reproduced Scores

subjects	Whole score/100	RSPAN/40+%	OSPAN/25+%	Anagrams/10+%	LSPAN/25+%
1	64.25	31.25=78.12	14.25=57	4.5=45	14.25=57
2	51	23.25=58.12	12=48	06=60	09.75=39
3	70.5	33.5=83.75	17=68	04.75=47.5	15.25=61
4	68.75	32.5=81.25	14.75=59	05.5=55	16=64
5	76.75	37.25=93.12	14.75=59	05.25=52.5	19.5=78
6	63	31.25=78.12	13=52	02.25=22.5	16.5=66
7	76.25	35=87.5	14=56	3.25=32.5	24=96
8	78.75	36.5=91.25	16.75=67	06.5=65	19=76
9	53.75	31.5=78.75	08.75=35	02.25=22.5	11.25=45
10	67.25	35.25=88.12	14=56	04=40	14=56
11	54.25	30.75=76.87	11.25=45	1.75=17.5	10.5=42
12	54.25	23.75=59.37	12=48	1.75=17.5	16.75=67
13	65.75	35.5=88.75	18=72	05.5=55	06.75=27
14	60	27.25=68.12	16.25=65	03.5=35	13=52
15	69	32.25=80.62	14=56	05.75=57.5	17=68
16	64.25	30.25=75.62	13.75=55	03.25=32.5	17=68
17	44.75	25=62.5	10=40	01.5=15	08.25=33
18	67.5	31.5=78.75	18.5=74	05=50	12.5=50
19	62	32.25=80.62	12.5=50	01=10	16.25=65
20	69.25	34.25=85.62	12.5=50	01.5=15	21=84
21	83	37.25=93.12	19=76	07.5=75	19.25=77
22	54.25	28=70	08.25=33	01=10	17=68
23	64.25	29=72.5	13.25=53	03.5=35	18.5=74
24	65.5	34.75=86.87	12.75=51	02=20	16=64
25	62.25	32.5=81.25	10.25=41	01.5=15	18=72
26	44.25	21.75=54.37	09.75=39	01=10	11.75=47
27	76	36.5=91.25	13.75=55	03.25=32.5	22.5=90
28	60.25	28.25=70.62	14=56	01=10	17=68
29	52	27.5=68.75	10.25=41	02.75=27.5	11=44
30	54.5	31.75=79.37	10.75=43	01.75=17.5	10.25=41
31	82.25	37.25=93.12	19.75=79	03.75=37.5	21.5=86
32	59.75	27.5=68.75	11=44	03=30	18.25=73
33	57.75	34.5=86.25	03.5=14	02.25=22.5	17.5=70
34	45.75	31=77.5	12=48	02.25=22.5	0.5=2
35	70.5	32=80	12=48	03=30	23.5=94
36	63.25	30=75	16.25=65	05=50	12=48
37	71	37.25=93.12	16=64	04=40	13.75=55

38	64	29.5=73.75	13.25=53	05.25=52.5	16.25=65
39	60	26.75=66.87	13.25=53	03.75=37.5	16.25=65
40	59.5	30.25=75.62	13=52	04=40	12.25=49
41	68.75	32=80	19.25=77	3=30	14.5=58
42	56	20.75=51.87	11=44	04.25=42.5	20=80
43	54.75	29.75=74.37	12.5=50	02.25=22.5	10.25=41
44	74.75	36.5=91.25	17.5=70	04=40	16.75=67
45	63	33.5=83.75	14.5=58	1.5=15	13.5=54
46	65.25	34.25=85.62	13.75=55	05.25=52.5	11.75=47
47	64.5	30.25=75.62	17=68	04.75=47.5	12.5=50
48	52.25	26.75=66.87	12.75=51	02.25=22.5	10.5=42
49	52.25	29.75=74.37	12.5=50	01=10	09=36
50	71.75	33=82.5	18.25=73	02.75=27.5	17.75=71
51	58.75	34.25=85.62	10.75=43	01=10	12.75=51
52	58.5	33=82.5	11.25=45	03=30	11.25=45
53	90.25	38.75=96.87	21=84	04=40	23.5=94
54	70.5	30.5=76.25	17.75=71	05.5=55	16.75=67
55	69	30=75	20=80	2.5=25	16.5=66
56	50	24.5=61.25	11.5=46	01=10	13=52
57	48	24.25=60.62	12.25=49	01.25=12.5	10.25=41
58	58.75	30=75	13=52	04.5=45	11.25=45
59	48.25	26.5=66.25	15=60	1.75=17.5	05=20
60	54.25	26=65	15.75=63	02.75=27.5	09.75=39
61	54	34=85	10=40	0.75=7.5	09.25=37
62	66.25	35.25=88.12	17.75=71	02.25=22.5	11=44
63	59.5	31.75=79.37	14.25=57	03=30	10.5=42
64	50.25	27.25=68.12	12.5=50	01=10	09.5=38
65	59.25	27.5=68.75	16=64	05.25=52.5	10.5=42
66	50	26.25=65.62	08.75=35	03=30	12=48
67	14,5	1.25= 3,12	0.75= 3	2.5= 25	10= 40
68	50,25	27.25= 68,12	12.5= 50	1= 10	9.5= 38
69	59,25	27.5= 68,75	16= 64	5.25= 52,5	10.5=42
70	50	26.5= 65,62	8.75= 35	3= 30	12= 48
Mean	$\overline{X}$= 61.48	$\overline{X}$= 75.24	$\overline{X}$= 53.83	$\overline{X}$= 30.88	$\overline{X}$= 55.69

Table A. 6.The Participants' Verbal Reasoning Raw and Reproduced Scores

Subjects	Whole score	Knowledge/ 20+%	Similarity/20 +%	Syllogisms/10 +%	Understanding relations/20+ %	Analogies/30 +%
1	73	20=100	16=80	03.5=35	13=65	20.5=68.33
2	49.5	11=55	12.5=62.5	01=10	17=85	08=26.66
3	43.5	11.5=57.5	12.5=62.5	01=10	10=50	08.5=28.33
4	36.5	11=55	02=10	01=10	11.5=57.5	11=36.66
5	27.5	07.5=37.5	08.5=42.5	02.5=25	02.5=12.5	06.5=21.66
6	47	15=75	08.5=42.5	04=40	14=70	05.5=18.33
7	31	07.5=37.5	08=40	03.5=35	08=40	04=13.33
8	60.5	20=100	07.5=37.5	01=10	12.5=62.5	19.5=65
9	35.5	08.5=42.5	08.5=42.5	01=10	07.5=37.5	10=33.33
10	49	11=55	16=80	01=10	15=75	06=20
11	25	05=25	02=10	06.5=65	05=25	06.5=21.66
12	34	11=55	12.5=62.5	01=10	00	09.5=31.66
13	39.5	05=25	11=55	01=10	17=85	05.5=18.33
14	35	06=30	02=10	06.5=65	13.5=67.5	07=23.33
15	31.5	08=40	09.5=47.5	01=10	08.5=42.5	04.5=15
16	54.5	12=60	08=40	06.5=65	13=65	15=50
17	30	00=00	15=75	03.5=35	07.5=37.5	04=13.33
18	30	08=40	07.5=37.5	01=10	07.5=37.5	06=20
19	46.5	11=55	11=55	01=10	12=60	11.5=38.33
20	41.5	11=55	14=70	01=10	04.5=22.5	11=36.66
21	50.5	15=75	11=55	01=10	15=75	08.5=28.33
22	25.5	02=10	16=80	00	07.5=37.5	00
23	37	07.5=37.5	04.5=22.5	01=10	09=45	15=50
24	36	04.5=22.5	11=55	03.5=35	08.5=42.5	08.5=28.33
25	34.5	08=40	04.5=22.5	02.5=25	08=40	11.5=38.33
26	56	03.5=17.5	11=55	03=30	08.5=42.5	20=66.66
27	48	8.5=42.5	08.5=42.5	04=40	12=60	15=50
28	34	08=40	02=10	06.5=65	02.5=12.5	15=50
29	37.5	11.5=57.5	11=55	03.5=35	07.5=37.5	04=13.33
30	36	05=25	16=80	02.5=25	05=25	07.5=25
31	75	20=100	14.5=72.5	04=40	17=85	19.5=65
32	65.5	20=100	11.5=57.5	01=10	15=75	18=60
33	47.5	11=55	12.5=62.5	04=40	04.5=22.5	15.5=51.66
34	36.5	04.5=22.5	08.5=42.5	01=10	08.5=42.5	14=46.66
35	41.5	6.5=32.5	13.5=67.5	01=10	11.5=57.5	09=30
36	56.5	16=80	11=55	04=40	11=55	14.5=48.33
37	44.5	11=55	07.5=37.5	00	08=40	18=60

38	28	04.5=22.5	04.5=22.5	04.5=45	05=25	09.5=31.66
39	43	08=40	20=100	06.5=65	05.5=27.5	03=10
40	34.5	11.5=57.5	05.5=27.5	04=40	08.5=42.5	05=16.66
41	25	02=10	08=40	04=40	11=55	00
42	79.5	20=100	11=55	04=40	20=100	24.5=81.66
43	28	11.5=57.5	04.5=22.5	01=10	05.5=27.5	05.5=18.33
44	32.5	14=70	08.5=42.5	02.5=25	03=15	04.5=15
45	24	08.5=42.5	07=35	01=10	07.5=37.5	00
46	29.5	05=25	08.5=42.5	03.5=35	08.5=42.5	04=13.33
47	20	04=20	04.5=22.5	02.5=25	09=45	00
48	68	15=75	11=55	04.5=45	15=75	23.5=78.33
49	11.5	03=15	05=25	01=10	02=10	0.5=1.66
50	24.5	2.5=12.5	06=30	06.5=65	09.5=47.5	00
51	50.5	12=60	07.5=37.5	01=10	11=55	19=63.33
52	44.5	08.5=42.5	08.5=42.5	04=40	14=70	09.5=31.66
53	30	07.5=37.5	08=40	05.5=55	07.5=37.5	1.5=5
54	57.5	11=55	16=80	06.5=65	07.5=37.5	16.5=55
55	45.5	14=70	09.5=47.5	02.5=25	05.5=27.5	14=46.66
56	20.5	02=10	08.5=42.5	02.5=25	07.5=37.5	00
57	34	04.5=22.5	11=55	01=10	02=10	15.5=51.66
58	47	08.5=42.5	11=55	04.5=45	08.5=42.5	14.5=48.33
59	26.5	00	07.5=37.5	02.5=25	11=55	05.5=18.33
60	49	07.5=37.5	12=60	01=10	17=85	11.5=38.33
61	28.5	06=30	12=60	03.5=35	06.5=32.5	0.5=1.66
62	55	15=75	09=45	04=40	09=45	18=60
63	21	04=20	08=40	03=30	04=20	02=6.66
64	64.5	13.5=67.5	16.5=82.5	03.5=35	20=100	11=36.66
65	28,5	6=30	12=60	3.5=35	32,5	0.5= 1,66
66	55	15= 75	9=45	4=40	9=45	18=60
67	21	4= 20	8=40	3=30	4=20	2= 6,66
68	64,5	13.5= 67,5	16.5=82,5	3.5=35	20= 100	11=36,66
Mean	$\overline{X}$= 40.07	$\overline{X}$= 44.16	$\overline{X}$= 46.95	$\overline{X}$= 28.11	$\overline{X}$= 44.42	$\overline{X}$= 31.44

Table A. 7. The participants Language Aptitude Scores, Working Memory Scores and Verbal Reasoning Scores

Subjects	Language aptitude	Working memory	Verbal reasoning
1	71,5	64,25	73
2	66	51	49,5
3	60	70,5	43,5
4	77,5	68,75	36,5
5	61,5	76,75	27,5
6	61	63	47
7	61,5	76,25	31
8	85,5	78,75	60,5
9	47,5	53,75	35,5
10	58,5	67,25	49
11	49,5	54,25	25
12	79,5	54,25	34
13	56,5	65,75	39,5
14	68,5	60	35
15	41,5	69	31,5
16	36	64,25	54,5
17	30,5	62	46,5
18	65	69,25	41,5
19	59	83	50,5
20	36,5	54,25	25,5
21	42,5	64,25	37
22	37,5	65,5	36
23	31,5	62,25	34,5
24	50,5	44,25	56
25	45,5	76	48
26	36	60,25	34
27	40	52	37,5
28	46	54,5	36
29	69	82,25	75
30	60,5	59,75	65,5
31	53,5	63,25	36,5
32	53,5	71	41,5
33	66,5	64	56,5
34	63	60	44,5
35	37,5	59,5	28
36	66,5	68,75	43
37	33,5	56	34,5
38	41	54,75	25

39	69	74,75	79,5
40	40,5	63	28
41	40,5	65,25	32,5
42	56	64,5	24
43	42,5	52,25	29,35
44	28,5	52,25	20
45	70	71,75	68
46	33	58,75	11,5
47	32	58,5	24,5
48	81,5	90,25	50,5
49	70,5	70,5	44,5
50	26,5	50	30
51	42,5	48	57,5
52	46	58,75	45,5
53	23	48,25	20,5
54	55,5	54,25	34
55	54,5	54	47
56	40	66,25	26,5
57	49	59,5	49
58	41,5	50,25	28,5
59	67,5	59,25	55
60	34,5	50	21

Appendix 4: the participants' scores in linguistic intelligence and its final factors

Table A. 8. The Participants Scores in the Different Factors of Linguistic Intelligence+ Final Linguistic Intelligence Scores

Participants	**Verbal reasoning score/40** + %	**Working memory score/40** + %	**Grammatical ability score/20** + %	**Overall linguistic intelligence score/100**
1	28,99= 72,47%	24,51= 61,27%	13,95= 69,75%	67,45
2	23,41= 58,52%	25,11= 62,77%	9,65= 48,25%	58,17
3	20,83= 52,07%	24,92= 62,3%	12,35= 61,75%	58,1
4	23,57= 58,92%	25,27= 63,17%	14,9= 74,5%	63,74
5	8,16= 20,4%	21,71= 54,27%	15,8= 79%	45,67
6	21,41= 53,52%	22,26= 55,65%	14,35= 71,75%	58,02
7	17,58= 43,95%	21,6= 54%	16,85= 84,25%	56,03
8	33,16= 82,9%	28,57= 71,42%	16,85= 84,25%	78,58
9	18,83= 47,07%	17,37= 43,42%	10,5= 52,5%	46,7
10	16,5= 41,25%	25,91= 64,77%	13,85= 69,25%	56,26
11	13,49= 33,72%	16,43= 41,07%	11,45= 57,25%	41,37
12	24,24= 60,6%	12,48= 31,2	16,7= 83,5%	53,42
13	16,83= 42,07%	30,07= 75,17%	8,45= 42,25%	55,35
14	18,83= 47,07%	23,56= 58,9%	12,95= 64,75%	53,04
15	16,5= 41,25%	23,66= 59,15%	10,55= 52,75%	50,71
16	17,41= 43,52%	22,81= 57,02%	11,05= 55,25%	51,27
17	13,24= 33,1%	20,06= 50,15%	10= 50%	43,3
18	22,24= 55,6%	17,31= 43,27%	16,65= 83,25%	56,2
19	21,33= 53,32%	31,91= 79,77%	15,2= 76%	68,44
20	7= 17,5%	15,05= 37,62%	13,05= 65,25%	35,1
21	15,16= 37,9%	20,55= 41,37%	14,4= 72%	50,11
22	10,91= 27,27%	20,03= 50,07%	10,65= 53,25%	41,49
23	11,49= 28,72%	17,72= 44,3%	11,95= 59,75%	41,16
24	15,99= 39,97%	14,58= 14,58%	10,2= 51%	40,77
25	15,41= 38,52%	23,87= 59,67%	17,25= 86,25%	56,53
26	16,83= 42,07%	14,91= 37,27%	8,3= 41,5%	40,04
27	15,08= 37,7%	17,47= 43,67%	9,4= 47%	41,95
28	10,66= 26,65%	16,48= 41,2%	13,1= 65,5%	40,24
29	30= 75%	29,46= 73,65%	16,6= 83%	76,06
30	29= 72,5%	21,77= 54,42%	12,55= 62,75%	63,32
31	16,41= 41,02%	23,25= 58,12%	12,05= 60,25%	51,71
32	16,58= 41,45%	25,46= 63,65%	12,25= 61,25%	54,29
33	26,33= 65,82%	23,42= 58,55%	13,75= 68,75%	63,5
34	23,25= 58,12%	19,73= 49,32%	13,75= 68,75%	56,73
35	11,57= 28,92%	19,26= 48,15%	9,15= 45,75%	39,98
36	16,33= 40,82%	21,45= 53,62%	14,05= 70,25%	51,83

37	12,66= 31,65%	18,08= 45,2%	13= 65%	43,74
38	7,08= 17,7%	20,18= 50,45%	10,35= 51,75%	37,61
39	32,41= 81,02%	30,12= 75,3%	14,45= 72,25%	76,98
40	14,16= 35,4%	18,42= 46,05%	12,9= 64,5%	45,48
41	13,33= 33,32%	20,81= 52,02%	12,45= 62,25%	46,59
42	10,91= 27,27%	22,86= 57,15%	14= 70%	47,77
43	12,33= 30,82%	18,28= 45,7%	11,45= 57,25%	42,06
44	4= 10%	17,93= 44,82%	8,6= 43%	30,53
45	30,24= 75,6%	25,8= 64,5%	14,35= 71,75%	70,39
46	8,19= 20,47%	14,86= 37,15%	7,85= 39,25%	30,9
47	4,16= 10,4%	20,5= 51,25%	11,75= 58,75%	36,41
48	27,41= 68,52%	27,58= 68,95%	18,9= 94,5%	73,89
49	19,16= 47,9%	27,22= 68,05%	15,7= 78,5%	62,08
50	7,33= 18,32%	15,47= 38,67%	9,2= 46%	32
51	18,75= 46,87%	15,96= 39,9%	10,1= 50,5%	44,81
52	19,82= 49,55%	19,95= 49,87%	13= 65%	52,77
53	4,5= 11,25%	18,12= 45,3%	3= 15%	25,62
54	18,57= 46,42%	16,55= 41,37	10,15= 50,75%	45,27
55	19,58= 48,95%	17,5= 43,75%	11,45= 57,25%	48,53
56	10,74= 26,85%	23,66= 59,15%	8,65= 43,25%	43,05
57	17,74= 44,35%	25,13= 62,82%	8,2= 41%	51,07
58	12,49= 31,22%	16,06= 40,15%	6,55= 32,75%	35,1
59	25,33= 63,32%	23,02= 57,55%	12,45= 62,25%	60,8
60	5,82= 14,55%	15,06= 37,65%	12,55= 62,75%	33,43

Appendix 5: the participants obtained scores in language learning achievement

Table A. 9. The Participants' Raw and Reproduced Achievement Scores

Subjects	S1 average	S2 average	Achievement mean average and its conversion to percentage
1	10.75	12.02	56.9
2	10	10.61	51.5
3	08.60	00	21.5
4	13.55	12.08	64.05
5	10.08	09.20	48.2
6	10.72	10.97	54.2
7	10.04	08.63	46.65
8	16.05	14.91	77.4
9	9.75	9.51	48.15
10	12.30	12.65	62.35
11	10.13	10.62	51.85
12	14.37	14.83	73
13	9.94	10.22	50.4
14	10.38	9.63	50
15	9.61	9.92	48.8
16	10.48	9.84	50.8
17	11.33	11.41	56.85
18	12.82	12.08	62.25
19	12.22	13.17	63.45
20	10.31	10.73	52.6
21	10.62	10.62	53.1
22	10.82	11.05	54.65
23	9.75	10.98	51.8
24	11.23	12.85	60.2
25	11	12	57.5
26	10.35	11.75	55.25
27	10.65	10.92	53.9
28	12.78	13.73	66.25
29	14.10	14.18	70.7
30	8.75	7.63	40.95
31	12.05	11.54	58.95
32	11.33	9.90	53.05
33	14.43	14.42	72.1
34	10.58	10.46	52.6
35	09.04	10.87	49.75
36	13.54	12.29	64.55
37	08.07	06.47	36.35
38	11.19	10.96	55.35

39	12.89	12.87	64.4
40	10.88	11.23	55.25
41	12.45	12.38	62.05
42	13.18	12.53	64.25
43	12.73	12.79	63.8
44	7.10	00	17.75
45	11.26	10	53.15
46	10.74	11.77	56.25
47	11.22	11.33	56.35
48	14.53	15.08	74
49	12	13	62.5
50	08	10	45
51	08.71	11.50	50.5
52	12	13	62.5
53	10.25	10.83	52.7
54	11	11	55
55	13	13	65
56	11	10	52.5
57	11.65	12.92	61.4
58	07.47	02.53	25
59	11.76	14.29	65.1
60	13	13	65

Résumé

Ce travail de recherche traite certains aspects cognitifs des différences individuelles qui influencent l'apprentissage des langues étrangères. L'étude explore la relation entre un type d'intelligence qui s'appelle « l'intelligence linguistique » et l'accomplissement d'une langue étrangère. Cette capacité cognitive elle-même est supposée inclure trois autres capacités: mémoire de travail, aptitude linguistique, et raisonnement verbal. De ce fait, trois tests de ces capacités cognitives ont été remis à un échantillon de 70 étudiants de première année, apprenant l'Anglais comme langue étrangère à l'université des frères Mentouri - Constantine. Des corrélations ont été établies entre les scores obtenus dans les trois tests. Ensuite, une analyse factorielle a été menée afin de déterminer les facteurs constituant de cette intelligence linguistique. Les résultats de cette étude confirment la présence de trois capacités avec une précision de désignation d'un facteur (de l'aptitude linguistique a capacité grammaticale). Une autre étude de corrélation a été réalisée entre le score global de la matière étudiée avec ces facteurs finaux (raisonnement verbal, capacité grammaticale, et mémoire de travail) ainsi que le score de l'accomplissement linguistique. Les résultats montrent des relations significatives entre ces deux variables aussi bien que deux facteurs finaux de cette intelligence: raisonnement verbal et capacité grammaticale avec une corrélation faible concernant le dernier facteur: mémoire de travail.

ملخص:

تسعى هذه الدراسة إلى تسليط الضوء على بعض الجوانب المعرفية للفروق الفردية التي تؤثر على تعلم اللغة الأجنبية، كما تسعى للكشف عن العلاقة بين صنف من الذكاء الذي يعرف بالذكاء اللغوي و النجاح في اكتساب اللغة الأجنبية، حيث افترضنا أن هذا النوع من الذكاء يشمل ثلاث قدرات فكرية: "الذاكرة العملية"، و "الكفاءة اللغوية"، و "الاستنتاج اللفظي".

و على هذا الأساس قمنا بإجراء ثلاثة اختبارات فكرية للقدرات السابقة الذكر لعينة تتكون من 70 فردا من طلبة السنة الأولى للغة الانجليزية بجامعة الاخوة منتوري–قسنطينة، ثم أجريت دراسة عوامل الترابط بين نتائج هذه القدرات الثلاث، و بعد إثبات العلاقة بين القدرات الفكرية السابقة الذكر قمنا بدراسة التحليل العاملي لتحديد العوامل النهائية للذكاء اللغوي، حيث تبين أن هناك تغيير في تسمية القدرة الثالثة من الاستعداد اللغوي إلى القدرة النحوية، و بعدها قدمنا دراسة ثانية لمعرفة مدى الترابط بين الذكاء اللغوي مع عوامله النهائية و معدل النجاح في اكتساب اللغة الانجليزية كلغة أجنبية. حيث تم إيجاد علاقة ملحوظة بين هذين المتغيرين لاسيما بين عاملين من عوامل الذكاء اللغوي (الاستنتاج اللفظي و الذاكرة العملية) و النجاح في تعلم اللغة الانجليزية، بينما لوحظت علاقة ضعيفة بين هذا الأخير و العامل الثالث أي القدرة النحوية.