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MEMORY AND INTELLIGENCE IN ALGERIAN SCHOOLED CHILDREN

A dissertation submitted in partial fulfillment of the requirements for the Magister degree in Linguistic sciences &English Language Teaching

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Dedication

I wish to dedicate my modest work to all my family:

-my parents who devoted their life to my education

- my brothers

-my sister for her intensive help and encouragement

Special thanks are due to my husband for his patience and care

Thanks to my friends for their moral support.

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I am also thankful to all the children who participated with pleasure in this study.
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Abstract

Our objective in this study is to investigate whether the Algerian primary school children who possess high mental abilities, in other words who are considered to be intelligent, own effectively good memorizing aptitudes.

Since the problem we are faced with concerns the relationship between memory and intelligence, the background ideas for our research have focussed on the theoretical foundations and results on memory and intelligence studies that have been reported in the literature. Mainly, two different theories have been proposed to investigate the memory structure and functions: The information processing approach theory, interested in how the information is organized and what are the processes used to access this information, and the Piagetian approach that focuses on the appreciation of human's memory done closely linked to the development of his logical competence.

In this study we will assume that there is a relationship between memory and intelligence, and that Algerian primary school children who have a good memory have higher intelligence scores than those with poor memorization capacities.

For this purpose, we used in our experiment two random groups of the same instructional level and of an equal size. They are pupils of fourth primary year among a population of 120 children aged between 10 and 11. Both groups were constituted of boys and girls.

An intelligence test has been designed to gather enough information about the pupils' cognitive capacities. Another test consisting of a series of memory tasks has been constructed to allow the collection of sufficient data about the primary school pupils' memorization.

From the analysis of our results of the memory and intelligence tests, we have derived that, in accordance with what was expected by theoretical studies, children intelligence performances seemed to have a strong relation with their memory abilities. This relationship can appear in terms of a good organization of knowledge in their memory structure or in terms of their abilities to quickly process the information, basically helped by their already acquired knowledge and previous experiences.

List of abbreviations and symbols

STM : Short Term Memory

LTM: Long Term Memory

STS: Short Term Store

LTS: Long Term Store

WM : Working Memory

r : Correlation coefficient

X,Y: Observations (Here the items of memory and intelligence tests)

N: number of individuals

pi: the pupil number “i”

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INTRODUCTION

I. General Overview

Cognitive psychology represents the dominant branch in psychological research today. One of its primary interests is the cognitive development in children.

Cognitive development refers to all the changes that may occur in an individual's cognitive structures, abilities and processes. Therefore, many questions have been the goal of deep investigations from both a theoretical and an experimental point of view. Some of these studies were concerned with human memory. A lot of psychologists have tried to understand how the human memory works, how we can memorize information and retrieve it. Others have focused their works on human intelligence. They wanted to comprehend how one can engage in different forms of reasoning to solve simple and complex problems, what may be the abilities that help the individual to understand elaborate ideas and how does one proceed to acquire new concepts and skills.

In spite of the fact that there are widely varying views within cognitive psychology, there are some basic principles on which most cognitive psychologists agree with.

First, some people are better than others at remembering what they have just seen, and others at remembering details about an event that happened long time before. But in the two cases scientists agree on the fact that for each of these two kinds of persons, the amount of information that can be processed by their mental system, at the same time, is constrained in some very important ways.

Second, the concept of memory implicitly includes a memory manager most commonly called, a control mechanism, required to use the information available in our mind. This explains why when someone is confronted with a new environment, he needs a more processing power or effort than when one is doing a routine task or is in a familiar environment.

Third, we constantly use information that we gather through the senses and information we have stored in memory in a dynamic process as we construct meaning about our environment and our relations to it.

At last, people manifest differences, i.e. different intelligence abilities, when they try to understand complex ideas, to reason, to plan and solve problems and to effectively adapt to the environment or to learn from experience. But they all need concepts or ideas that have to be provided by their memory. Therefore,we may deduce that there exists a link between memory and intelligence.

II. Aim of the study

Our main objective, in this study, is to analyze the different parts of the natural cognitive processes and the learning processes within a group of Algerian schooled children of ten to eleven years old.

III. Statement of the problem and question

The problem we are faced with concerns one kind of relationship between memory and intelligence: what are the possible links between memory and intelligence. In other words are we more intelligent if we have a good memory? Or the other way around: does good memory entails intelligence? Or are memory and intelligence necessary interactive (transactional) processes? The question about their relationship is a very complex one, and needs careful studies and cautious and convincing arguments.Thus, the basic question which we ask is:

Do Algerian primary school children with high intelligence abilities retain more than Algerian primary school children with low intelligence abilities?

IV. The hypothesis

There is a relationship between memory and intelligence. We hypothesize that Algerian primary school children who have a good memory are more intelligent than those with poor memorization capacities.

V. The methodology and research design

In this dissetation, we will attempt first, to expose the theoretical studies and results of investigations that can help to answer the question and then try to examine the findings of our own research based on some battery of tests we constructed on memory and intelligence investigations on a group of sixty pupils, of an Algerian primary school, aged between ten and eleven to confirm or disconfirm the hypothesis. Our aim is not to measure the intellectual quotient (IQ) of our children but try to find out if there exists a given relation between their capacity for memorization and their abilities to think from the battery of the tests.

Our experimental work is designed for two random groups of thirty children from a population of 120 pupils. They belong to Aissous Rabah primary school. They are in their fourth school year. The two groups receive the same educational programme

The memory and intelligence tests constructed for the experimental study are based on the educational programme taught in the classroom and the school books used by the pupils. We have taken into consideration three main subjects : Arithmetics, language and civic education, for the elaboration of the tests' items. Of course, the degree of difficulty in the memory and intelligence items varies gradually according to the instructional level of the pupils. Full detail on the research design will be given in the chapter on experimentation.

VI. Organisation of the thesis

This study is organized as follows: the first chapter is devoted to the exposition of the most influential theories of memory. The first section of chapter one describes the theory called "The Stage Theory" which is based on the work of Atkinson and Shiffrin (1968). The model proposed assumes that information is processed and stored in three stages, namely, the Sensory Store, the Short Term Store and the Long Term Store. In this theory, data is thought to be processed in a serial, discontinuous manner when it moves from one stage to another (or one store to the next).

The second section concerns the theory exposed by Craik and Lockhart (1972). It is labeled "The Levels-of-Processing Theory" or the "Information Processing Theory". In this approach the information process is done on a continuum from perception, through attention, to labeling and meaning. The key point is that all stimuli that activate a sensory receptor cell are permanently stored in memory, but at different levels of processing (i.e, elaboration) contribute to an ability to access, or retrieve, that memory. In the third section, we will present the Piagetian model of memory.

The last section of chapter one concerns Working Memory. In 1986, Baddeley and his colleagues proposed the first model of the functional architecture of human working memory. The model presented is made up of three main components: the central executive, the articulatory loop and the visuo-spatial sketch pad. The articulatory loop and the visuo- spatial sketch pad are “slave systems” in which verbal and visual information are respectively stored. The central executive is reserved to control the communication between these two systems and between working memory and long term memory.

Concepts of human intelligence have been explored in chapter two. A brief historical review exposes the different approaches that have been used to investigate the area. The Psychometric approach, the most widely used one to measure intelligence has been suggested historically by Alfred Binet, and is based on a battery of selected questions or tasks to which the subjects have to answer. Their performance on all the items can provide enough information to analyze their mental abilities. Other theories such as the one advocated by Spearman (1927), worked on what can be considered as a common property (or factor) to all these tests, called “ factor g”. Other approaches, investigated from other perspectives, as the developmentally- based conception of intelligence proposed by Piaget, and the socially based one articulated by Vygotsky, will also be presented. Exploring various forms of personal intelligence, Howard Gardener proposed in 1983, the theory of multiple intelligences.

In chapter three, we will try, on the basis of what has previously been said, to make the link between memory and intelligence. Three aspects of intelligence tasks will be explored. First, the reasoning ability, measured by the general factor “g”, then the abstraction and modelisation ability, and third the speed of information processing. For each of them, we will present the main ideas that may help to clarify the relation with memory structure capacity, with the useful aid of some theoretical and experimental results from the literature.

The second section of chapter three is concerned with the problem solving abilities and the influence of people’s motivation on what they intend to learn. This also will help us to understand and clarify the mechanism of learning since problem solving can be seen as part of our intelligence.

Finally in the last chapter, the experimental results obtained from a sample composed by two groups of thirty pupils of 10 or 11 years old, drawn randomly from a population of schooled children of the same age(c.f. for more details ch. four), are studied with care and used as a means to obtain answers. We first present the conditions in which the experimental work has been performed then, the batteries of memory tests and intelligence tests given to the children and at last, examine, on the basis of the analysis of the collected data, what conclusions we can achieve on memory and its link to intelligence from the obtained scores.

In our dissertation, we have attempted to expose and use the useful and available works of some researchers in this field, i.e. memory and intelligence. We have tried to do our best to clarify, to some extent, the question "are we more intelligent if we benefit from a good memory" relying on what has been proposed by the various scientists and theoreticians.

CHAPTER 1. Memory: Overview of the different theories

1.1 Introduction

Memory is a property of the human mind: the ability to retain information. There are multiple types of classifications for memory, based on duration, nature and retrieval of perceived items. Different models have been proposed within the memory literature.

In this chapter, we will first focus on the two different theories proposed to investigate the memory structure and functions. In spite of the fact that the multi-store model of memory is now seen as being too simplistic, it will be presented here because it still provides the starting point for viewing memory processes, and the memory stores it has are still accepted today.

The second theory, is an information processing approach which considers the human memory as a “ knowledge base” or a library. It is more interested on how the information are organized and what are the processes used to access to these information.

At the end of the chapter, we will present the Piagetian model of memory. Since Piaget did not work directly on memory functions, his appreciation of human memory has been elaborated closely to the cognitive development research he performed on the development of children’s logical competence.

1.2 The multi-store Model of Memory

Atkinson and Schiffrin’s multi-store model conceptualizes memory as a combination of permanent structural components and control (or transient) processes. These processes aid the transfer of information between the components. In the multi-store model architecture (Atkinson & Shiffrin, 1968) given in Figure 1.1, three discrete storage sub-systems are present. A Sensory Register, a Short-Term-Store and Long-Term-Store. Each storage is believed to have four characteristics: Its capacity, its trace duration, the code in which information is stored and at last the control process supposed unique for each store.

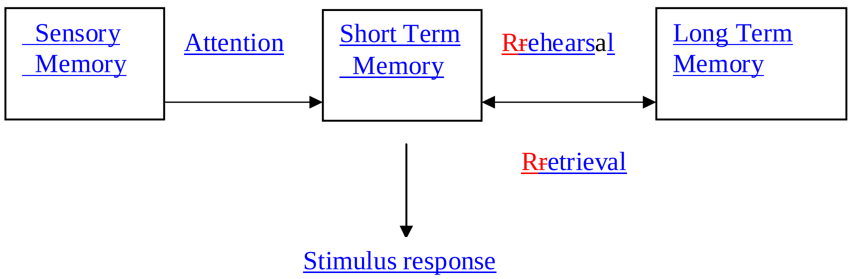


Figure 1.1 : *The multi-store model of memory (Atkinson & Shiffrin, 1968)*

According to memory theorists, we can define these three different memory stores as :

1- *The sensory store*, which stores limited amounts of information for very brief periods of time. This information is an initial impression of the external stimulus and decays rapidly unless it undergoes further processing.

2- *The Short Term Store (STS)* , which stores information for somewhat longer periods of time but is also of a relatively limited capacity. The length of time information remains in the short-term store depends on whether it undergoes rehearsal or not.

3- *The Long Term Store (LTS)*, which has a large information capacity and is capable of storing information for a very long period of time. The long-term store is presumed to be an unlimited, relatively permanent storage system.

As we have mentioned earlier, these three stores are well represented in the Atkinson and Shiffrin Model (1971). Information is processed in the same manner, through the same steps in the three different but interdependent stores. All encode, store and retrieve information. Therefore, Encoding, storage and retrieval represent stages of memory processing.

The first stage, termed *encoding* refers to the operation of transforming a perceived physical, sensory input into a kind of simply identified representation which can be inserted into memory. The second step, *storage*, refers to the process of retention of the encoded material in memory. The last operation, *retrieval*, refers to how stored information is retrieved to be reused. One remark should be made which is that if information is not easily encoded, consequently it is stored and retrieved with difficulties.

1.3 Information Processing Model of Memory

Levels of processing, an influential theory of memory suggested by Craik and Lockhart (1972), abandoned the idea of the existence of three memory stores model of memory. This first model assumed that characteristics of a memory are determined by its "location" (i.e., fragile memory trace in short term store and durable memory trace in the long term store). As an alternative, Craik and Lockhart proposed that information could be processed in a number of different ways and the durability or strength of the memory trace was a direct function of the depth of processing involved.

Moreover, depth of processing was postulated to fall on a shallow to deep continuum. On one hand, by “shallow processing” they mean that processing words is based on their phonemic and orthographic components. This leads to a fragile memory trace that is predisposed to speedy forgetting. On the other hand, deep processing or semantic based processing results in a more durable memory trace.

A typical concept employed to investigate the Levels of Processing Theory is the incidental-learning paradigm. Results revealed superior recall for items processed deeply compared to those items processed at the more shallow level (Eysenck, 1974: Hyde & Jenkins, 1969) (in Gross, 1985). Memorising some content verbatim, without associating it to any existing system of knowledge and experience about the world may make the information temporarily available.

What we seem to remember best and recall when needed are data that we have already related to a given existing set of knowledge linked to our proper world.(Baddeley,1998)

The processing of words based on their phonemic and orthographic components leads to a fragile memory trace that is susceptible to rapid forgetting. On the other hand, deep processing or semantic based processing results in a more durable memory trace.

From information processing psychologists point of view, contents of knowledge can differ from one person to another but the organising structure and mechanisms for accessing these knowledge are at some level the same.

1.3.a) Memory components

The main difference with the previous theory remains in the fact that the components of memory structure are related and classified with regards to the information types used rather than location of this information.

Psychologists believe that human knowledge is represented as a network in which conceptually similar entries are associated with one another.

The links between the nodes (concepts) are of different types: describing a property (is, has or can) or describing a mental image of the concept (looks like) (Lieury, 1996).

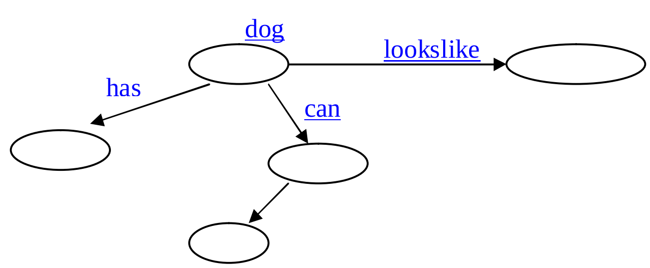


Figure 1.2 : *Network representation of memory*

Tulving 's (1973) model focuses on the nature of the material that is stored in human memory. His updated model distinguishes three kinds of memory based on content: episodic, semantic and procedural.

Two types of knowledge are distinguished:

Declarative: knowledge that corresponds to "knowing what" and **procedural** knowledge corresponding to "knowing how to perform an activity". This type of memory is composed by:

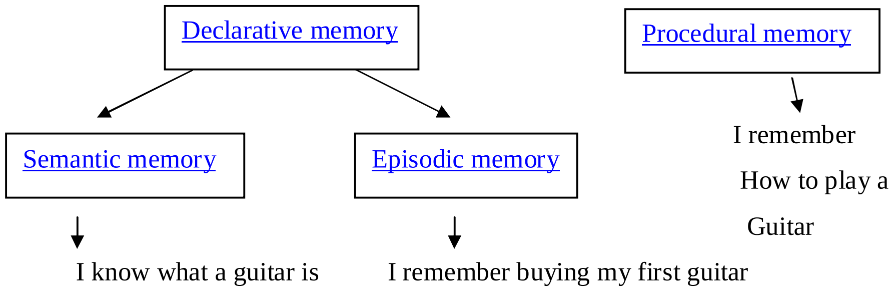


Figure 1.3 : *Declarative and procedural knowledge*

Declarative memory can be of two types :

1. **Semantic memory**: is the organized knowledge about the world. Essentially, it contains all the learning that we have accumulated throughout our lives. The information strongly associated to the node (concept), for example "pigeon", corresponds to our sense of the average prototype of a "pigeon". Prototypes represent a means by which we can abstract the common elements.
2. **Episodic memory**: Often related to personal experience, it stores information about when events happened and the relationship between those events. The complex collection of temporally organized events is called "script".

- **Non-declarative (or Procedural memory):** involves knowing how to do something like tying a shoelace. It is often difficult to describe verbally, as it seems instinctive. Tulving argues that procedural knowledge is the first system to develop during infancy, followed by semantic knowledge as we learn, and lastly, compilation of episodic memory consisting of events that we encounter in life, (Wikipedia, 2004)

1.3.b) Spread or depth encoding

Craik and Tulving in 1975 proposed that it might be more appropriate to talk of a spread of encoding than some continuous hierarchical set of analyses conducted on information. Memory is thought of as a continuum of encoding ranging from traces based upon the less permanent encoding of physical features to more durable encoding of semantic features (Craik and Lockhart, 1972)

Spread of encoding suggests that a memory trace may be developed that includes additional information within the dimension of orienting activity as well as information from other dimensions. When a trace begins to be elaborated, there is an activation of associations including other semantic and non-semantic features.

From that intentional recall is frequently better than incidental recall. Thus, it would appear that some additional elaboration of stimulus trace is carried out in the intentional recall condition at both semantic and non-semantic levels. (Craik and Lockhart, 1972)

Additional support for spread of encoding is found in the '*Congruity effect*'. When a positive answer 'yes' is given to a question, responses are always remembered better than those with 'No' responses. They would appear to provide a more meaningful encoding context that induces in the information processor to construct more elaborated memory traces.

It is absolutely critical that the learners attend to the information at this initial stage in order to transfer it to the next one. There are two major concepts for getting information into STM from Sensory Stores: Individuals are more likely to pay attention:

- To a stimulus if it has an interesting feature. We are more likely to get an orienting response if this is present.

- If the stimulus activates a known pattern.

The encoding specificity: The encoding specificity principle of memory (Tulving & Thomson, 1973) provides a general theoretical framework for understanding how contextual information affects memory. Specifically, the principle states that memory is improved when information available at encoding is also available at retrieval. For example, the encoding specificity principle would predict that recall for information would be better if subjects were tested in the same room they had studied in versus having studied in one room and tested in a different room.

Processing strategies : Craik and Lockhart (1972) suggested that it is how information is rehearsed that matters. Memory is improved if information is rehearsed in a deep and meaningful way. They called this depth of processing. Rehearsal being the main method for transferring items from STM to LTM, they therefore distinguished kinds of rehearsal.

- *Elaborative rehearsal:* is a type of rehearsal proposed by Craik and Lockhart (1972) in their Levels of Processing model of memory. Elaborative rehearsal involves deep semantic processing of a to-be-remembered item resulting in the production of durable memories; it helps then to produce long term retention. For example, if you were presented with a list of digits for later recall (4920975), grouping the digits together to form a phone number transforms the stimuli from a meaningless string of digits to something that has meaning.

- *Maintenance rehearsal :* Maintenance rehearsal involves rote repetition of an item's auditory representation. In contrast to elaborative rehearsal, this type of rehearsal does not lead to stronger or more durable memories. It keeps the information in an immediate memory

In a set of experiments, Craik and Tulving in 1975, proved that the questions asked to subjects fix the level at which words are encoded. The test has been presented under intentional or incidental conditions. As a result, semantic encoded words are remembered better than those non-semantically encoded.

There is a number of reasons why semantic elaboration facilitates retention more than other types of encoding. A non-semantic oriented activitiy may direct the learner’s attention to part of stimulus (ex: the first letter of a word).

Information retrieval:

To complete the memory model we need to address the issue of information retrieval. When we try to remember something we naturally attempt to generate retrieval cues. Our efforts focussed on how to re-establish the context in which we learned something. The works of (Thomson and Tulving in 1970-73 and Fisher and Craik in 1977) (in Gross, 1985) gave *further support* for the idea that recall is facilitated by retrieval cues that are congruous with the encoding context. Children remember best when retrieval cues help to reinstate the learning.

The conclusion is that if we want to improve children's memory performance in the sense of to help them to remember their lessons we must help them to relate these lessons to what they have already acquired.

Even if we know from what precedes that oriented questions help to fix the information, it has been demonstrated that we cannot say exactly at what level the information has been encoded. Separation into semantic and physical features is not objective since when children are asked to retrieve an attribute of an item, they associate also the information on other attributes of this same item.

One of the most important notions that have been advanced out of the levels-of-processing research is the idea of 'intentionality' i.e. whether or not, when someone tries to remember something, has to do with what is remembered.

Some experiments have reported better recall of words under intentional conditions compared to incidental memory conditions. Two experiments conducted by Gross and Montes in 1981 (in Gross,1985), revealed that informed subjects elaborate a memory trace to include attributes that were likely to facilitate an anticipated recall task.

1.3.c) The Three stage view of memory, History and Discussion

Now that we have briefly summed up the major memory processes and the three memory stores we can , more deeply, probe each memory store, starting with the sensory store.

1.3.c.1. Sensory memory

It is certainly a little bit hard to achieve it but just try for a short moment of time to imagine your life deprived from your senses. It would be impossible for you to hear, to see, to smell, to taste, or to feel. What a strange idea it would be? But, it would probably convince you of the high importance of sensations from the world. It is important to note that, psychologists study sensation because our thoughts, feelings, and actions are largely a reaction to what our senses do. Indeed, without our senses we would be lost in a tasteless, odourless, neutral world.

In psychological research, scientists define a sensation as “a message that our brain receives from our senses.” (Sternberg, 1996). The sense in psychology is considered as a “physical system that collects information for the brain from the external world or from the internal world of the body and then translates this information into a language that the brain understands.” (Wikipedia, 2004)

The environment makes available a variety of sources of information (light, sound, smell, heat, cold, etc.), but the brain only understands electrical energy. The body has special sensory receptor cells.

There are many sensory memory systems that are intimately involved in our perception of the world. The sensory memory refers to initial recording of information in our sensory system. The information interpreted by the visual system is stored for less than one second in *the iconic memory*. It corresponds to the brief visual persistence of information. For the auditory phenomenon, the information is stored in what is called *the echoic memory*. Its duration is a bit longer than the first and is supposed to last average 500 ms (for iconic) or 3 seconds (for echoic). All our sensory receptors provide data to our sensory store which sends it to short-term store.

1.3.c.2. Short Term Memory (STM)

The development of the theory of “Short Term Memory” *(STM)* was a revolutionary event in the history of cognitive psychology in the 1960’s. It clearly represented the power of the new cognitive methodology which accounted for a lot of data in a way that had not been possible with previous behaviourist theories. At that moment in history, psychology almost completed its separation from behaviourism.

The first one who anticipated the theory of Short –Term-Memory was Broadbent in1958. In 1969, Waugh and Norman, brilliant scientists, gave an influential formulation of the theory (Anderson,1995) . However, it was Atkinson and Shiffrin who brought to the theory its most systematic development (Atkinson and Shiffrin, 1968). This theory had enormously influenced psychology and ideas for it played a crucial role in some modern theories.

Short Term Memory is an important component of memory stores. It keeps information from *few seconds up to one minute or two*. It has a limited information capacity. The Short term store is fed by a series of sensory registers which are micro-memories associated with perception. All what is perceived in the immense surrounding environment can be momentarily retained in this store, then led to long term memory or elapsed a short time later. So to sum up, Short-Term-Memory acts as a controller feeding in new information and selecting particular processes for pulling information out of the Long Term Memory

To clarify the role of (STM), we should try to provide some answers of theorists to several questions.

Why do we forget even simple information and how can we keep ourselves from forgetting?

To answer such a question, one has to tackle the three stages of information processing in relation to *STM*. Although there is a significant disagreement among psychologists about how we lose information from STS, they have reached fairly a widespread compromise as to how we preserve it.

The prevailing technique we use to maintain information in short term storage is rehearsal. What do we mean by this term? It is the repeated recitation of an item (Sternberg, 1996). In other words, it is an over learning of the material. It is the repetition over and over again of items of information in the relatively permanent memory (L T M).

Every time an item is rehearsed, it is supposed to be committed into a relatively permanent Long Term Store. However, if the item doesn’t reach a Long Term Memory representation and leaves Short Term Store it will be lost forever since new information will always be coming in and push out old information from the limited Short-Term-Store (Anderson,1995). This will be better discussed in the subsection on forgetting.

1.3.c.2.1 Forgetting

Let's now try to examine "*forgetting*" in (*STS*) There are simple information such as a phone number or names of people that we effortlessly forget after a brief period of time. Of course, researchers and psychologists, in particular, deeply investigated the area. As a result, many theories have been proposed, each advocated by groups of scientists arguing and claiming the effectiveness of theirs. The two most outstanding theories are respectively "*interference*" theory and "*decay*" theory.

"Interference" refers to competing information causing us to forget something, and "decay" refers simply to the passage of time causing us to forget. Perhaps, it would be better if we examine each at a time.

a) interference theory

During the 1950's two leading groups of scientists obtained the same results independently and almost at the same time as stated by Merton in 1973 (in Sternberg,1996). In 1959, both the Brown and the Peterson and Peterson' studies were taken as confirmation for the existence of Short-Term-Store and also for the interference theory of forgetting, according to which forgetting occurs because new information interferes with, and ultimately displaces old information in the Short Term Store (Sternberg,1996).

- In 1959, the Petersons showed that forgetting happens if the subject is prevented from thinking about or rehearsing a material. In their experiment, they presented their subjects with sequences of three unrelated consonants. Immediately the subject had read them he or she was shown a three – figure number and asked to start counting backwards from it in threes. After an interval ranging from 3 to 18 seconds he or she was asked to recall the original three consonants before going on to the next three, which would be followed again by the backward counting task and then recall. The results of the experiment showed that the subjects have difficulty discriminating between the three letters they have just been shown and the various triplets that have been previously presented; the greater the interval the greater the confusion.

Two main kinds of interference have been distinguished in memory theory and research: retroactive interference and proactive interference.

- **Retroactive interference (or retroactive inhibition):** the forgetting of old material caused by new material is called retroactive inhibition. It implies that the new material somehow supersedes the old one. This type of interference is due to an activity or a task occurring after we learn a given material, but before we are asked to recall that learnt information. Since counting backward by threes occurs after learning the trigram in the Brown –Peterson experiment, we consider this task as a retroactive inhibition.

- **Proactive interference (or proactive inhibition):** the effect of earlier learning on later one is named proactive inhibition. It is as if the old trace is substituted for the new one. Proactive inhibition is caused by an activity happening before we retain the material.

Does proactive interference actually operate in forgetting of material stored in the Short Term Store?

A study conducted by Keppel and Underwood (1962) (in Sternberg,1996) suggests that it does. Indeed, the two psychologists argued that in the Brown Peterson experiment it is proactive interference and not retroactive interference which is responsible of forgetting. This point of view may elicit a deeper interpretation about this topic. It seems to be ambiguous in relation to what has already been established. The only probable explanation is that the trigrams learned earlier interfered with subjects' ability to remember later trigrams. In other words, the more prior material learnt, the greater the extent of interference. Keppel and Underwood indeed found that there was almost no forgetting when the subjects didn't have any previous syllable to remember. Furthermore capacity to recall the trigrams diminished as their number increased.

From this discussion concerning both proactive and retroactive interference, we can say that the two types of inhibition may affect recall of material

b). Decay Theory

Decay theory affirms that due to time effect, the memory trace progressively weakens till the information completely disappears unless something is done to keep it strong enough to resist time influence.

Nevertheless, it is important and potentially helpful to bear in mind that decay theory is extremely difficult to test and prove because it is almost impossible to prevent subjects from deliberate or even unconscious rehearsal. If you ask subjects not to think about something in particular, although they may do their best to avoid thinking about it, they probably do it in vain.

Nevertheless, evidence exists for decay in short–Term-Store, even if it is not as strong as evidence for interference. But, still it is uncertain about the extent to which the interference is retroactive, proactive, or both.

Till now, we have discussed the retention and forgetting of any information in Short-Term-Store without showing interest in the amount of material retained or lost. What we already know is that STS is a system that permits the holding and manipulation of limited quantities of information over brief intervals of time. *What about its capacity?*

1.3.c.2.2 The capacity of immediate memory

The question of capacity of immediate memory was one that preoccupied a great number of philosophers during the 19^{th} century. The first experimental work to be done on this problem was carried out in 1881 by a London school teacher, John Jacobs, who was interested in measuring the mental capacity of his pupils.

He proposed a technique which had played a significant role in psychology ever since. This measure is called "memory span". Miller (1956) (in Sternberg,1996) noted that our short-term-memory capacity consists of 7 items +/- 2. The longest number of items that can be immediately repeated back. For example, when a subject is presented with a sequence of items, say digits, and required to repeat them back in the same order, the length of the sequence is gradually augmented until a point is reached at which the subject always fails; the sequence length at which the subject is right half of the time is defined as his or her digit span (Baddeley, 1998). In other words, your span is the length at which performance reaches its limits.

Generally, most people can manage six or seven digits but there is quite a large range of capacity, with some people managing only four or five and others getting up to ten or more.

It is important to note that you can improve your performance. If you utter the sequences aloud you will probably do better than if you simply read them to yourself. This is due to the fact that articulating and hearing the sounds of numbers registers them in the brief echoic memory store mentioned earlier.

In 1964, Wickelgren found that one can also proceed differently by grouping the digits rhythmically. Studies and experiments comparing different modes of grouping concluded that grouping in threes is best and that a small gap, which can be heard by the listener, between successive groups may be helpful for better retention. (Baddeley,1998).

So far we agree on the fact that a memory span consists of 7 items +/- 2. But these items can be simple such as digits, or something more complex such as letters or words …

Imagine that you are presented with letters. Do you think you will be capable of recalling all of them immediately? You probably have better chances if you pack several letters into a simple *chunk*. Consequently, you will have to recall 7 meaningful items rather that 20 meaningless ones. For example, we couldn't hold in STM this string of 21 numbers: 10100,1000,10000,1000,100. However, if we chunked them into larger units, such as 10,100 1000,10000,1000 and 100 we will manage to reproduce easily the 21 numerals as 6 items. (Sternberg, 1996).

For a better understanding of the situation, suppose that you are presented with a list of words and are required to remember them in any order. This is what we name a "*free recall*", which is in contrast to "*serial recall*", where the items are recalled in exactly the same order in which they were presented or to "*paired associates recall*", where the items are put in pairs; you are given the first item and your task is to provide the second.

If you think that you resemble most people, you will notice that your recall of words is best for items at and near the end of the list, second best for items near the beginning of the list, and poorest for items in the middle of the list.

These results in performance represent the *recency effect* as well as the *primacy effect.*

Superior recall of words at and near the end of the list is a recency effect which reflects recall of the most recent items, the last few presented. Superior recall of words at and near the beginning of the list is primary effect which reflects recall of the most prior items, the first few presented.

Needless to say that the recency effect can be disturbed without any difficulty by interpolating a small amount of distraction, such as adding five single digits in the recall of words.

Because of the divergence between the recall of fresh and early items it has been argued that the former depends on short-term-memory, while the latter is due primarily to the effects of Long-term store.

One should be aware that there is another means of measuring memory which is the recognition task, where the experimenter produces an item, and you have to indicate whether it is one that you have already learnt (Sternberg,1996).

We can expand our understanding of Short-term Store, by exploring its relation to the acoustic code. In 1964, Conrad suggested that material in our Short Term Store is processed largely in terms of speech sounds (Conrad, 1964), whereas our Long term-Store depends mainly on meaning. In his experiments, this psychologist noted that most of the errors made by his subjects were not random but had some thing in common. They shared a similarity in sound with the correct items presented, despite the fact that they were visually presented.

These findings propose that STM relies on a speech- based code. Perhaps, other kinds of resemblance lead to the same result as the acoustic one.

1.3.c.3. Long Term Memory (LTM)

Among the different types of memory, the one which corresponds more to the lay people's view of memory is "*Long Term Memory*". This mainly represents the amounts of information that are stored for considerable periods of time, sometimes indefinitely (Baddeley, 1998).

Remembering your own name, how to speak, where you lived as a child, how to ride a bicycle, where you went in summer holidays last year, or where you were five minutes ago are all supposed to belong to the Long Term

Storage.

In our previous discussion, we have noticed that one way of maintaining information in STM to lead it to LTM is through rehearsal or over learning of that material. Another way is by consciously dealing with the information to comprehend it. Probably an even more important operation that we can accomplish is by *generating associations* that link what we already know to the new information.

We have also concluded that the STS depends mainly on an acoustic code whereas information in the LTS appears to be basically semantically encoded. That is, encoded by the means of meaning of words. This does not reject the fact that obviously we can keep both visual images and acoustic information in our LTM (Sternberg,1996).

The first studies and experiments done by psychologists to probe human memory consisted in non-sense material (c.f. Ebbinghaus'On memory',1885)(in Baddeley,1998). What we remark and can assert is that very little of our learning in real life involves meaningless material and that the psychology for nonsense is therefore of a limited value. In recent years, things have changed and nonsense syllables have been replaced with real words. Needless to say that words are different and are not considered to be alike. Thus, we behave with words differently.

One way to explain semantic coding is to use test words that bear a semantic relationship to other test words.

In 1953, William Bousfield presented subjects with different word categories but in a random order so that members of the various categories were thoroughly intermixed. Then, subjects were asked to perform a free recall. The subjects recalled successive words from the same category more frequently than would be expected by chance. It thus seems that subjects were remembering words by *grouping them into categories*.(Baddeley,1998).

Indeed, grouping words into categories or giving the categories to subjects before asking them to recall the words have proved to be sufficiently helpful for them.

1) Visual or Verbal

In an influential paper, Fergus Craik and Robert Lockhart (1972) speculated that the quantity of data kept in long term Store depends on how "deeply" it is processed during learning. This for instance meant that written words are first processed purely in terms of their visual characteristics, then these words are transferred into an acoustic representation, and that these subsequently evoke the appropriate semantic features. A shallow processing which stops at eliciting the different visual characteristics can only rise to a relatively impoverished memory trace which will be of little help in the operation of recalling the words. If one is asked to probe the word according to its sound like, however, it is fundamental to outgo the superficial visual analysis and attend to its sound. This is supposed to generate a rather more robust and useful trace. However, processing the word in terms of its meaning requires a more profound analysis, thus creating a richer and more durable memory trace (Baddeley,1998).

All this, doesn't mean that only meaning is stored, otherwise we could not learn to talk or to understand speech.

To conclude, we can assume that information that is encoded in terms of a rich and detailed representation of the world is likely to be more accessible than material that is processed in terms of a simpler or more impoverished scheme.

***2) Storage and forgetting in LTM**:*

We rely heavily on our LTS because it contains huge amounts of information that we need to function in our daily life. We have seen how data is encoded but what about its storage?

It seems obvious that rehearsal represents one of the various ways which facilitates information transfer from STS to LTS. If you operate a mere repetition, recall will not be effortless. If you elaborate the items in a way that makes them more meaningful to you, you will make them more memorable because passive rehearsal will not improve memory.

What do we mean by elaborative and meaningful processing? This involves embellishing the item to be remembered with additional information (Anderson, 1995). A concrete evidence of this factor comes from the 1969 experiments of Bobrow and Bower.(in Anderson,1995).

These investigators asked subjects to process simple subject-verb-object sentences. There were two conditions of interest. In condition one, subjects were given sentences written by the experimenters. In condition two, subjects were asked to generate their own sentences. After examining the different sentences, subjects were prompted with the first noun and were required to recall the second. The results obtained in the experiment showed that, in generating their own sentences subjects had to think and concentrate more carefully about the meaning of the two nouns and their possible interrelationship; similar demonstrations have been provided by Jacoby (1978) and by Slamuka and Graf (1978).(in Anderson,1995)

3) Organising

Memory is often compared to an enormous library full of rich and important information. If we want this library to be useful, the data must be accessible which implies that it needs to be organised and catalogued. Unless information is stored in a methodical way, it will not be reachable when needed (Baddeley, 1998).

From our previous discussion, we can claim that our long term memory is capable of storing huge amounts of information. But this information must be accessible, this means that it needs data to be organised. The process of organisation seems to be a crucial one, and the reason why it is so important is that unless information is stored in an orderly and systematic may, it will not be accessible at the appropriate time. In other words, remembered with difficulties or completely forgotten

There have of course been many laboratory demonstrations of the importance of organisation for memory. This has been easily shown in an experiment conducted in 1969 by a group of psychologists mainly Bower, Clark, Lesgold and Winzenz who asked subjects to remember two lists of words. The test takers organised the words *hierarchically* and did not recall them intermixed.(Baddeley,1998).

There is another useful organisation of the material which involves instructing the subjects to think of their proper personal organisation in a particular way, example a story, because linking words in a story makes them more memorable.

One of the most frequently used techniques for organising material is that of visual imagery. Let's make this point clearer. Imagine that you were trying to link two completely independent unrelated words like rabbit and steeple, so as to remember one of them if you are provided with the other. A good and efficient strategy would be to visualize a rabbit and a steeple interacting in some way; you might for example, envisage a rabbit clinging to the top of a steeple even if the image seems to be bizarre. Having created an interactive image, you will find that if you are given one word of the pair, the other will pop up too (Baddeley, 1998).

Information can also be organised in another form in memory. Probably the most illuminating studies divide memory into *semantic* and *episodic* memory.

4) Semantic memory:

It reflects our general world knowledge. It consists of our memory facts that are not unique to us and that are not recalled in any particular temporal context (Tulving (1972) in Sternberg,1996)

Knowing the meaning of a word, the chemical formula of salt or the capital of France would all be examples of semantic memory.

5) Episodic memory:

It represents personally experienced events or episodes, which is the kind of memory we use when we learn meaningless lists of words, or when we need to recall something that occurred to us at a particular time or in a particular context. Going to the dentist a week ago, or meeting your uncle in the street last Friday.

It is obvious that there is a distinction between specific personal memories of individual incidents and generalised knowledge of the world, which has been acquired over a lengthy period of time.

All of us possess a colossal store of general knowledge which we take for granted and which develops and augments with our experience in this world. This knowledge is structured exactly in the same way as the world itself is structured and organised. In general, the more we know the more complete and precise our organisation of that knowledge will be, and the easier it will be to incorporate new data or retrieve old one. (Baddeley,1998).

6) Other components of learning and information in LTM:

So far, we have discussed the semantic memory without mentioning any thing about its components. It is said that semantic memory is concerned with association between words. In fact, it is more concerned with concepts- ideas to which a person may allocate diverse features and with which the person may connect other different ideas which are in some occasions clearly linked to words but are not in themselves words. These concepts when associated and organised into a cognitive framework help us understanding the memory processing. Such a structural organisation is called Schema (Sternberg, 1996).

To be clear, a schema may be for instance, having lunch. This word includes an integrated package of information that can be brought to interpret such an event. In other words, all what you have experienced concerning lunch and what you have learned from others as well as from other information sources concerning lunch.

In our discussion we have already seen the effect of interference of both types retroactive and proactive on recall in Short Term Store. It also plays this role in Long Term Memory with additional information that prior knowledge may help or hurt new learning.

Many factors affect our ability to store or to forget information such as passive and elaborative rehearsal, organization of information, both retroactive and proactive interference without neglecting the fact that prior knowledge can be either positive or negative for learning i.e., it can aid or spoil the learning of new data.

Another factor which may have an influence on our storage or forgetting of material is the temporal pacing of learning.

While studying people’s LT recall of Spanish vocabulary Harry Bahrick and Elizabeth Phelps (1987) (in Baddeley,1998) discovered that when people’s learning is spaced over a period of time; in other words, when they acquire knowledge via "*distributed learning*", they tend to learn better. On the other hand, when learning is crammed together all at once they are less efficient at performance. This is known as "*massed learning*". The greater the distribution of learning trials over time the more that people remember. This makes us to assume that it would be very helpful to adopt such principle in studying. As far as studying is concerned "little and often" is an excellent percept but does one thinks that this would be true for all types of knowledge? As one might expect, some questions rise to the surface regarding the amount of information held in LTS and its duration.

It wouldn't be an easy task to provide an answer, but we can say that after a series of ingenious demonstrations, psychologists argued that it is almost impossible to measure the capacity of LTS, as well as it is hard to suggest means of measurement.
Scientists don't know how to determine the limits of LTS and there by find out its capacity.

Perhaps we can never prove that all information has not been stored. There is no satisfactory agreement about the capacity of LTS. In 1978, Hintzman postulated that it is immeasurable; of course, others don't share this viewpoint.(Sternberg,1996)
After considering all what has been said before, we may argue that since the limits of capacity of LTS can not be identified, we can suppose that perhaps not all what we experience is stored and not all what we learn is stored.
It is somehow confusing because one cannot be sure of a concrete scientific evidence to rely on when advocating a given point of view.

What is of equal difficulty as LTS capacity to identify is how long information lasts in the LTS. At present, we have no proof that there is an absolute outer limit to how long information can be stored.

There is abundant evidence in support of durability of Long term memories. An interesting study on memory for names and faces was conducted by Harry Bahrick, Phyllis Bahrick, and Roy Wittlinger in 1975 (in Sernberg,1996). Subjects were required to memorize names and photographs of their high school classmates. The results of the experiments showed that even after 2 years, subjects were able to recognize and identify names and at the same time matching names and photos.

1.4 A Piagetian Model of Memory

Jean Piaget was a Swiss psychologist known for his research in developmental psychology. He worked for over fifty years observing and studying children and their behaviours. This motivated him to begin his studies on cognitive development in children. He worked in the first quarter of the Twenthieth century in the laboratory of psychology founded by Alfred Binet.

Piaget works on memory have been done closely related to the cognitive development research .He performed on the development of logical competence of children.

In 1969, Piaget and Inhelder have observed that specific memories of past events are actually better over a period of time rather than worse (Kail & Pellegrino, 1985). This appears to be in contradiction with what the traditional notions of long-term-memory would predict. They distinguish between memory in a broad sense and memory in a narrow sense:

In a broad sense, memory is considered as an operative component of the intellectual scheme and is about what one understands on his or her world based upon past experiences.
In a narrow sense, memory refers to more traditional usage of memory ie. the collection of information, perception and imitation. It is said to be the figurative component. This figurative aspect of memory does not exist independently of the operative one. They are related in a certain way.

Qualitative classification of memory ***:*** Piaget and Inhelder, proposed three distinct types of memory ,namely : recognition, reconstruction and recall.

- *Recognition* founded in the first few months of life is the earliest type of memory, is inherent in every sensory motor habit. The content of this memory is perceptual.

- *Reconstructive memory* requires the reproduction of a relationship between various elements in some set of objects or events. Developed during the second year of life, this is the child's ability to represent actions. Reconstruction also facilitates the accommodation of intellectual schemes.

- *Recall* is the developmentally most advanced form of memory. To recall information, children have to remember both objects and the relationship between them.

These developmental sequences reflect the nature of intellectual development. From that, we may say that recognition relies on perception, reconstruction on imitation, and recall upon mental imagery.

1.5 Working memory

1.5.a) Introduction

Although the Atkinson and Shiffrin model, or some variant of it, was extremely famous during the sixties, it was starting to lose some of its popularity few years later.

By the early 1970s, this model was encountering some problems. These problems were pointed out after profound studies conducted by psychologists on people having particular deficiencies in memory. Some patients with defective short-term-memory showed good long term learning, while it was assumed that maintenance of an item in short term store was sufficient to guarantee long-term learning.

If the only way to reach LTM is via the limited capacity (short term store) STS, then logically someone whose STS is almost non-existent should have great difficulties. However, what is noticed is that such patients clearly do not suffer this handicap; they are able to learn normally. This presents an evidence for the Atkinson and Shiffrin model difficulties.

From this, Craik and Lockhart (1972) asserted that the ancient view of a STS relying on acoustic code and feeling before they reach LTS was no more acceptable by people of profession.

Consequently, these two famous psychologists proposed a new approach to memory studies, which was termed "The levels of processing approach". This approach was essentially concerned with the role of coding in learning. They argued that there was a relationship between the manner in which material is processed and the probability of its recall. In other words, it is more a theory of LTM than STM. The work stemming from levels turned to more and more in the direction of studying some of the retrieval factors from LTS. This led to the concept of working memory.

1.5.b) Definition

The key feature of the levels of processing approach is the emphasis on working memory, which is regarded *as a specialised part of LTM*. Within working memory is STM, which is the small reservoir of information of which we are consciously aware at any given moment. From this perspective, working memory holds only the most recently activated portion of LTM, and it moves these activated elements into and out of STM (Sternberg, 1996).

According to (Baddeley,1998), one leading researcher on the topic of memory, working memory is "..*a system for temporarily holding and manipulating information as part of wide range of essential cognitive tasks such as learning ,reasoning and comprehending.*"

that allowed several pieces of information to be held in mind at the same time and interrelated.

After many experiments in laboratories, Graham Hitch and Alan Baddeley (1970's) argued that working memory seemed to be a flexible and complex system, therefore they decided that in order to study the system in a thorough free way the best strategy would be to isolate the system components. They supposed the existence of a core system, a system that controls all the sub-components, and they named it a "central executive" This key component was, as it was assumed, helped by other subsystems, or slave systems, thereby freeing a portion of its own capacity for performing various information processing tasks (Baddeley and Hitch,1974).

The presentation and the discussion of Baddeley's model, would be done on the basis of the structure recalled in the figure bellow.

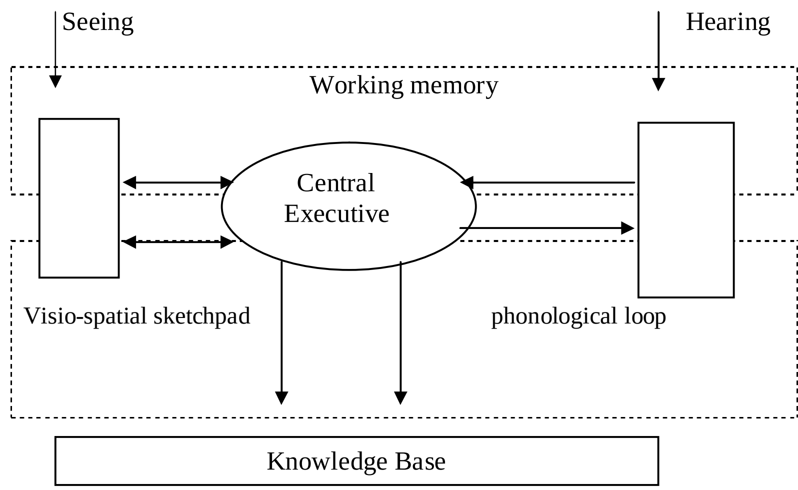


Figure 1.4 *Tripartite model of Working Memory*

1.5.b.1 The phonological loop

The first slave system was called the articulatory or the phonological loop. The system involved a store *(Phonological short–term- store)* and a rehearsal process. Speech inputs go directly into the phonological store, while non-speech inputs go into the sub-vocal rehearsal process. This later is used to restore decaying information in the phonological store, and to change non-speech inputs such as drawing, pictures , into their phonological form . It appears to exist for helping phonological Long-term learning, as in the case of acquiring new words in both one's native and foreign language. There are three basic reasons to prove, to a certain extent, the existence of such a system.

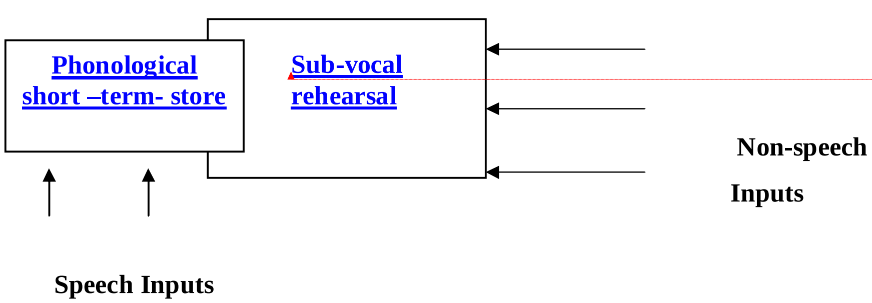


Figure 1.5 *Articulatory loop*

1. The phonological similarity effect

It reflected information storage. The effect of acoustic similarity may be explained in two manners. This can be seen in the subjects' errors more precisely, their errors tend to be phonologically similar to the correct item given. For example, a subject when recalling a string of letters may recall G instead of B or S in the place of F. In the same way, subjects find it harder to recall sequences of items that have similar speech sounds. For instance, OBCTPC is harder to remember than KWYLRQ; and can, cap, man, map is harder than pen, day, cow, bar, rig (Baddeley, 1966 in Baddeley,1998)

2. A second source of evidence came from the observation that an irrelevant spoken material in English or in Arabic could disrupt the immediate recall of visually presented digits. This suggests that the recall process is occurring at the sound level.

   Unlike noise or instrumental music, speech and singing can access the ST Speech based store and affect the memory trace. It is suggested that a special filter is capable of keeping noise and music out of STS (Salamé and Baddeley, 1982,in Baddeley 1998).

3. Third and last reason which can be considered as a proof for the articulatory loop existence was generated from the various experiments done for the purpose to study word length effect on memory span by Baddeley, Thomson and Buchanan,1995,in Baddeley, 1998). These three psychologists found that there was a relationship between the word length and memory span.

   If you try to recall two different sequences of words such as:

   - Malta, Chad, Burma and Chile
   - Ethiopia, Australia, Afghanistan

   You would probably do better when recalling the string containing short words rather than long words. They concluded that the reason long words were harder to remember was because our subjects said the words to themselves under their breath(subvocal rehearsal). The longer the word, the longer it takes to say, and the greater the time taken to rehearse the sequence of syllables, the more time there is for the memory trace of earlier words to fade away

The scientists reached another finding which was a clear link between the rate with which an individual could read out strings of words and his or her memory span. In other words, fast talkers were good rememberers. But, was this obvious for all memory tasks and to what extent it can be true? (Baddeley ,1998)

Counting is a cognitive task with a speech component. It uses the articulatory loop. There is something which must be pointed out. It is sub-vocalisation which plays a significant role in normal counting at least in our culture because there are other cultures that do not use sub-vocal counting rather relying on their fingers or something alike**.** We can also remark sub-vocalisation use in reading.
In general, people when reading hear what they are reading spoken in some form of inner voice which may be liked to phonological loop. But, this is less important in adult's reading.

Important researches on phonological loop have clarified its role in working memory:
They emphasize three functions **:**

- Stores of phonological information for average two seconds ;
- Refreshes the material in the phonological store as needed ;
- converts non-verbal material into verbal form through sub-vocal rehearsal.

1.5.b.2 The visuo-spatial sketch pad

Definition

The visuo-spatial sketch pad is assumed to be a system for maintaining and manipulating visual images, and as such it is useful in taking advantage of imagery for learning

A great number of psychologists and experimenters have been interested on the topic of visual imagery in recent years and have put focus on the role it may play in learning verbal material in particular.

Baddeley assumed that the articulatory loop was not the only (mnemonic) device we have for rehearsing material. He also proposed that we can use what he called the visuo-spatial sketch pad for rehearsing images. He argued that this mechanism is also used for keeping information in working memory**.**

Visual imagery mnemonics are extremely efficient ways for remembering lists of words. But, words are different. Logically, words that are imageable may probably be more easily memorised than non-imageable words. .(Baddeley,1998).

Some intriguing questions led scientists to probe the area of visual imagery such as whether images are in some sense stored in the brain or created from some abstract representation directly. Two controversial groups have appeared, those advocating the first view point investigated the topic, looking for similarities between reading information from mental images and the process of perceiving. This investigation was successful. Strongly associated with this approach is Roger Shepard of Stanford University, in California. He had experimented on the similarity between imagery and perceiving.

What has visual imagery to do with working memory?

Hitch and Baddeley suggested that spatial information was probably stored in LTS in an abstract code, but one way of using and manipulating some of such information was through a spatial slave system. That system used the same devices that were used in perception. Without forgetting, of course, that this sub-system was controlled by the central executive component of working memory.

But, what is the evidence for such a point of view?

Obviously, an experiment may give answers to such a question. In 1965, Brooks tried to find an answer.. In one of his experiments, subjects were shown a block capital letters**.** They were asked to hold it in their mind’s eye and, starting at the bottom left, to classify each corner as a “yes” if it involved the bottom or top line of the letter and as a “No” if it did not. Subjects were required to perform the task verbally or by pointing to the word. It was harder for them to respond by pointing than by speaking.(Baddeley,1998).

The opposite happened when subjects were given a sentence to remember and to judge words to be nouns or non-nouns. Performance by pointing was less difficult than verbally answering.

We can deduce from these two experiments that in a visual imagery test a visuo-spatial task such as pointing appears to use some of the capacity of the imaging equipment, leaving less capacity available for mental imagery, but the same sort of task do not interfere with heavily verbal tasks such as classifying nouns, or remembering sentences (Baddeley, 1998).

At last, Baddeley and other theorists suggested that the role of the visuo-spatial sketch pad in working memory includes**:**

- Providing temporary storage of visual and spatial information
- Refreshing images in the sketch pad as needed
- Generating images

1.5.b.3. The central executive

The phonological loop and the visuo-spatial sketch pad are supposed to be controlled and supervised by a more important component, the "*central executive*".
It can put information into any of these sub-systems or retrieve it from them. It can also translate information from one system to another (Anderson, 1995).

Description: The central executive includes a model of attentional control system of human action, referred to as the Supervisory Attentional System. This model shows that a lot of automatic type processes are handled with schema or "templates" of how the process should occur.

The contention scheduler handles conflicts between schemas, based upon environmental triggers (stimuli). The Supervisory Attentional System deals with new activities or items that require non-schema-based changes in current processing loads.

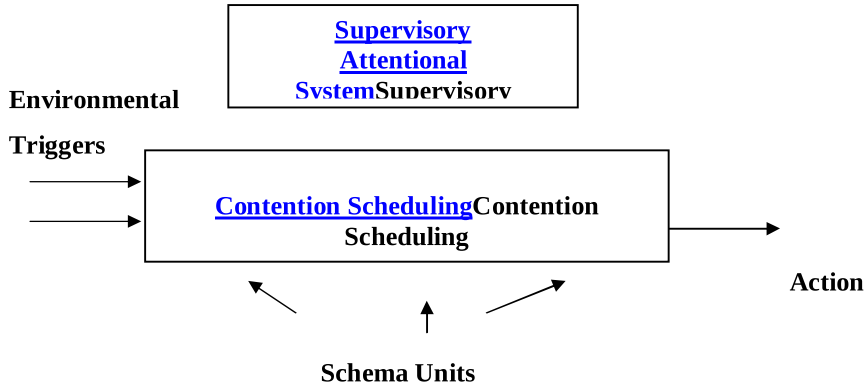


Figure 1.6 *Central executive structure*

Baddeley argues that ‘‘the central executive” component of working memory is assumed to be a limited capacity, attentional system that controls the phonological loop and sketch pad and relates them to LTM’’.

It is supposed to be more complex than either of the two slave systems, which makes it considerably harder to investigate.

The approach to working memory is based on defining it in terms of combining memory and *processing*. Therefore, tasks to perform this function are designed. They help to measure the capacity of working memory. Thus, difference in capacity can be related to difference in performance, i.e. comprehensibility or problem solving,

This approach has had huge success in examining and investigating language comprehension. One of the methods used to measure the capacity of working memory is “working memory span”. (Daneman and Carpenter,1980 in Baddeley,1998) . Subjects were presented with clusters of sentences. They were required to read out each sentence. Then, after the last sentence recall the final word of each sentence. Most of them could manage 4 sentences. This is considered as a good memory span.

Other profoundly conducted studies showed that subjects with a high working memory span have good passage comprehension.

If you consider the following example, where a child might be praised for refusing to share a piece of cake with his sister, who later in the passage revealed to be on diet. After reading the passage the children were asked whether the adult's action was appropriate or not, low working memory span were to forget the relationship between the two pieces of information in the passage and criticised the adult's action. Oakhill and al. interpreted these results in terms of a central executive deficit rather than a specific language problem (Oakhill, Yuill and Parkin, 1988, in Baddeley 1998).

No one can be in a position to assume that the studies and research made with the purpose to study working memory are sufficient, the fact is that we have gathered a very limited amount of knowledge concerning the topic. Nevertheless, the concept of working memory is already proving valuable.

Taking every thing into account, the role of the central executive has been listed by Baddeley and others such as Norman and Shallice (1985) :

- responsible for controlling transmission of material between the phonological loop and the visuo-spatial sketch pad
- Allocation of attention
- Controlling communication between working memory and other memory stores (LTM)
- Involved in mental arithmetic, logical reasoning and generation of random letters and numbers

1.5.c) A new model for working memory

Recent works of Baddeley in (Baddeley, 2002) on the theory of Working Memory, have reviewed the three components concept of working memory given previously . This work focused on the link between the WM and Long Term Memory and on the processes allowing the integration of information from the component subsystems. In 1996, Baddeley suggested that the role of the central executive is that it forms an interface between the subsystems (phonological loop and the visuo-spatial sketch pad).

Since the tripartite model involves the fact that the two subsystems are of limited capacities, and that the central executive is a purely attentional system without its own storage capacity, it has been difficult to answer the following questions:

- Immediate memory is sensitive to semantic similarity, and memory span for unrelated words is susceptible to vary with words frequency and imageability which are presumed to represent the LTM rather than the phonological loop.
- How the information from the two subsystems are combined since we know that even simple verbal span shows combined verbal and visual encoding? If the two stores are separate how and when the items of information are combined?

1.5.c.1. episodic buffer:

The problems of working memory model all came from the fact that information needs to be integrated from the subsystems and from LTM in a way that allows active maintenance and manipulation. To solve this problem, a fourth component was proposed, *the* "*episodic buffer*".

The episodic buffer is assumed to represent a storage system using multimodal code. It is assumed to be episodic in the sense that it holds integrated episodes or scenes and to be a buffer in providing a limited interface between systems using different codes.

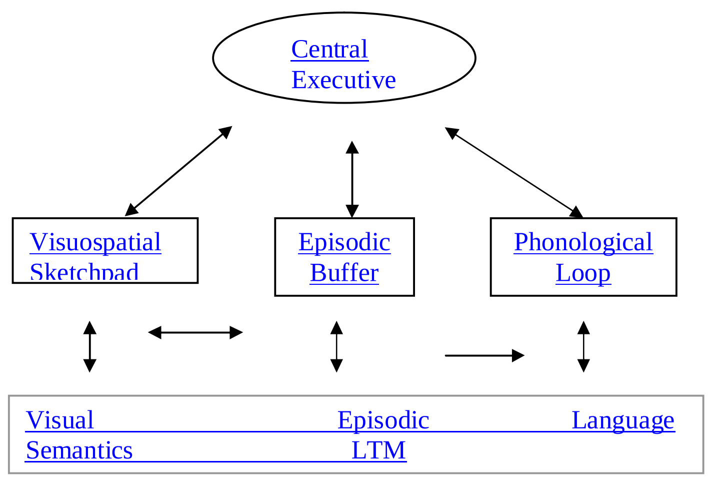


Figure 1.7 *Structure of Working Memory with LTM links*

The episodic buffer is assumed to be capable of combining information from LTM and the two subsystems. The lack of arrows within the model directly linking the subsystems to the buffer represents the fact that transformation depends on the central executive.

1.6 Conclusion

The levels-of-processing theory, however, has provided some research that attests to the fact that we "know" more than we can easily recall. The two processes most likely to move information into long-term memory are elaboration and distributed practice (referred to as periodic review in the direct instruction model).

Within the information processing model of memory, it is assumed that information coming into the information processing system is processed in a hierarchical fashion, in a series of processing stages, corresponding to varying depth of analyses.

From researchers point of view, the most interesting and controversial notion to come from Piagetian studies on memory is the idea of children's long-term-memory improvement with time. Piaget reported in a set of experiments that children recollection of past events improves over time. Other researchers don't agree with the Piagetian view of this positive improvement of long-term-memory since they judge that when compared to memory regression the improvement is less impressive and they believe also that there are some other factors which help this L-T-M progress as the enhancement for communication skills. The reason given to explain that seems to come from the fact that Piaget has included in his sample a wider age range, increasing then the likelihood of finding improvement of recall (Gross,1985).

Working Memory performs several functions and is supposed to be a multi-components system. The phonological loop is seen as an active subsystem, which temporary stores the verbal information. The trace within is assumed to decay over around two seconds if it is not refreshed by rehearsal. Its role is at the origin axed on the processes used for the development of speech perception and production.

The visuo-spatial sketchpad appears to play an important role in spatial orientation and solution of visuo-spatial problems. It is also expected to form an interface between visual and spatial information accessed either through our senses or from Long Term Memory. With the new configuration, the central executive is now a purely attentional system using the episodic buffer as a new limited capacity store to combine different information types. In the chapters 2 and 3, we will deal with intelligence and expose the relation between Working Memory and general intelligence.

CHAPTER 2. Intelligence

2.1. Introduction

Since many decades, the study of intelligence has been demanding sustained efforts and genuine research on the part of scientists. There is no such actual and accurate definition for intelligence which may be accepted by all. Various psychologists belonging to mental testing were among the first experimenters to study this phenomenon, if we can term it like this, but other approaches, more or less contemporary, appeared in order to clarify, in probably a more detailed way intelligence in the area of cognitive psychology and the developmental psychology of *Jean Piaget*.

Although there is a great difficulty in defining intelligence, it seems that at a certain time in the history of psychology there is a common point of view shared by most psychologists mainly psychometricians and lay people, which specifies that "intelligence is what intelligence tests measure". (Kail & Pellegrino, 1985).

In addition to the fact that there is no single observable characteristic of some one indicating his or her intelligence, we then arrive to the conclusion that most of people think they possess this noble faculty, at varying degrees.

What we can assume and which may be satisfactory for a large number of humans, is that, the term intelligence can be used in two ways. First, it can refer to discovering a chemical element in nature, writing a symphony, or designing an aerodynamic structure. Each of these would probably represent an intelligent act. Second, it can represent mental processes that give birth to those intelligent acts such those just cited. But the problem we are faced with is that we cannot observe these processes directly. That is why we rely on intelligent behaviors to study indirectly mental processes.

According to Sternberg, intelligence is goal directed adaptive behavior (Sternberg, 1996). We are almost sure that there are perhaps as many definitions of intelligence as there are intelligence researchers and theoreticians. All trying to find out answers to unanswerable questions such as those about the definition of intelligence or about the ways, which can lead to the findings.

Scientists argued that because there are so different ways to be intelligent, there are also many conceptualisations of intelligence. They also point out to the fact that individuals differ from one another in their ability to understand ideas or to learn from experiences and that even for one person her or his intellectual performance will vary on different occasions (Neisser et al.,1996).

In order to understand recent thinking about intelligence, we have to go back to the early works and theories proposed by scientists such as Galton, Binet,Guilford and others who have built up the foundations of intelligence research.

Therefore we are going to begin our discussion with the psychometric tradition, which represents the branch of psychology that has been mainly concerned with intelligence testing and measurement. Then, we enlarge our study through the developmental psychology of Piaget, which is undoubtfully a major source of information on the growth and development of intelligence.

Defining Intelligence:

This mental faculty is still considered as a challenge for those scientists such as psychologists. It is hard to agree on one definition since each researcher views it from a different angle and puts emphasis on some characteristics which have been less considered or completely ignored by his/her colleagues. In 1921, 14 well-known psychologists presented to people and their scientists their different opinions of intelligence and intelligence measurement. It would be noteworthy to say that in spite of the variety of their responses two major themes were shared by most of them:

The ability to learn from experience, and the capacity to adapt to the surrounding environment.

It is important to note out that the first feature means avoiding repeating our own mistakes and the second implies that clever people not only get good scores in intelligence tests but their cleverness is seen also in their attitude with others, the organisation of their life in general and how they handle a job.

What is extremely astonishing is that 65 years later, these two themes, learning from experience and adaptation to the environment, still figure in the contemporary experts definition with a new heavy focus on cognitive processed culture.

2.2 Psychometric Approach:

2.2.a) Foundations :

Throughout the twentieth century, the measurement of intellectual ability has focused on two major functions: they were constructed to help education, in other terms, they were meant to aid educators to adapt instructional programs to learner's abilities. The other objective for those tests was to provide data for psychometric investigation. Mental tests were supposed to produce enough information to enable researchers propose theories of human intelligence. Use of mental tests for this purpose started in the 1880's in Europe.

After the results obtained by Alfred Binet on retarded children (M. Huteau and J. Lautrey, 1997), psychometric tests have been used for different purposes, such as selection, diagnostic and evaluation. The most widely used tests are not intended to measure intelligence itself but some closely related construct (Neisser U. et al, 1996) : school achievement, specific abilities etc.. ; Some of them use only single type of item or question but those are useful only for specific purposes, The more familiar measures of general intelligence such as the Weshler tests and the Stanford-Binet include many different types of items, both verbal and non-verbal tests. Test-takers are asked to give meanings of words, complete a series of pictures, indicate the word that does not match with other ones, etc.. Their performance can then be scored to yield several sub-scores as well as an overall score.

Sir Francis Galton (1822-1911) was a British scientist, explorer and statistician. He has been labelled "the father of mental tests" (Boring, 1950 in Kail & Pellegrino,1985). Influenced by Charles Darwin theories of evolution, he argued in his theory entitled *"Human Faculty"*, that human beings are distinguished through their capacity for labour and their sensibility to physical stimuli (Sternberg, 1996). He believed that simple sensory, perceptual and motor processes formed the fundamental elements of human intelligence. He considered that intelligence was more hereditary than a product of the environment.

Galton was also interested in the works of the Belgian astronomist and statistician Quételet, who has discovered that physical characteristics such as height, weight had a bell shaped or normal distribution in human populations. Therefore, Sir Francis Galton wanted to know whether psychological differences between people were systematic, (Kail & Pellegrino, 1985). He tried simple tests of equal vision and hearing with a large number of people in his laboratory but the findings were not fruitful because he was a victim of the sheer amount of data he obtained.

In the USA, the first proponent of a psychology of difference and mental testing was Cattell. As was the case for Galton, James Mc Keen Cattell major contributions resided in establishing the bases of a developing science rather than in the impact of his research (Kail& Pellegrino,1985)

In accordance with Galton, Cattel believed that sensory, perceptual and motor processes were the fundamental elements of thought. Therefore, he constructed tests and administered them with students. He was the generator of the term "mental test". His tests aimed at measuring college students, and it was expected that the scores obtained would say which students would succeed in college. There was no link between his works and college achievements (Wissler, 1901in Kail&Pellegrino,1985).

One of the Cattell's students, Clark Wissler investigated 21 psychological tests in 1901. He thought that if the same group of people did well (or poorly) on large numbers of the tests, then the test revealed some general construct of intelligence. Unfortunately, his achievements led him to doubt on the existence of a think as general ability.

A special need in education made Alfred Binet (1857-1911) in France, one of the most famous psychologists of this era. He is recognised as the creator of the first intelligence test. In 1904, he was asked to develop a test, which would permit to identify mentally retarded children to enable them to attend instruction in special schools (M. Huteau and J. Lautrey,1997).

With the help of his own student Theophile Simon, he designed what was labelled the "1905 Scale", consisting of various tests of varying degrees of difficulty, this test faced many revisions after its first conception. Therefore, a new scale appeared in 1908, where new items were included and a new method for calculating a child intellectual level was administered as well as a larger standardisation group was used.

For Binet, intelligence consists of three distinct elements: direction, which resides in the fact of learning what has to be done and how to do it, adaptation which refers to customising a strategy for performing a task, then monitoring and adapting that strategy while implementing it, and criticism which represents the ability to criticize your own thoughts and actions.

But can these three elements be applied to all types of problems, simple or complex?

Binet proposed that it would be better to segregate children in schools not on the basis of their chronological age but relying on their *mental age*. By mental age we mean their level of intelligence compared to an "average" person of the same chronological age (Sternberg, 1996). If a child of ten years old performs on a test, which is designed for an average person of 12, the child's mental age will be 12 without taking into consideration his chronological age.

William Stern, a German psychologist, assumed that the use of mental age alone is less useful if we consider a group of children of different chronological ages.

In 1912, he proposed to measure intelligence by using an "Intelligence Quotient" (IQ): a ratio of mental age (MA) divided by chronological age (CA.), multiplied by 100. This ratio can be shaped mathematically as follows.

$$IQ = \frac{MA}{CA} \times 100.$$

For historical reasons, the term IQ is often used to describe intelligence test . It originally referred to an "Intelligence Quotient" that was formed by dividing a so-called mental age by chronological age , but this procedure is no longer used (NEISSER U. et al. , 1996).

A profound revision of the Binet -Simon scales was made by a professor of psychology at Stanford University, Louis Terman, who achieved it after 6 years of research. His revision was not a mere translation of the Binet scales into English but the outcome was a completely new elaborated scale, one usually termed the 1916 scale. To sum up, Terman added new ideas to the items and restructured the scoring in terms of ratio IQs instead of mental age.

Among the reasons which led to the popularity of the Stanford-Binet scales were the fact that Terman expressed a child's level of performance in terms of an intelligence quotient, and the other fact that he provided clear, detailed instructions for each problem. In addition, Terman's Standardisation of sample of the scale included 1400 individuals.

It would be unjust to ignore the importance of the Simon –Binet scales because they represent a different starting point from the approach to intelligence. Binet argued that intelligence, this enormous faculty, could not be reduced to simple perceptual –motor (as proposed by Galton and Cattell) building blocks, rather it represents more complex processes; such as memory, mental imagery, comprehension, judgement and autocriticism (Binet and Henry, 1896; Binet and Simon, 1908in Kail& Pellegrino,1985).

While Cattell and Galton focused their works on the basis of proposing psychological theories, Binet concentrated his attention on both the theoretical and the practical level. He tested children instead of adults as did Galton and Cattell and he suggested that the nature of intelligence changes as children grow older (Kail& Pellegrino,1985).

There was an another giant who proposed tests which were accepted as being among the most perfect ones in that time, and which were called the Wechsler scales after the American psychologist, David Wechsler. They consisted of three scores: a verbal score, a performance score and an overall score. Let's examine each one at a time.

The verbal score involves tests such as vocabulary and similarities, where the test taker has to say how two things are similar.

The performance score involves tests like picture completion, which requires identification of a missing part of an object, picture arrangement which consists of rearrangement of a scrambled set of cartoon like pictures into an order that tells a coherent story.

The overall score takes into consideration both the verbal and the performance scores.

In 1974, Wechsler argued that intelligence does not stop at test scores measurement but intelligence shapes our daily life (Sternberg, 1996).

In the study of intelligence and many other psychological phenomena, the questions asked by the scientists have largely specified their answers. During the first half of the twentieth century most psychologists wanted to map the human mind in order to understand intelligence so as to reach that aim, they needed tools to chart the innermost regions of the mind; concerning research on intelligence, the most suitable tool seemed to be Factor Analysis, a statistical method and model for separating a construct –intelligence- into a number of distinct components. So, the dominating idea in that period was whether intelligence was a series of independent specific mental faculties or whether intelligence was more general and global.

Let us have some notions about the topic "Factor Analysis", before we further our discussion on the eminent theorists of that time.

Factor analysis is based on studies of correlation. In other words a correlation coefficient is computed. What is meant by the latter? It is simply a statistic used to quantify the relationship between two variables. This statistic usually termed (r), can take on values from –1 to 0 to +1. Values of (r) that are close to +1 indicate a strong relationship between variables.

A factor analysis might involve different successive steps: (1) Give a large number of people various tests of ability, (2) determine the correlation among those tests, and (3) statistically manipulate those correlations to simplify them into a handful of factors that seem to summarise people's performance on the tests.
Among the main competing theories, the main ones were probably those of Spearman, Thurstone, Guilford, Cattell, and Vernon. (Sternberg, 1996).

<u>The "g" factor</u>: Charles Spearman is considered as the inventor of factor analysis. On the basis of factor analytic studies, he argued (1927) that there was an evidence for a two factor theory of intelligence. In other words, intelligence could be understood in terms of both a single general factor "g" which was involved in performance on all measures and a set of specific intellectual Factors (s) which were thought to be involved at some level in all measures of intelligence. In Spearman's opinion, the specific factors were of only casual interest, while the general factor provides major data to understand intelligence, this eminent psychologist assumed that the general factor is derived from individual differences in mental energy.

It was the first psychological theory of intelligence to be developed according to mathematical precision and statistical techniques which generated a vigorous debate in the testing movement, a debate that continues today.

Thurstone (1938) administered a large battery of mental tests to undergraduate students at the University of Chicago. He didn't share Spearman's opinion about the general ability factor. He therefore suggested an alternative theory that focused mainly on independent, primary mental abilities. He thought that intelligence could not be reduced to a single general factor but to seven factors equal in importance. According to him, the seven mental abilities are:

(1) Verbal comprehension measured by vocabulary tests ; (2) word fluency, measured by tests requiring the test taker to think of as many words as possible that begin with a given letter, in a limited amount of time; (3) inductive reasoning, measured by tests which require on the part of the test taker to establish given relationship in a pattern of figures, numbers or letters; (4) spatial visualisation assessed by tasks that require the individual to judge whether two terms rotated in space are the same or different ; (5) number facility, measured by computation and simple mathematical problem solving tests ; (6) memory assessed by pictures and word recall tests ; and (7) perceptual speed , measured by tests that require the test taker to recognise small differences on pictures, or to cross out the a's in strings of various letters.

Many advocates of the Spearsman's general factor "g" and Thurstone's primary ability factors came into the psychological scene. A profound debate which started concerning general intellectual ability versus specific primary abilities was almost solved by the appearance of hierarchical theories to account for correlational data.

This type of theories was advocated by Burt in1949. Two basic hierarchical theories have been proposed. The first one created by Vernon in 1965, represents an extension of Burt's theory and the British focus on the general factor. The second one was described by

Cattell (1963,1971)(in Kail& Pellegrino,1985) and represents an emphasis on primary abilities, major characteristic of American School.

Vernon's Theory*:* This theory, proposed in 1965, is based on a factor analysis approach that begins at the top of the hierarchy.

It is a kind of decomposition from the top to the bottom of the general factor into sub-factors and even those sub-factors are factored. It means that this type of top-down approach can proceed through a number of independent successive levels, each level having less general significance than the preceding one.

At the top we can find "g" –below the "g" level two major group factors which are respectively ,verbal educational ability and spatial practical mechanical ability. Each of these group factors can be further divided into finer subdivisions such as perceptual speed and spatial ability. Such decomposition can be continued in order to derive more specific factors. (Kail& Pellegrino, 1985)

Cattell's Multiple-Factor Theory*:* The theory proposed by Raymond Cattell in 1963and revised in 1971 represents his trial for synthesising Thurstone's and Spearman's views of intellect.

Cattell accepts both the primary abilities and the general factors. Unlike Vernon's, his theory is a bottom-up approach to factor analysis. The decomposition into factors here starts from the specific to the less specific to the general. The result is, therefore , a hierarchy built up from the bottom. In his theory he argues that intelligence consists of two major sub-factors: Fluid ability and Crystallised ability. The former requires understanding of abstract and often novel relations as required in inductive reasoning tests. The latter represents the accumulation of knowledge.

If we compare both theories, Cattell's and Vernon's we can notice that they are similar although some little differences the labels used to denote different factors and levels in the hierarchy as well as their interpretation.

Guilford's Structure of Intellect Theory

In Guilford's three-dimensional Structure of Intellect (SI) theory, intelligence is viewed as comprising operations dimension, contents dimension, and products dimension. There are 5 kinds of operations (cognition, memory, divergent production, convergent production, evaluation), 6 kinds of products (units, classes, relations, systems, transformations, and implications), and 5 kinds of contents (visual, auditory, symbolic, semantic, behavioral). Since each of these dimensions is independent, there are theoretically 150 different components of intelligence.

It is interesting to note that Guilford was interested in creativity. He developed firm convictions regarding the ability of individual difference among people.

From his view, "Intelligence" is too complicated to be subsumed by a few primary mental abilities and "g" factor

Guilford researched and developed a wide variety of psychometric tests to measure the specific abilities predicted by SI theory. These tests provide an operational definition of the many abilities proposed by the theory. Furthermore, factor analysis was used to determine which tests appeared to measure the same or different abilities. Its major application (besides educational research) has been in personnel selection and placement.

2.2.b) Inter-correlation among tests

Through the analysis of the results of a test, scientists have noticed that individuals rarely perform equally well on the different kinds of items. One person that scores well on verbal items may not score so well in spatial items. However, the obtained scores for subsets of items are positively correlated. People who score high on one subset are likely to be above average on others as well.

These correlations can be clarified by the factor analysis, but the results of such analyses are controversial themselves. Spearman in 1927 underlined the role of factor “g” which represents what all the tests have in common. Thurstone in 1938 presented a group of factors such as memory, verbal comprehension or number facility. One common scheme today presents something like a hierarchy of factors with “g” as the apex. But, there is no full agreement on what “g” actually means. It has been described as a mere statistical regularularity by Thomson in 1939, a kind of mental energy by Spearman in 1927, a generalised abstract reasoning ability by Gustafsson in 1984, or an index measure of neural processing by Reed and Jensen in 1992 (c.f. NEISSER U. and all, 1996). There have been many discussions on the utility of IQ and "g". Some theorists are critical of the entire psychometric approach, for example, Ceci , Gardner, Eysenck, Herrnstein and Murray. Their critics do not concern the stability of the test scores nor the fact that they predict certain forms of school achievement, but they believe that all these tests and factors are not sufficient since they ignore important aspects of mental ability and then new approaches have been proposed, mainly those concerning multiple forms of intelligence by Gardner (H. Gardner, 1996).

2.2.c) Characteristics of test scores

A great number of experiences and tests assessed that tests scores are "stable" during development. For example, IQ does not have to change in time. The average change between age 12 and age 18 was 7 points. For IQ values the most important variation was about 18 points. It's important to understand the significance of this stability property. A child who's IQ remains the same at 6 years old to age 18 does not mean that the performance throughout that period is the same. An 18 years old person with this stable score is at the mean of 18 years old other individuals (Neisser U., and al.,1996).

Scientists have shown that for one person the tests scores are correlated. To deal with this correlation aspect, they used a "correlation coefficient ", called "r" which measures or estimates the degree of relationship between the two sets of scores. The value of "r" helps to know how well one of test can be used to predict the other.

Some pairs of tests are more correlated than others. The correlation has been shown to be positive, and has been described in Spearman (1927) as "positive manifold". For him variance of the scores on each test can be attributed to general factor "g". In spite of the fact that "g" based factor hierarchy is the most widely accepted, some theorists consider it as misleading because a large number of human abilities, even those that are proved to have intellectual components, are outside of standard psychometric tests.

Prediction of school performance : The correlation between test scores and school achievement, particularly between IQ and grades is about .50, such correlation accounts only for 0.25 of overall variance. That is why it seems clear that school learning capacities depend on other personal characteristics. Even if children with high scores seem to learn more than those with lower scores, external factors like style of teaching and instruction methods can significantly increase or decrease this correlation (Neisser U., and al.,1996).

2.3. New approaches

2.3.a) Multiple Forms of Intelligence

Howard Gardner theory exposed in his book “Frames of Mind”, (1983) pointed out to the fact that there are different or multiple intelligences. He argued that the study of intelligence should be completed by the analysis of the behaviour of those people who are experts in different domains, music or athletism etc... From his view, the scope on psychometric tests is narrow since it considers only linguistic, logical and spatial intelligence.

On the other hand, Sternberg’ theory proposes three fundamental aspects of intelligence. Namely, he distinguishes analytic, creative and practical intelligence but only the first can be measured by mainstream tests. He clearly makes distinction between the comportment of test takers when they are supposed to solve what is called analytic (academic) problems, formulated by others (teachers), clearly defined, coming with all the information we need to solve them and having in general one single right answer or solution. And on the other hand practical problems, not completely formulated, poorly defined, require information seeking and prior-every–day experience and motivation and personal involvement. An important form of practical intelligence is tacit knowledge, defined as << action-oriented knowledge, acquired without direct help from others that allows individuals to achieve goals they personally value>>. Questionnaires designed to measure tacit knowledge have been developed for example for business management.

Other scientists demonstrated that practical intelligence is relatively independent of school performance or scores on psychometric tests. Street children are capable of doing the mathematics required for the survey of their business even if they have failed mathematics in school. Ceci and Liker in 1986 found that the reasoning of the most skilled handicapped poeple was very complex and the assessment given on the basis of IQ test was irrelevant in the prediction of the complexity of their thinking (Neisser U., and al.1996).

2.3.b) Developmental Progressions

There are mainly two theories linking intelligence to developmental progression:

Piaget's theory: From Piaget's point of view, intelligence develops in children through the continually shifting balance between the assimilation of new information and the accommodation of cognitive structures themselves to the new information. He has relatively little interest in individual differences. It has been shown that Piaget's tasks (those proposed to children) can be modified to serve as measures of individual difference, the new questions obtained can be fairly related to psychometric tests (Neisser U., & all,1996).

Lev Vygotsky's theory: This Russian psychologist, in the early 30s (his work being published after his death in 1934,in Russian first, and then in English in the 1960s and 1970s) argued that intellectual abilities have social origin. For example, language and thought first appear in early interactions with parents, and continue with the society and school. Traditional intelligence tests ignore the level of performance that a child might reach with appropriate help from a supportive adult, what he called the "zone of proximal development". Such tests are static, measuring only the intelligence that is already fully developed. "Dynamic testing", in which the examiner provides guided and graded feedback, can go further to give some indication of the child's potential. These ideas are supported by a number of contemporary psychologists (Neisser U., and al, 1996).

2.3.c) Biological Approaches

Some scientists have recently investigated the study of the brain as the basis of new idea of what is intelligence and how we can measure it. They tried to relate some aspects of these tests performance to different characteristics of the brain functions. For example, they study the arborisation of cortical neurones by Ceci (1990) (in Neisser et al.,1996), and nerve conduction velocity by Reed and Jensen (1992) (in Neisser et al.,1996), and Hormones by Vernon (1993) (in Neisser et al.,1996).

2.4. Piaget's Theory of Intelligence

2.4.a) Introduction

Jean Piaget (1896-1980) was one of the most influential researchers in the area of developmental psychology during the 20th century. Piaget originally trained in the areas of biology and philosophy and considered himself a “genetic epistemologist”. He was mainly interested in the biological influences on "how we come to know." He believed that what distinguishes human beings from other animals is our ability to do "abstract symbolic reasoning."

Piaget believed children's schemes, or logical mental structures, change with age and are initially action-based and later move to a mental level.

When considering intelligence, Piaget focuses on the mental processes that occur, rather than on the actual measure of the intellect. He uses four areas to define intelligence. These areas are a biological approach to looking at intelligence, the succession of the stages, knowledge, and intellectual competence.

2.4.b) Key Concepts of Piaget's Theory

Process of Cognitive Development. As a biologist, Piaget was interested in how an organism adapts to its environment (Piaget described it as intelligence.) Behaviour (adaptation to the environment) is controlled through mental organisations called schemes that the individual uses to represent the world and designate action. This adaptation is driven by a biological drive to obtain balance between schemes and the environment (equilibration).

Piaget proposed this theory of childhood cognitive development in the 1920's. Since that time, there have been many criticisms of Piaget's theory. Most developmental psychologists discussed about whether children actually go through these four stages in the way that Piaget proposed, and further that not all children reach the formal operational stage. After all this criticism, Piaget has had a major influence on all modern developmental psychologists. He proposed four major stages of development and from his fundamental idea is based on the fact that children's cognitive performance is directly related to the stage they are in. He also argued that a child's cognitive performance depends more on the stage of development he was in than on the specific task being performed.

Jean Piaget proposed the idea that cognitive development consisted of the development of logical competence, and that the development of this competence consists of four major stages (sensori-motor, preoperational, concrete operational, and formal operational). Stage movement is an important factor of Piaget's definition of intelligence, because Piaget states there are specific sets of criteria that must be met and mastered at each stage. In order to move from the first stage to the next, the child must master that specific set of criteria. Although Piaget has approximate ages assigned to stages, a child's competence is only measured by what stage he is in, not by age. If the child can only perform tasks that are at the preoperational stage, he is, at regardless of age, assigned to this stage of development see (Gross,1985) and (PiagetPsyweb, 2005).

The Sensori-motor stage (infant : from birth to 2 years old):

During the sensori-motor stage, infants "think" with their eyes, ears, hands, and other sensori-motor equipment. Knowledge of the world is limited (but developing) because it is based on physical interactions and experiences. Piaget said that a child’s cognitive system is limited to motor reflexes at birth, but the child builds on these reflexes to develop more sophisticated procedures. They learn to generalise their activities to a wider range of situations and co-ordinate them into increasingly lengthy chains of behaviour.

In this period, children begin to acquire object permanence at about 8 or 9 months(the range of variations is about one month or two) and fully develop it at about 18 months (memory). Physical development, and namely mobility, allows the child to begin developing new intellectual abilities. Some symbolic abilities as language are developed at the end of this stage.

At the end of the sensori-motor period, a child now can recognize that he or she is a separate, independent person in the world, which leads to why children become centered on themselves in the preoperational stage (two to six years)

Pre-operational stage (Early Childhood from 2 to 7 years):

At this age, according to Piaget, children acquire representational skills in the area of mental imagery, and especially language. They are very self-oriented, and have an egocentric view; that is, preoperational children can use these representational skills only to view the world from their own perspective.

In this period, intelligence is demonstrated through the use of symbols, language use matures, and memory and imagination are developed, but thinking is done in a no logical, no reversible manner. Egocentric thinking predominates

Concrete operational stage (7 to 12 years) :

This stage is also characterized by a loss of egocentric thinking. As opposed to pre-operational children, children in the concrete operational stage are able to take into account another person’s point of view, with their thought process being more logical, flexible, and organised than in early childhood. They can also represent transformations as well as static situations. In this stage intelligence is demonstrated through logical and systematic manipulation of symbols related to concrete objects.

Their thoughts turn toward the world at large and they begin to understand about things distant in time and space. The child develops a systematic, coordinated method of seriating that reflects a completely developed seriation structure, leading to the development of number concepts. By the end of the concrete stage, he/ she can do a lot of operations.

The concrete logical child moves from simple classification to multiple classification and class inclusion.

They are capable of conservation of physical quantities, and mathematical operations on numbers (they can add, subtract, multiply, divide, place in order, substitute and reverse). But children are still quite limited in their ability to generate possibilities systematically or to test hypotheses which require keeping track of multiple possibilities

Formal operational stage (Adolescence and adulthood (from 12 years old to adult)):

In this stage, intelligence is demonstrated through the logical use of symbols related to abstract concepts. Early in the period, there is a return to egocentric thought

Persons who reach the formal operational stage are capable of thinking logically and abstractly. They can also reason theoretically. Piaget considered this the ultimate stage of development, and stated that although the adolescents would still have to revise their knowledge base, their way of thinking was as powerful as it would get.

2.5 Conclusion

According to Piaget, four interrelated factors: Maturation, experience, social interaction, and equilibration allow movement from stage to stage. Maturation is the physical and psychological growth that occurs in the child at a specific stage. When a child thinks and interacts with real (or concrete objects) in his environment, he makes experiences. Social interaction involves the child socializing with others, especially other children. The last factor of stage movement is equilibration, this occurs when the child brings together maturation, experience, and social interaction in order to build mental schema. Equilibration is considered to be the tendency for children to seek cognitive coherence and stability.

More recent studies have cast some doubt on Piaget's theory of homogeneous performance within a given stage. Instead, it is now believed that performance varies greatly within each stage and depends more on the acquisition and development of language, perception, decision rules, and real-world knowledge for each individual child. It is now thought that not every child reaches the formal operational stage. Whether Piaget was correct or not, however, it is safe to say that this theory of cognitive development has had a tremendous influence on all modern developmental psychologists.

It is obvious that intelligence is not the only factor that affects individual's achievement, motivation and cultural or social environment can have a great influence and affect the tests scores obtained. Intelligence is also a joint product of genes and environment.

Beard (1969) argued that many significant aspects have been ignored by Piaget when discussing experiences with children. Piaget did not attach importance to individual differences in ability and the affective influences on thinking because a severe emotional deprivation may limit intellectual development.

Although the order of the periods of development is constant (for Piaget), the age at which a stage is realized can not be accurately fixed.

According to Piaget, children fail the problem of transitive inference because they lack concrete operational skill such as reversibility. But in 1971, Bryant and Trabasso showed that children's difficulty was not in their inability to reason transitively but in their inability to remember the premises. (Kail & Pellegrino, 1985)

By transmitting new information school affects intelligence. Some skills are, in general, typically learned in school: systematic problem solving, abstract thinking, repeated manipulation of basic operations and symbols. that is why the school helps to develop different intellectual skills. Therefore, tests of intelligence, including those skills, may predict school achievement moderately well.

CHAPTER 3. Memory and its relation to Intelligence

3.1. Memory abilities and intelligence

3. 1.a) Introduction

Are we more intelligent if we have a good memory?

In view of what has been exposed on human intelligence, it is not obvious to answer such a question. Of course, many examples of retarded children who are able to achieve very complex mathematical operations and are not capable of remembering very simple words or writing their name, suggest that there could exist a kind of separation between memory and intelligence abilities. In fact, some patients with a damage in some parts of their brain, supposed to hold different memory functions, continue to progress in their mental development.

To deal with such a question we have first to define, relying on chapter 2, some criteria of what will be here considered as a measure of human intelligence. So, the following three aspects of intelligence tasks will be explored. First, the reasoning ability which may be measured by the general coefficient "g", then the speed of information processing and at last, the abstraction and the models inference ability. We will focus on what has been previously presented, to relate these three aspects to memory functions.

3.1.b) Working memory capacity and its relation to executive attention and general factor "g"

We know that our short term memory benefits from a limited capacity. The amount of information that can be processed by the system is then limited. That is why we cannot learn too much information at the same time.

Recent progress in experimental and neuro-imaging research has given more details on information processing requirement of working memory tasks. The conclusions that have been made are: first, that Working Memory capacity (WMc) and "g" are highly related. Second that WMc—g relation is probably based on executive attention control mechanism supported by the prefrontal cortex. (Andrew R.A et al. 2003).

To study the relationship between working memory and intelligence, researchers have to define how they will measure WMc. The characteristics of battery of the WMc tasks have to be clearly defined. WM span tasks reflect something different from simple span tasks since they involve a kind of attention control that does not exist in the simple span tasks. WM span predicts "g" in a way that simple span tasks do not. It is imperative then to understand the basic process that contributes to the generation of WM span tasks.

When given two sets of elements (letters), a person is asked to recall them after a short moment. Therefore, two cases are distinguished. In the first possibility, there is no overlap in the set membership. No letter was a member of the two sets at the same time. In the second situation, some letters were members of the two sets. The result was that WMc was related to retrieval speed and accuracy in overlapping conditions only. (Andrew R.A and al. 2003).

In another experimental work, the subjects' task was to orient to a visual cue presented in their periphery (a flashing stimulus). They were also required to detect a target that was presented at the same location as the cue. In another version of this task, the target was moving in the opposite direction of the flashing stimulus. In the second case, the subjects had to make more concentration efforts to move their eyes to follow the target ignoring the flashing stimulus.

In conclusion, it has been shown that WMc is related to performance in situations where the executive attention control mechanism is needed to fight some form of interference, be it proactive interference, response competition or habitual but inappropriate response. The executive attention ability will support the active maintenance of the goal relevant information to face up to interference.

Localisation studies, found in neuro-imaging on investigations into the brain region invoked by WMc tasks suggest that the dorso-lateral prefrontal cortex (DLPFC) and anterior cingulate cortex (ACC) are involved. The same conclusion has been made for the localisation of the executive attention and "g".

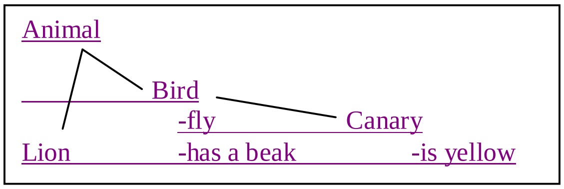
3.1.c) Memory organisation and its relation to the speed of information-processing

In the Sensory Register, it is assumed that the modality in which information is stored is similar to the sensation that gave rise to it (i.e. auditorilly or visually) information. It has been concluded that even young children are able to represent a variety of information in sensory register in a manner similar to the adults'.

The storage of information is here linked to the delay of the presentation of the stimulus and the ability of children to selective auditory attention. But in contrast to that, semantic memory is developed later, around 10 years old. Tulving (1972))(in Gross,1985) argues that procedural knowledge (procedural memory), as it seems instinctive, is the first system to develop during infancy, followed by semantic knowledge as we learn, and lastly, compilation of episodic memory consisting of events that we encounter in life.

The improvement in children's memory performance is attributed to their growing appreciation of semantic features of items and their ability to generate suitable and compatible cues for retrieving the contents of memory. Old children are able to consider the meaningful relationship between a number of items. Semantically encoded words, compared to others have been found to be remembered best across a wide range of ages. Younger children may be less sensitive to the semantic properties than older ones.
It has been proved that the semantic organisation of information is not really effective before 10 years old.

In semantic memory, concepts are organised hierarchically, as already in the previous chapters. Categories are nested into other categories and so on like in an arborescence scheme or tree. Therefore, the concept "bird" is a sub-category of the concept "animal". The properties are also linked and positioned at the same level as the concept itself. It means that the property "have a beak" is associated and ranked with the concept "bird" in our memory.



It has been shown (Andrew R.A and al. 2003) and (Lieury, 1996) that the reaction time (speed of information processing) is as longer as the semantic distance that help us to relate the concepts and properties or concepts between them. This distance is the number of all the stages (nodes) necessary to make the connection between the two concepts.

When children learn about “pigeon” and “goose”, when they are asked if “pigeon is a bird” or if “goose is a bird”, their speed of information processing is faster for the first sentence. Since the goose does not fly and is big, they naturally have stored the information far from the definition of bird. Of course, this does not seem to be logical. In fact a child when asked if “goose is a bird” will compare the properties of a goose with the more salient and general properties of a bird (a prototype) namely that it is known to be small and that it flies. He may need time to realize that goose is a bird (Lieury, 1996).

Since episodic memory is associated with the personal experience in different occasions, to know about one concept, all the data collected about this concept (subject) relevant here to his episodic memory will help him to shorten the semantic distance.

Developmental studies have shown that older children use the categorical properties of word lists to facilitate recall. They impose a certain order upon the stimulus when they memorise the information and then, try to use this organisation to retrieve them.(Lieury, 1996).

Episodic memory is supposed to be fitted in semantic memory (seen as sub-memory of semantic memory). That is why, it has been revealed that the strategy training and the multiplication of experiences on the same subject improve scores in WM span tasks and shorten the semantic distance. Training children to attend selectively would improve memory performance

3.1.d) Organisation of LTM, Working memory capacity and its relation To the capacity of modelisation and problem solving

When faced with a new problem to solve, children do not systematically succeed in applying a strategy which has been already used successfully on similar problems.

The transfer of their solving strategy on the new problem is not obvious and some elaboration of new abstract schemes is necessary. We are then faced with two cases:

-Some children will keep in their long-term memory a very constrained and specific number of situations (or problem model) elaborated with the help of the solution of the first problem. Consequently, they will use the first strategy, only if the new problem is very similar, in its presentation, (text writing) with the previous one. When the presentation of the second problem is different from the first they will fail to solve the new problem.

-Some other children, after their successful first problem solving, generate in their long term memory a new scheme, much more elaborated and complete in terms of properties description of the different variables used in the first problem. In this case, they will be able to apply the previous problem solving strategy for a large class of new problems.

The precision of the elaborated model seems to be linked to children's capacity to abstract the representation of the world and the use of symbolic information.

Two aspects are then important to be mentioned (Lieury, 1996):

- The way they have organised the information stored in their long-term memory and the semantically well understood and acquired subjects.

Since long-term memory is said to be organised on the basis of associations, theorists believe that children's concepts are fragmented and incomplete, but as children grow older, formally fragmented categories are combined and strengthened to represent more adult like conceptual groupings.

- Their capacity to connect the information manipulated by their working memory to the information already stored in their long-term memory.

3.2.e) Conclusion

The relationship between memory capacity and intelligence is still an open question. However, we can explore some principles generally accepted by cognitive psychologists: a human organism has been genetically prepared to process and organise information in specific manners and the human mental system is of a limited capacity. This leads to argue that the amount of knowledge that can be processed by the system is constrained in some very important ways.

The second point is that a control mechanism processing is needed for the storage, retrieval and manipulation of information. In addition to that, the executive function that oversees this process will use up some of our memory capacity. And, when one is learning a new task or is confronted with a new environment, the executive function requires a more processing power than when an individual is doing a routine task or is in a familiar environment where he enjoys certain easiness.

Faced with new changes, we exploit two-way flows of information as we try to make sense of the world around us. We constantly utilize information that we gather through our senses and information we have stored in memory in a dynamic process as we construct meaning about our environment and our relation to it.

When a child interacts with concrete objects in his environment, makes experiences, or solve new problems, the relevant observations he makes and the appreciation of a kind of new properties on the things he is manipulating, will create new links between already known elements in his memory or introduce new concepts that have not been seen before. Building and storing new data and logical relationships between those semantic and visual information will probably demand some mental efforts. He will then add new links in the organization (tree) of his memory. This in fact, explains in what ways consists the role of intelligence in enhancing, empowering and consolidating semantic memory.

3.2. Problem solving and Motivation

3.2.a) Introduction

Most educators regard problem solving as the most important outcome of life. Education and training efforts engage learners in well structured (textbook) problems, while real world problems are nearly always ill-structured.

The most commonly encountered problems, especially in schools, are well-structured problems. These well-structured "application problems" require the application of a finite number of concepts, rules, and principles being studied to a constrained problem situation.

We will present in the following chapter, the information processing approach and Piagetian approach to problem solving.

3.2.b) Information processing Approach

The Information-Processing Approach has focused fundamentally on what children know about *logical problem solving rules*. From this point of view, the information processing theory characterises the problem solving as "*the sequential application of well known set of rules*". When children are observed, each of them had his "own" strategy when trying to use and combine these rules to solve a given problem. The use of different strategies for problem solving are thought to be typically age levels related.

Children demonstrated to use some rules while not others. In many situations, the scientists have noticed that children know logical rules but they fail to use them during problem solving. The reason given here is related to the fact that they have some limitations in other sub-processes underlying problem solving. Another reason for their failure to use logical rules is that they simply may not have acquired them. They know the rules but they have not already understood the real meaning of these rules.

In the other case logical rules should be used more frequently and more adequately. It would also be anticipated that training children to use logical rules should increase the frequency with which they are applied to problem solving tasks.

3.2.b.1 Analysis Method:

From information processing view, it is obvious that problem solving of any type is intentional. Problem solvers, for well defined problems, also know that there is in general a set of different solutions and the answer is one of these possibilities.

Two different strategies can be used to approach a given problem :

Focusing : For some kind of problems, solvers try to write down all the possible solutions and eliminate successfully less relevant solutions by asking questions and getting new information on the problem.

Scanning : when solvers generate a set of possible solutions and test each one independently. The solver ignores the information from past outcome trial

The recognition that problem-solving behaviour is strategic led to think about what types of rules are used when solving problems. In order to examine rule use, researchers developed several experimental paradigms.

The Blank-Trial Procedure: Levine (1966)(in Gross,1985) for example, developed the blank-Trials procedure in which problem solvers had to discover some experimental defined solution to a problem defined by a deck of cards. Every card has two pictures on it, each is the exact opposite of the other. Each time a card is shown, the solvers are asked to point out the picture that they believe has the answer.

By examining performances on this kind of problem, researchers can deduce a variety of information on hypothesis testing behaviour and the use of logical rules. The use of hypothesis and logical rules should also be accompanied by a strategy for solving problems.

Three strategies have been pointed out by Gholson, Levine and Phillips (1972)(in Gross,1985). First Focusing and hypothesis checking (formulate a set of all possibly relevant answers to a problem and eliminate information successively from that set as more information about the problem and its solution became available) then the scanning (Generate trial-to–trial guesses about possible problem solutions, seemingly ignoring information from past outcome trials) and at last dimension checking (the problem solver imagine a list of dimensions and proceeds through the list, testing one dimension at a time. When a hypothesis is tried and disconfirmed at or after the second outcome trial, the problem solver should realise that it is logically impossible for other hypotheses within the same dimension to be correct; thus, that dimension is abandoned and another is tested.

The blank trial procedure has several qualities that limit its use with children. First, it is extremely a time-consuming procedure and, second, due to scoring prescriptions, some of the data pertaining to rule and strategy use must often be excluded from analyses.

The Introtact Probe Procedure The modified version of the blank-trials procedure is called the introtact probe procedure. Instead of the blank-trial, problem solvers are simply asked to state what they believe to be the answer to the problem.

3.2.b.1.1) Hypothesis Testing, Rule Knowledge, and Strategy Use.

Problem solving researches showed that children do not spontaneously use hypothesis testing (consistently and consciously) when solving a problem until they reach the second grade. The frequency with which they use them increases during the early elementary school years. The progression performed is also observed on their ability to use logical rules.

By the second grade, children tend to use the win-stay, lose-shift and local consistency rules at above chance levels. They use also feedback consistent hypothesis.

Strategies are plans that guide choice behaviour during problem solving. In the use of strategies, striking changes are found in children's co-ordination of information during problem solving. During the early elementary school years, children began to use hypothesis checking strategies, and finally to the more advanced strategy, focusing ,by early adolescence (Gholson,1980)(in Gross,1985). By the second grade, most children attempt to solve problems by testing hypothesis. Pre-school children do not hypothesize spontaneously, they are unable to co-ordinate the information in a meaningful fashion to solve a problem efficiently.

Two possible explanations for why changes occur. One of these is that sub-processing deficiencies may attenuate the application of a variety of logical rules and the other is that children may need to learn how to use specific logical rules.

Sub-processing deficiencies : Young children are less efficient information processors than old children . In our review of perceptual and mnemonic abilities of children, we saw reliable age related changes in ability to acquire and store information.

Considering young children perception of stimulus events, we have noted that they do *not*:

- discriminate the stimulus fields as accurately as do the older.
- resist to distraction
- consider several dimensions simultaneously.

Children who had received stimulus differentiation training with feedback generated more hypotheses and were less likely to show stereotypic response patterns. But, in general, stimulus pre-training has a little effect on young children but seems to be particularly effective on concrete operational children.

Memory limitations: Changes occur to memory during childhood. It is apparent that children's mnemonic limitations could affect the manner in which they solve problems. Young children have limited short-term memory capacity than old children. They fail to use a variety of control processes including rehearsal, chunking,interactive imagery etc… to facilitate information retention. It has been shown (Gross,1985) that memory deficiencies reduce problem solving efficiency in older children.

Other researchers showed that memory aid conditions the children to use more hypotheses and to use more focusing in solving problems.

They also find that the amount or type of information to be remembered affect problem Solving performance. When the number of items to manipulate increases, there is less efficiency problem solving. The types of information used is also important. Children solve problems more easily when we use colours and images.

3.2.b.1.2 Rule instruction and strategy training

To develop their problem solving abilities, children are helped to be familiar with different problem solving strategies. Two methods can then be used, those based on direct training to acquire new rules and the other based on modelling.

Direct instruction: the problems of training have been proved to give a real contribution to the development of problem solving children abilities only if it is based on focusing or on a combined focusing and scanning procedures. Scanning alone will not effectively help to improve the capacity of new strategies development. It has been also demonstrated that this direct training method is effective only with children during primary school and earlier.

Modelling: Not all the modelling conditions help to improve strategy and rules induction. Cognitive model conditions are more effective on children than exemplary model conditions. In addition to that, positive influence on concepts attainment is proved only for old children. (Gross,1985)

3.2.b.2 Synthesis Method:

In this method, children are trained to use all the given information of the problem to be solved to make prediction on a possibly new direction and step by step go further in the solution construction. At each step when his prediction is disconfirmed, he tries to move in a new direction

Information processing to Problem solving approach, gave some results on age related children behaviours when faced with a problem solving task, but did not give explicit information about the mechanisms responsible for changes in children abilities to learn new rules and skills, (Gross,1985).

3.2.c) A Piagetian approach to problem solving

From Piaget's point view, intelligence is linked and strongly influenced by one's stage of development. Some of our intellectual capacities are then acquired on higher stages but are not available in lower stages. The intellectual abilities are progressively acquired with age (Tibble and Morris, 1978).

With these considerations, the basic question on problem solving is not interested in *"how children use the logical rules"* as it was the case of information processing approach, *but "why do the children use the rules they do"?*

From that, intellectual tasks are performed by children if they can first :

- symbolically represent the world
- understand properties of objects and relationships between them.

The second point is based on the "*operationalisation*" of thought (Gross,1985).

To understand why children solve the problems in their own fashion, we must first consider the nature of the intellect.

Development of a system of rules :

The aim capacity acquired by pre-operational children is their ability to use symbols. But, despite the intellectual achievement obtained across the use of semiotic function, the thought of these young children is limited (unidirectional and static).That is why, it seems obvious that these children perform poorly on a problem requiring analytical reasoning.

To be able to think or to manipulate thought, children have to assimilate, what it is called "transformation scheme" that is the logical relationships that exist between the elements of the world.

Piaget believed that a common set of operations underlies concrete operational thought. Three operations are considered here: classification, conservation and seriation.

Classification :

Since the basic idea of classification is the manipulation of groups of items and arrangements hierarchically, to be able to manipulate items grouped in classes we need to use a particular kind of knowledge about these classes. That is why, different points have to be appreciated (Gross,1985) and (PiagetPsyweb, 2005)..

- In each class, one has to define the property called "intention of the group", that is the membership between the different members. Defining the attribute of this later property helps to know what are the members of this class.
- Membership between objects of the same class cannot exist in the actually exclusive class.
- A class may be described by a list of things that can be included in it.

To be able to classify objects, children have to assimilate a set of logical operations which help to materialise the relationship between objects

- The addition or (composition or union) cl*1*+cl*2*=CL. (cl*1,2* are subclasses of CL: here considered as a new class)
- The reversibility (induced by the first) CL-cl*1*=cl*2*
- Associativity
- Identity (taking the opposite of a thing from itself produces identity)

$cl1 - cl1 = 0$

- Resorption : $cl1 + cl1 = cl1$ (a class combined with itself produces itself and from that a subclass added to a higher class produces the higher one i.e. $cl1 + CL. = CL.$

With his experimental set of tests used with children, Piaget works on classification focussed on two primary questions (Gross,1985) :

- When can children sort or use classification schemes?
- When do children use class inclusion?

From the results of these experimental tests, Piaget, attested that knowledge of classification develops between the age of 5 and 7 years (late pre-operational children). However, he pointed to the fact that their abilities to sort things by shapes or by colours do not mean that they truly understand the mechanism of classification or the nature of classes. In support of this, he explained that pre-operational children did not assimilate *class inclusion*. Class inclusion is defined as " *knowledge about how an item's membership in one group is also related to groups that are both super-ordinate and sub-ordinate to the one in which it is included».*

The justification of such behaviour is found in different intellectual limitations, namely that young children fail to consider two dimensions at a time. They cannot consider and hold in mind two elements at the same time. The child fails to understand that a given class (sub-class) can be a part of a higher class.

Remarks on the classification results: The studies performed by other theorists see (Gross,1985), proved that children under some conditions, (for simple problems with a few items, or after training sessions), can classify much earlier than originally proposed by Inhelder and Piaget. (3 and 4 years old children). The classification tasks can also be affected by the type of objects they have to classify (abstract grouping or natural ones as collection). Even when these children succeed in these classification exercises, there is a remaining question of whether or not they have reached a logical understanding of class hierarchy. In spite of these positive results, Piaget maintains that to truly understand classification, children have first to understand class inclusion.

Later works have proved that rather than finding evidence for class inclusion before the age established by Piaget, they found that class inclusion develops relatively late in the concrete operational period. They also thought that earlier before that age, children adopt a kind of empirical counting rather than a specific ability of reasoning about subordinate/super-ordinate relationships. But , it is obvious that in general, all theorists believe that some operational knowledge is necessary for performance on class inclusion problems.

Conservation:

During the operational period, children acquire the ability to conserve the properties of objects. As it was the case of classification, the ability to conserve is also depending upon the assimilation of logical operators. The operations directly related to this reasoning faculty are "identity, negation and reciprocity". Piaget also believed that operation underlies children performance on conservation tasks but also observed that if the properties to be conserved are easily dissociated from children 's own actions, the children could conserve it earlier.

Different experimental results showed that "*conservation of number*" is the earliest property to be conserved (6-7 years old). Children with a logical understanding of numbers appreciate the additive and subtractive properties and understand notions of identity and compensation. From Piaget's point of view, identity is not sufficient to conserve.

Conservation of continuous quantities as volume, surface :. Children had, in some experience, to reason about what happened to the amount of water as it is poured from a narrow jar into a wide one. Piaget argued that logical knowledge of liquid quantity is based on the logical understanding of changes in two dimensions namely height and width. Changes in each of the two dimensions are compensated by changes in the other. Thus, for example, conservation of volume is acquired by children of 10 years old.

Remark: Piaget argued that for conservation, it is necessary to use identity and compensation. Some other scientists (Bruner ,1964, Acredolo ,1979 and Glastone ,1981 in Gross,1985) do not share this point of view since they believe that identity is sufficient for conservation and that compensation is not necessary. Their works showed, for example, that on the one hand, some children can predict conservation of the amount of water and at the same time will predict no change in water levels, and when they see the new water level in the narrow jar, they will maintain a conserving judgement. On the other hand, there were some other children who predict conservation and anticipate the change in water level but when they see the level of water in the narrow jar they have tried to switch their response to non-conserving judgement

Seriation: Young children, when given a number of objects, can easily choose the biggest and the smallest object in the group of objects. However, if these elements can be ordered and form a series, young children will not be able to arrange them. Piaget has suggested that young children may construct logically a relationship between adjacent elements but fail to understand globally the construction of a series.

It is only about 6 and 7 years old, that children show they understand that some items of a series can be larger than some members while being smaller than others. They start to understand the reversible nature of the ordering operation.

As with classification and conservation, some works done by others showed that young children, with adequate training session, could seriate much earlier than 6 years old. Trabasso in 1974, demonstrated that children with a training session can seriate and use transitive inference (A>B and B >C then A > C) if they manipulate a reduced number of items in a series but he believed that, for the children who fail to do it, the problem is due to their inability to retain sufficient information about the premises that were to be reasoned about. However, Russel in 1981, proved that memory deficiency interpretation of transitive inference is not the reason for which young children fail in transitive inference problems (Gross,1985).

An other point of view, the one of Breslow in 1981, based on Piaget work, suggests that children who really understand the mechanism of seriation will construct knowledge of the series in a qualitative fashion and that they can insert a new element into the series only if they have an operative understanding of the relationships in a series.(Gross ,1985)

3.2.d) Theories of motivation

In everyday life, people are motivated to take action for different reasons. These actions can be physiologically based reactions such as those to satisfy the needs for food or socially based ones such as our goals and projects. consequently, different approaches have been proposed to study how and why we are motivated.

Earlier approaches to motivation, namely, *instinct theory* and *drive theory*, have tried to understand motivation from a biological and a physiological point of view. Instinct theory is based on the fact that our behaviour is either inherited (not learned) such as fear from a predator, or stereotyped that is we engage the same reaction to fear (running) or at last related to mankind and will not be present in other species.

Drive theory believes that we all have dissimilar physiological needs and compulsion we feel to meet our needs (known as drive) to reduce the drive to satisfy our needs.

3.2.d.1 Recent approaches to motivation

Recent approaches to motivation studies have integrated some type of "awareness" in human behaviour to explain why and how we feel inclined to act.

Further, we will briefly present each of these approaches and attempt to explore in more details the relationship between motivation and problem solving.

3.3.d.1.1 Physiological view of motivation

Three theories for comprehending the rapport between motivation and the physiology of the brain are considered here:

Arousal theory: When asked to take a test, students of equal intelligence and subject knowledge have different reactions during the test. The one who does not care about the test, the second who wants to do well but is not anxious and the one who is extremely nervous. In view of this theory, these students vary in their amount of "arousal" which is the level of alertness and wakefulness. Yerkes and Dodson [1] showed that people will perform most efficiently when their amount of arousal is moderate. According to that, the second student, who is both motivated and relaxed will do the best performance. At low levels of arousal, people feel bored and unmotivated and at high levels they feel fearful and lack self-confidence. The optimal level of arousal appears to vary both with the task and with the individual. For simple tasks, the optimal level of arousal is moderately high, whereas for

[1] (1) Yerkes and Dodson are two mathematicians working in the USA at the beginning of the 2Oth century. Their law (Y/D law) has been used fruitfully by psychologists in the 2Oth century

difficult tasks the optimal level of arousal is moderately low i.e. there is an adequate relationship between task difficulty and arousal.(Sternberg,1996)

Opponent-Process theory: People try to find emotional neutrality. When people feel emotions, an opposing motive brings us back to the neutral baseline. This theory explains why we are motivated to seek substances to which we are addicted.

Homeostatic-regulation theory: Homeostatic-regulation is the tendency of the body to preserve a state of equilibrium. We regulate the need for food and liquid as well as the control of body temperature. This regulation is controlled by the brain. For instance, when the brain senses that the stomach is full, it signals the body to stop eating.

3.2.d.1.2. clinical view of motivation

This approach to motivation accounts for physiological needs but is based on aspects of the personality:

Murray's theory of needs: He believed that people possess particular individual differences in the level of these needs.(Sternberg,1996)

He stated that the environment creates forces which lead people to respond so that they adapt. How people cope with the world can be understood largely in terms of interaction between their internal needs and the various pressures of the environment. About many needs, there were affiliation, power and achievement.

McClelland's Need for achievement: The achievement motive, which involves competition with internalised standard of excellence, is present in every culture. .(Sternberg,1996)

Maslow's Need hierarchy: Abraham Maslow (1906-1970) suggested his hierarchical theory of motivation. He explains that lower levels are first needed to be, then people look for satisfaction of those of higher levels. According to him, there exist five levels of needs: physiological (food), safety and security, belonging (other people care about them), self-esteem, self-actualisation (fulfill our own potential). .(Sternberg,1996)

3.3.d.1.3 Cognitive view of motivation:

Cognitive approaches propose a variety of perspectives for the analysis of motivation. Albert Bandura has made a severe critical analysis of the theory of physiological needs. He considers that a human being, because of his psychological capacities, can anticipate the reward even if he does not get it. (Sternberg, 1996)

Psychologists have wondered what else might motivate us, beyond satisfying our physiological needs and avoiding pain, why we become interested in particular fields of study.

They distinguished Intrinsic motivators, that come from within ourselves (we do something because we enjoy it) from extrinsic motivators which come from outside of us.

Students might study hard in a given subject because they are really excited about the material and want to learn it or might study hard because they want to get an A. Our system of education is based on grade and diploma. It has been argued that people do their most creative work when they are intrinsically motivated

Edward Deci in 1971 (in Sternberg, 1996) showed that extrinsic motivators can have an unconstructive effect on intrinsic motivation. Extrinsic motivators can weaken intrinsic motivation. Fortunately, not all extrinsic rewards have a negative effect.

3.2.e) Conclusion

Whatever may be the differences between the scientists' point of view on problem solving such as the one of information processing approach defining problem solving as: "*the sequential application of well known set of rules*" and the Piagetian view interested in "*why do the children use the rules they do*"?, it seems that there is an age related change in the ability to use information since young children are less efficient than older ones when faced with a problem solving task.

Consequently, the use of hierarchical and causal modeling of problem seems to come also later at the end of concrete operational stage. Most concrete operational children seem to succeed more by using training strategies. Concerning motivation, young children generally have intrinsic motivators but they need extrinsic motivators.

CHAPTER 4. Experimentation

Our objective in this study is not to test the pupils in order to classify them and to find out who is the best, the most intelligent or the most brilliant in memorizing. We are not comparing these children in the previously stated manner but, we aim at collecting enough data about their reasoning capacities and memorizing abilities so as to identify the possible link between their memory and their intelligence.
In this chapter we have just tried to verify if the theories discussed in the present dissertation are or are not confirmed in our population of pupils.

4.1 The condition of the experimental set.

- **The subjects submitted to the test:** Before defining the battery of memory and intelligence tasks, let's first remind that this experimental work has been done in an Algerian primary school, called Aissous Rabah, with two groups of 30 pupils of 10 and 11 years old, from a population of 120 pupils of both sexes.

- **The choice of memory and intelligence items:** the choice for the items of the tests was not an easy task. In fact, in order to be able to exploit in the most fruitful way the pupils results, our selection was meant to respect a certain number of criteria, on one hand, and to make us able to identify precisely what we were measuring on the other hand. Among these criteria:

- Too complicated or too simple tests would be of no utility. The test must absolutely be constructed on the basis of the knowledge taught to the individuals at school. The test has to be of a degree of generality (not too much specific domain) so as not to exclude pupils on the basis of their interest in the different domains. It has to be adapted to the population in terms of difficulty degree so that it permits to measure the target mental process.

- There is a wide range of tasks which may help to establish which cognitive capacity we are studying, therefore, we were obliged to choose the type of items relying on the contents of the schoolbooks provided to the pupils and the teachers' help and instructions.

- We know that the results may be influenced by the time at which the tests have been given to the pupils (some pupils can be tired at that moment or they can show a little attention for different reasons). The only way to be sure that our set of items is stable and does not suffer from this temporal influence, is that we have to propose it to different groups at separate moments.

  This option was not possible to achieve because of some reasons of organisation. In addition to that, we are aware of the fact that this double testing can represent a negative aspect because of the effect of learning, even if we know that this influence is not considered as a mistake. To partially solve the problem we have :
- Informed briefly but in a tactful manner the pupils about what is going to be done in these exercises.

- To avoid the stress of an exam, we told them that: there will be no scoring and that their answers will not be related to the exams of their respective teachers and that no mark will be given and no control on what they are going to do.

- Our objective is to do some experimental work trying to motivate these pupils. The newness of the tasks to be performed led to a positive behaviour towards the tests on the part of the pupils and made them very concentrated. It clearly appeared that they did their best to be attentive to each of the tests.

- The two tests which were proposed to the young pupils had been objectively constructed, administered, observed and scored for there was just one observer; there was no possibility to use inter- observer reliability, because this needs time and training of a given observer(a teacher in the same school, for instance). We relied on our own measurements and interpretations of the results of the statistical tests of correlations. The same scale was used for evaluating the children's performance .The global score is on 20 for each test, intelligence and memory tests. The twenty points have been distributed on the different items of both tests as accurately as possible.

4.2. Memory tests.

4.2.a) Visual short memory span: ***<u>(global score: 4 pts)</u>:***

1. Three series of circles were presented to the pupils **<u>(score : 0.5 pt)</u>**

(Four) OOOO

(Three) OOO

(Two) OO

They were then asked to recall the exact number of circles

(Rq: At this point our pupils were marked)

- 44 pupils found the exact number (~73%) : pupil n° 1 to pupil n° p44
- 16 pupils failed giving this number (~27%) **:** pupil n° 45 to pupil n° 60

2. In the second test, a number of circles of different colours were drawn on the black-board. Pupils could see them for a short moment for exactly 1 minute. Then , we closed the board to hide the drawing. At last, the pupils were required to give the number of the colours used**. <u>(score: 0.75 pt)</u>**

- 24 pupils (~ 40%) found the number of colours
- 36 pupils (~ 60%) could not

<u>Distribution of pupils:</u>

- p1..p5, p 7..14, p16..p19,p29,p30, p40, p34,p35,p40,p52, p55
- p6,p15,p20.. 28, p31..p33,p36..39,p41..51,p53..54,p56 ..60

3. In the third test, different geometric forms have been presented to the pupils (c.f. Appendix :1, Figure Ap.1)). Circles, rectangles and triangles of various colors and which were different in size and shape. In the middle, among these figures, there was a square. (**<u>score: 1.25 pt)</u>**

The figures were hidden, then the children were expected to give the right number of one specific figure i.e. the square.

- 49 pupils (~82%) said that there was only one
- 11 pupils (~18%) failed to answer (said that there was no square or said that there were more than a given number (say two).

Distribution of pupils:

- p1.- p40, p42..45, p48,p55,p58..p60.
- p41,p46,p47,p49..54,p56, p57

4. In the fourth test, different circles of the same size but of different colours were presented in a given order **(score: 1.5 pt)** :

O O O O O O

White – Red – White - White - Red - White

The pupils had to recover the right order

- 25 individuals (~42 %) gave the right order
- 35 individuals (~58%) could not (different orders have been proposed)

Distribution of pupils:

- p2..p4,p7..10,p14, p18..20,p23,p25, p26,p28..31, p34,p42.. 43, p53..55,. p60
- p1,p5..6,p11..13,p15..17,p21..22,p24,p27, p32..33,p35,p36..41,p44..52,p56..59,

Discussion (items: 1, 2, 3 and 4)

1. In the first test, the pupils were asked to give the total number of circles. The goal of the test of this memory task was previously known. That is why, most of them had enough time to concentrate on one single task, namely recalling the number of circles. The pupils who failed have tried to answer quickly; that is why they provided the wrong answer. Only two of them said that they did not have sufficient time to memorize the number. Other factors could be the newness of the task itself on the one hand, and the lack of interest on the other hand.

2. The results of the second test indicated clearly that when the question was not previously known, a certain number of pupils thought that it would be the same question as the one previously asked (proactive interference). The 24 pupils, who succeeded in giving the right answer, have naturally noticed that there was new information, the colours of the circles. From the previous failure in task 1, the pupils expected to be asked on more than one aspect.

3. Most of the children, in the third test, were able to say that there was only one square. They did not mix between the only one square and the two rectangles. The other geometric forms are of different sizes and shapes. The pupils who said that there was more than one square thought that they did not pay too much attention to the size of the different sides of the rectangles.

4. In the fourth test, when asked about the way they proceed to memorize the order of (WRWWRW) among the 25 first pupils who succeeded, 23 used implicitly the "chunking" technique. They noticed the Repetition of the same order W R W. In this activity, we start to notice a training effect (the degree of newness decreased). Those who failed were able to recall freely the circles (there were two red and four white), ie. Serial recall was more difficult for them than free recall. At this step of the test, most of the children had understood how to behave towards these memory tasks. In other words, they started to realise that they can concentrate on different aspects

4.2.b) Combined visual and verbal (writing) items: ***<u>(global score: 3.5 pts)</u>***

5. Images of different things and animals were stuck on the board. (c.f. Appendix :1, Figure Ap.2)). **<u>(score: 1.5 pt)</u>**
Chicken- Dog – Foot – Cat- Table – Hand- Book –Cow –Duck - Horse –Chair – Pen
The pupils were set to examine the pictures for 2 minutes. After hiding the drawings, the pupils were asked to say if there was an "eagle" and a "car"

- 53 pupils(~88 %) said "no"
- 7 pupils (~12%) said "yes" to at least one of them

<u>Distribution of pupils:</u>

- p1..p26, p28..p44,p48, p50.. p53,p54..p56,p59, p60
- p27, p45.. p47,p49, p57..p58

6. 12 images of different things and animals were stuck on the board. **. <u>(score: 2 pt)</u>**
Children were asked to retrieve the images without any order specification:
They were asked to write down the words of all the pictures they can remember after having looked at them for 2 minutes.

- 32 pupils (~53%) retrieved 12 images ,

- 18 pupils (~30%) retrieved 11 images,
- 9 pupils (~15%) retrieved 10 images,
- 1 pupils (~2%) retrieved 9 images

Distribution of pupils:

- p2..16,p18, p23..28, p31,p34..38,p44, p55
- p1,p19..22,p29..p30,p39..p.43,p51..53, p60
- p27,p32..33,p45,p46,p47..p50,p54,p57 p59
- p 56

Discussion (items : 5, 6):

In these two tasks, children had to perform a simple memory span task. In fact, the question asked in task 5 was simpler since the children did not have to memorize the whole number of things and animals to say if there was an eagle or a car. Among the 53 pupils, 41 said that they would not succeed to recall all the contents but they were sure that there was neither of the two “eagle and a car”. More than 50 % of the group succeeded in giving the right answer, certainly because of the cues given to them, ie. precising whether there was an eagle or a car.

Almost all of them found more than the maximum of items we can keep in our immediate memory in task 6.There were pupils who utilized a semantic association:

- Those who made association by categories of, animals (dog and cat) human body, (foot and hand), writing and reading things (book and pen) etc...
- Others used an alphabetical association. The words which start with the same letter (in Arabic): “**(k)** adem” (foot) – “**(k)** at” (cat)- “**(k)** alem” (pen)) or (book “*k*itab and (chair) “kourssiy”.

4.2.c) Simple Numerical memory span. (score: 2.5 pts)

7. For a task of serial recall, pupils were asked to remember a series of numbers. This string was given in a certain order and the children were required to provide exactly the same order.

3-5-8-11-13-17-20-25

(Correctly Ordered Numbers == CONu)

- 17 pupils (~28%) / 8 CONu, p1.. 5, p23,p25..28, p33..34, p19, p44, p55
- 10 pupils (~17%) / 7 CONu, p6..p8, p11, p20, p24, p29, p31, p37, p38 , p60
- 5 // (~9%) / 6 CONu p9 ; p10, p14, p15, p17..p18,
- 4 // (~7%) / 5 CONu p12, p16, p22,p32
- 6 // (~9%) / 4 CONu p35,p36,p46,p48,p54,p59,
- 4 // (~7%) / 3 CONu p45, p50,p51,p58
- 5 // (~9%) / 2 CONu p41, p49,p47,p57, p53
- 7 // (~11%) / found out 8 numbers in disorder p21,p27, p30,p40,p42..43, ,p39
- 2 pupils (3%) didn 't recall the numbers; p56,p52

Discussion Item 7: When remembering a list of words or numbers, children of less than seven years old, recalled more the last words of the list (recency effect) than those at the beginning of the list (primacy effect). But, during their first school years they learn to use rehearsal process on (immediate memory) in such a manner as to prevent it from decaying . With this learning phenomenon, the results obtained are the inverse of what we can expect, they have effectively learned to keep in mind, the beginning of the list more than the last numbers of the list. 61% of the pupils were able to retrieve (7+-2) as it has been stated by Miller in 1956.

4.2.d) Working memory span ***(<u>score: 6.5 pts)</u>***

Since simple span tasks, already proposed to children, do not clearly involve a kind of executive attention control needed to fight some form of interference, two working memory span tasks were proposed.

The first one, concerned with a list of numbers for which, in addition to the fact that the pupils have to recall freely a series of numbers, they were asked to give the ones that are twice the others. The second will help to measure their temporarily organisation of the information stored., their capacity to reorganize the information given in their short term memory and how they will face the interferences between the different parts of the story (their capacity to connect the information manipulated by their working memory to the information already stored in their long-term memory).

8. In test number 8, pupils were asked to recall freely a series of 8 numbers and to say if one is the double of the other.

***score:* 3 pts** = **1.5** (for retrieving the numbers)

+**1.5** for (doubles): (2 double of 1) (4 double of 2) (8 double of 4) (10 double of 5)

1 – 2 – 4 – 5 – 7 – 8 –10 – 11

- 35 pupils (~59%) retrieved the 8 numbers
- 28 pupils of them found (the four doubles),
  - 7 of them forgot that 2 is the double of 1

- 14 pupils (~23%) recalled 7 numbers (from the beginning of the series and 9 pupils of them forgot the doubles)
- 7 pupils (~11.5%) recalled 6 numbers (three of them forgot two doubles)
- 3 pupils(~5%) recalled 5 numbers and kept in mind only one couple
- 1 (~1.5%) pupils recalled the 8 numbers and added one number: recalled two couples ((2 and 4) and (5 and 10)).

Distribution of pupils:

-p1,p4,p6,p8,p11..12,p16,p19,p21,p23,p25,p27..29,p31,p33..34,p38.40,p42,p44,p51,p53.55, p60

-p3,p18,p22,p30,p35,p37, p48

-p2,p14, p20, p30,p59, (p5,p9..10,p17,p26,p41, p47,p49.50)

-p7,p15,p24,p43 (p36,p52, p58)

-p46,p56,p57

-p13.

Discussion items 8 When given the list of numbers, the children had to perform two tasks at the same time. They recalled freely the set of numbers and pointed out at the numbers which were twice other numbers in the same list. Several aspects were then observed:

- The children who succeeded to recall the 8 numbers (adding or not another on the list) had performed on average well in the second task. These children have selectively managed the two tasks separately, even if they kept in mind that they had to achieve as well the other task.
- Most of the pupils could not see that 2 is the double of 1. In fact, when recalling the list of numbers they were completely concentrated on their retrieval memory task and that is why they did not see at all that at the beginning of the list the second number is the double of the first one.
- The other pupils, who did not succeed to recover all the list of numbers (24 pupils), have been influenced by the second task achievement, when they remembered that there was number 4 or 10 in the list, they tried to keep in their mind that the numbers 4 or 10 are respectively the double of 2 or 5. At that time, they lost their concentration trying unsuccessfully to recover the other numbers of the list.

Even if this task does not present a very strong overlapping condition in the set membership (a number is present in the list and is the double of another one),the children had to make more concentration efforts to keep in mind a second goal achievement which can be seen here as an interference.

4.2.e) Long term memory (score :7 pts)

9. The subjects in this test were required to listen to a story (c.f. Appendix :1, story 1). The story was told with images. The images were on the board in front of the children's eyes. One hour later, They were required to recall (write down) all the story relying on the pictures stuck on the board during the listening phase and their recall . They did the task 30 minutes after that phase. **(score: 3.5 pt)**

- 42 pupils (70%) recalled the story entirely
  (10 pupils (8%) recalled the story but they made some mistakes)
  for example : changed rats by snakes)
- 11 pupils (18,5%) recalled only a part of the story
- 1 pupil (1,5%) recalled (one event)
- 6 pupils (10%) did not understand the story.

Distribution of pupils:

- p1,p3,p4..6,p8..9,p12..13,p19,p23..25,p32..35,p39,p41,p43..44,p46..48,p51.53, p55..57,p59,p60 (p7, p11,p14,p16,p18, p20,p28,p37..38, p54)
- p2,p10, p15,p17p21..22,p26,p29, p31, p40 p42
- p27
- p30,p36,p45,p49,p50,p58

10. In the tenth test, another story had been narrated to the pupils, they were not helped with drawings (c.f. Appendix :1, story 2).. Three days later, they were asked to recall the story by their own.(**score:3.5 pt)**
    - 28 pupils (47%) recalled the story
    - 10 pupils (16,5%) recalled the beginning of the story
    - 13 pupils (22%) recalled the story but forgot some details
    - 7 pupils (11,5%) have changed some elements
      but recalled the entire structure of the story (crown by hat) and (rat by frog)
    - 2 pupils (3%) did not understand the story

Distribution of pupils:

- p2,.p4..5,p9,p11,p14,p18..20,p24..25,p27.28,p30,p32..35,p38,p41,p44,p46..48,p51.53 p57,p59,p60
- p10, p17,p26,p31,p36,p39, p42,p50, p45
- p6, p7, p8,p12,p13,p15,p21,p22, ,p23, ,p29,p37,p40,p43 p54,
- p1,p3, ,p16, , p55.. p56
- p49,p58

Discussion(items: 9 ,10): The pupils were required to listen to a story and to recall (write down) all the story relying on the pictures stuck on the board during the listening phase and the recall phase.

- More than half of the children (42) retrieved all the story. They did not have any problems with the elements or the events that had been reported.
- A few of them (5) could recall all the structure of the story and the relationships between the events but forgot some details (changed rats by snakes). Typically, it was an

interference coming from long –term memory, since they did not concentrate on the strong semantic associations of the concept of snake, to be able to keep it in their short term memory.

- Those who recalled only a part of the story did not keep in mind all the events, they said that after a certain level, most of the events were mixed up with the rest and they got confused on what happened after, even if they knew some other elements (because a few images were stuck on the board) they could not say what exactly happened. For the last 6 pupils who did not understand the story, even with the help of images, the lack of linguistic knowledge was at the origin of their failure.

For item 10: understanding a story is affected by our capacity to build a hierarchical model in our mind. To structure this model, it is necessary to understand the causality links that exist between the events and actors.

The comprehension of the text depends on different factors, namely those relative to the child and the others relative to the structure of the text. From that, the ability of children to understand the story and to recall it is related to :

- their linguistic knowledge
- their capacity to assimilate new things
- their capacity to structure all what they heard and to construct the hierarchical model in their mind.

Another explanation which can be taken into consideration is

The time factor: in test 9 the pupils recalled the story 30 minutes after but, in this activity they did it 3 days after. The pupils recall in activity 9 was stimulated with some cues (images) but not in this activity.

But even we suppose that the pupils were accustomed with the activity of

recalling a story, since it was the second time, this does not lead to a better performance

4.3 Intelligence tests

The aim of our intelligence test is not to evaluate the instructional level of the children but their ability to solve the problems of different degrees of difficulty, to learn how to adapt and to use the already known knowledge to new situations.

4.3.a)Verbal tests: (Vocabulary, comprehension and similarities). <u>(global score: 6 pt)</u>

1. Vocabulary :What does the term “pail” refer to? (**<u>score: 0.5 pt)</u>**

Is it: a- an animal

b- a plant

c- a thing

- 60 pupils (100%) succeeded in answering the question : (p 1 .. 60)

2. Comprehension<u>:</u> Children were asked to define the term “School” . (**<u>score: 0.75 pt)</u>**

- 36 pupils (~ 60%) defined it as “ A place of learning ”
- 18 pupils (~ 30%) gave a physical description of the place (chairs , tables , board) and the function of the place (learning).
- 3 pupils (~ 5%) defined it as a physical place with a structure (details of chairs tables ,board)
- 2 pupils (~ 3%) said that it was a thing (influenced by the previous item)
- 1 pupil (2%) spoke about it as representing “the future”

<u>Distribution of pupils:</u>

- p2-p8,p12-p13,p15-18,p21,p24,p26-27,p29-31,p34,p36,p40-43,p46-47,p50,p53-54,p57-60
- p1,p9,14 ,p20,p23,p28,p32-33p35,p37-39,p44,p48,p51-52,p55-56,
- p19,p22,p25
- p45,p49
- p11

3. Similarities<u>:</u> What are the similarities and differences between the dog and the fox (**<u>score:1.25 pt)</u>**

- 35 pupils (~ 58%) gave physical similarities
- 11 pupils (~ 18%) talked about physical differences

- 14 pupils (~ 24%) (social difference) said that the dog was a domestic animal and that the fox was not.

Distribution of pupils:

- p1..2,p4, ,p14..20, ,p24..p37, ,p46..48, p50,p51,p54..56,p59..60
- p6,p9..12, p22, p40..44,
- p3,p5,p7..p8,p13,p21,p23,p38..39,p45,p49,p52..53,p58.

4. **Vocabulary** : Link each subject with the corresponding verb. (**score: 1.5 pt)**

- 36 pupils (~ 60%) found the four links
- 16 pupils (~ 27%) joined three pairs
- 6 pupils (~ 10%) found two correct answers
- 2 pupils (~ 3%) gave only one right answer

Distribution of pupils:

- p1-2,p4-p6,p8-p9,p11-p12,p14,p17,p20,p24-p25,p27-p28,p30,p32-p36,p38-p41,p43-44,p46 p48,p51,p53-p54,p57,p59
- p7,p10,p13,p18,p19,p22-23,p26,p31,p42,p50,p52,p55-56,p58,p60
- p3,p16,p21,p29,p31,p37,p45
- p15, p49

5. vocabulary : Pupils are asked to choose the letters of the word “cat” among a set of letters (5 letters for the Arabic word “cat”(cf: Appendix :1,Figure Ap.3)) (**score: 2 pt)**

- 45 pupils (68%) gave the right answer
- 10 pupils (17%) forgot the two first letters “el” or the last letter “tu”
- 2 pupils (3%) had written the word before giving the answer
- 3 pupils (5%) added one letter
- 1 pupil (2%) took more letters than he should

Distribution of pupils:

- p1..2,p5..7,p9..12,p14,p16,p18..20,p22,p24..27,p29..33,p35..44,p46,p49..51,p53..57,p60
- p13,p15,p17,p23,p34,p45,p47,p52,p58..59
- p8,p4
- p3, p21,p28
- p48

Discussion items (1 to 5.)

From the results of **item 1**, it comes that all the children have at least acquired the concept of the "pail" and know to which category it is associated . As to the second item, in which they have been asked to give the definition of the word "school", most of them said that school is directly linked to learning achievement. According to their answers, we can say that they gave a higher rank of importance to the function characteristic rather than to the physical characteristic.

Item 3, helps to measure the way they have organised and explored their semantic information .It appears that the dog and the fox are physically very close to each other. In here, it seems obvious that the semantic properties available for the dog are also immediately available for the fox. The second more relevant information they gave is from their own social personal experience (episodic memory). In fact, the most important difference between the two animals is that the dog has been domesticated by the human being. The physical differences were given less importance by the pupils.

In **item 4,** they had to link the verbs with the subjects. This simple grammatical test informed us about their knowledge of the grammatical structure of the sentence. This task will allow us evaluating their linguistic capacity to decipher and comprehend any written piece. This will help us predicting some difficulties for the next tasks. From the results, we can state that more than 95%, of the pupils are familiar with the basic grammatical structures.

In **Item 5**, pupils are asked to find the letters of the word cat in a set of letters. Since the children have reached the concrete operational stage, as described by Piaget, they are able to hold in mind the word cat and to manipulate it. Here, they are supposed to be able to dissociate all the letters of the word while maintaining it by implicit rehearsal in their working memory. All the children have been able to use their symbolic thinking except two of them that have been obliged to write the word down on the paper when looking for the letters

4.3.b) Performance tests :

6.Arranging images . (**score: 0.5 pt)**

Children had been given one set of different geometric forms and colours (circles, squares and triangles). The question was to put in different sets all those of the same form.

- 46 pupils (~ 77 %) succeeded in grouping the different forms in three sets
- 5 pupils (~ 8 %) Put the three different sets for each form but forgot some of the forms
- 3 pupils (~ 5 %) mixed the different forms
- 4 pupils (~ 7 %) have ordered the forms, without the sets
- 2 pupils (~ 3 %) did not understand the question

<u>Distribution of pupils:</u>

- p1-p6,p8-p15,p17-p19,p21-p24,p26,p28-p35,p37-p40,p42-p44,p46-p48,p52, p54-p55,p57,p59-p60

-p7,p25,p27,p36,p51

-p41, p48,p58

-p16, p20, p45,p53,

-p49,p56

4.3.b.1) Mathematics :(lists , series and equations, problems resolution).

(**<u>score global : 6.75 pt)</u>**

7. Lists: Reorder the following 8 numbers by an increasing order .(**<u>score: 0.5 pt)</u>**

25 2 18 10 13 50 7 31

- 46 pupils (~ 77 %) succeeded to order all the numbers
- 8 pupils (~ 13 %) forgot one number
- 6 pupils (~ 10%) inversed the order (>)

<u>Distribution of pupils:</u>

- p1-p5,p7-10,p12,p15-19,p21-33,p35-38,p40,p42-44,p47-48,p51-55,p58-60.
- p13,p14,p20,p34,p39,p41,p49, p56
- p6,p11,p45..46,p50,p58

8. Mathematics (Series): Complete the flowing sequence of numbers without going beyond number 50

(**<u>score: 1 pt)</u>**

5 - 10 - 15….

- 46 pupils (~ 76 %) succeeded to complete the series
- 9 pupils (~ 15 %) gave the right answer but did not stop
- 1 pupils (~ 2 %) gave five right answers (5…25)
- 4 pupils (~7%) failed completely

<u>Distribution of pupils:</u>

- p1-2,p4-5,p8-9,p11-13,p15-17,p19-26,p28,p30-33,p35-39,p41-44,p46-48,p51-55, p57-60

-p3,p7,p14,p18,p27,p34,p40,p49

-p6

-p10,p45,p50,p56

9. Equations: Three mathematical equations had been presented. (**<u>score: 1.5 pt)</u>**

Ex: 8+11= 5+(?) 25+25=(?)+50 12+(?)=24+4

Children were asked to find the fourth number (?).

- 28 pupils (~ 47 %) succeeded to find the three numbers (one for each equation)
- 3 pupils (~ 5 %) gave the right answer to only two of them
- 10 pupils (~ 16 %) gave the right answer to only one
- 19 pupils (~ 32 %) failed completely

<u>Distribution of pupils:</u>

- p1-3,p5,p7,p9-10,p15-17,p20-25,p28,p31-35,p37,p41-42,p44,p51,p60
- p4,p8,p48
- p11-p13,p18,p20,p30,p38,p43,p55,p59
- p6,p14,p26-27,p29,p36,p39-40,p45-47,p49-50,p52-54,p56-58

10.Problem resolution.1: Teacher drew 5 flowers on the board then explained that each flower contained 4 petals (c.f. Appendix :1, Figure Ap.4)., then wrote

. O . = .

- Look at the following picture then complete what is missing?). (**<u>score: 1.75 pt)</u>**

  The answer 4*5=20.

- 44 pupils (~ 73 %) gave the right answer
- 16 pupils (~ 27 %) thought that it was an addition , they did not understand (4+5)

<u>Distribution of pupils:</u>

-p1-5,p7,p9-10,p12-13,p15-18,p20-22,p24-25,p27-29,p31-34,p36-39,p41-44,p47,p50-52,p54,p56-60

- p6,p8,p11,p14,p19,p23,p26,p30,p35,p40,p45,p46,p48-49,p53,p55

11. **Problem resolution.2:** A mathematical problem has been given. It starts as follows. A grocer brought 9 crates of potatoes in his shop. Each crate weighs 15 KG. what is the weight of the potatoes? He sold his potatoes 20 Dinars the kilo. What price did he gain?

    Pupils were asked to read and solve the problem. (**<u>score: 2 pt)</u>**

    To solve this problem, they needed to go through two steps:

    Solution: 15*9=135KG and 135*20=2700 DA

- 30 pupils (~ 50 %) succeeded to solve the problem (went through the two steps)
- 20 pupils (~ 34 %) gave the right first step
- 10 pupils (~ 16 %) failed to give the two steps

<u>Distribution of pupils:</u>

- p2-4,p6,p10,p12-13,p15-18,p20-21,p24,p30-32,p35,p37,p39,p41-44,p47,p51, p53-55,p59-60

-p1,p5-7,pp9,p11,p14,p22,p23,p25,p28,-29,p33-34,p36,p38,p40,p45,p50,p56

-p8,p19,p26,p27,p46,p48,p49,p52,p57-58

4.3.b.2) Analysis and synthesis abilities in concrete situations (<u>global score: 6.75 pts)</u>

12. The pupils were asked to look at two pictures of a classroom.(cf:Appendix:1,Figure Ap.5)).

Then the question was: In which classroom do you want to study? (**Score: 0.5 pt)**

- 59 pupils (~ 98 %) said the one which is in order,
- 1 pupil (~ 2 %) said the second one(the one which was in disorder),

Distribution of pupils:

- p1 to 48,p50 to 60

- p49

13- Teacher stuck seven pictures representing different situations. Then, she told the pupils. Here are seven situations: examine them carefully then tell which one you can do and which one you cannot?). .(c.f. Appendix:1, Figure Ap.6) (**score: 1.75 pts)**

Pupils were asked to identify the normal or the unusual situations

1. picture one represents a young boy playing football in the street …… wrong
2. picture two represents a woman who is watering her garden……………true
3. picture three represents a school child building a fire inside the classroom...wrong
4. picture four represents a schoolboy writing in his copybook on his table…..true
5. picture five represents a girl peeling a potato on the floor……. wrong
6. picture six represents a pupil throwing rubbish in the basket…… true
7. picture seven represents two pupils fighting each other…….wrong

- 59 pupils (98%) of pupils found the right answers
- 1 pupils (2%) made 3 mistakes

Distribution of pupils:

- p1..44,p46..60

- p45

14 - Pupils were asked to link the figures and the sentences (c.f. Appendix 1. Figure Ap.7). : (**score: 1.5 pts)**

1- Picture 1: represents a pupil putting the book in its place on the shelf …..(3)
2- picture2: represents a pupil raising his finger to answer his teacher's questions…..(1)
3- picture 3: represents pupils leaving the classroom in a disciplined manner ….(2)
4- picture 4: represents a pupil giving something to the teacher…….(4)

Now the four sentences are :

2- I raise my finger to answer the question
3- We leave the classroom in calm
4- I put the book in its place on the shelf
5- I give my teacher what I find in the courtyard

- 52 pupils (~ 86 %) succeeded to link the four pictures to the corresponding sentences
- 2 pupils (~ 3%) made two mistakes
- 3 pupils (~ 5 %) made three mistakes
- 3 pupils (~5%) made four mistakes.

<u>Distribution of pupils:</u>

- p1..p9,p11..p18,p20..p25,p27..p29,p31..34,p36..39,p41..44,p46..47,p49..60
- p10, p35
- p26,p40,p48
- p19,p30,p45

15 - Read the following statements then identify the wrong and the correct situations (**<u>score: 1 pt)</u>**

1- Khaled rung the door bell of his neighbour then escaped
2- Houda found a watch in the courtyard . she gave it to her teacher
3-I sharpen my pencil on the floor
4- I stand up on my chair in the classroom
5- When my neighbor is absent, I take care of his bird
6- Samir slept and left the radio on all the night

7-Said uses a pail of water and a sponge to wash his car

8- Farida left the water tap open when she was brushing her teeth

9-I found some money in the courtyard so I took them for myself

10- Salim was late at dinner but he didn't apologize.

- 40 pupils (~ 66 %) found 10 correct answers
- 13 pupils (~ 22 %) gave one wrong answer (5 pupils did the same mistake sentence 4 ,the others a different mistake)
- 6 pupils (~ 10 %)gave 2 wrong answers (5 of them chose the fourth sentence and another)
- 1 pupils (~ 2 %) made 3 mistakes

Distribution of pupils:

- p1..2,p4..5,p9,p11..12,p14..p17,p19,p21,p23..30,p33,p35,p37..39,p41,p43..44,p46..49
- p3,p7-8,p13,p18,p20,p22,p31,p32,p34,p42,p51,p54
- p6,p10,p36,p40,p50,p58
- p45

16-The pupils were presented with a strip cartoon (c.f. Appendix 1. Figure Ap.8). They were required to identify the morality of the story

- What do you learn from the following story?(they read alone ,understand and answer).). (**score: 2 pts)**

- 38 individuals (~ 63 %) answered correctly (26 said the aim was : playing with matches is dangerous; 12 said : don't leave children alone at home)
- 15 individuals (~ 25 %) had retold the story (i.e.they hadn't understood the question)
- 7 individuals (~ 12 %) gave a title to the story (correct titles)

Distribution of pupils:

- p1..2,p4..7,p10,p12..p13,p15..p17,p20..22,p24,p25,p28..29,p31..p35,p37..39,p41..42,p44, p51..53,p55..57,p59..60
- p8,p9,p11,p14,p18,p19,p26,p36,p40,p43,p45,p47,p54,p58
- p3,p23,p27,p30,p48..50

Discussion of tests of performance

Items 6:

Given one set of different geometric forms and colours (circles, squares and triangles), the question was to put in different sets, all those of the same form. Most of them identified the fact that for three different forms, they need three different sets. From chapter III, the concrete logical child moves from simple classification to multiple classification and class inclusion. From that, the notion of a set of elements is also acquired at this stage. That's why most of them succeeded in this item.

Items 7,8:

In these items, they had to reorder 8 numbers by increasing order and to complete a series of number (multiples of 5). Most of them succeeded to perform these two tasks. The seriation ability is acquired, and they understand well, the relationships between the members of the series. This result is in line with what is expected by the work of Piaget, and different other psychologists, from children at this age. Those who inverted the order did not really concentrate on the meaning of the word "increasing" and used the opposite significance.

Item 9: In his activity the pupils were asked to solve the mathematical equations which had been presented .

8+11= 5+(?)   25+25=(?)+50   12+(?)=24+4

At this age, most of the children do not use a systematic strategy (transferring the terms to the other side of the equation) to solve these equations. Most of them tried to use fingers or mental counting. The 16% of the pupils that have achieved only one question used fingers and because the two last equations have moderately biggest numbers for them they failed in their counting.

Items 10,11: In the first test, we have used a model that has already been used by the teachers inside the classroom. Five flowers on the board and each flower contains 4 petals, then we write

. O . = .

73% of the pupils understood what was going on. In this situation, only one possibility has to be considered, finding the global number of petals. More than 25% of the pupils did not respect the primary properties of all numerical transformations, ie they cannot add / subtract, divide and multiply two quantities only if they have the same dimension. Adding flowers to petals does not have any acceptable meaning.(petals are a sub-class of a larger class which is a flower)

In the next item, pupils were asked to solve a given problem, without any code use or information specification more than the written text To solve this problem, they needed to go through two steps: Only half of the pupils succeeded to synthesise the two steps.

Item 12: They were asked to look at two pictures of a classroom and say in which classroom they want to study. Almost all the pupils said in the first one(classroom) which was in order

Item 13: Pupils were asked to identify the normal or the abnormal situations; most of them succeeded in understanding and appreciating these situations. This helps to see whether they make a distinction between what is accepted by the morality and what is not. This gives a certain data about their social knowledge and their interaction with the society.

Item 14: When asked to link the figures and the sentences, pupils performed well. The two sentences, which were more ambiguous, were:

- I raise my finger to answer the question
- I give my teacher what I find in the courtyard

Most of the pupils have mixed the answers. For the picture that represents the pupil raising his finger, they thought that he was asking the teacher first to give her something.

Item 15: Pupils had to identify the wrong and the correct situations among those given. Repeated mistakes have been found in the performance of several children. Namely they failed to answer statement 4. (I stand up on my chair in the classroom) and statement 8 (Farida left the water tap open when she was brushing her teeth). For statement 4, it seems that they tried to answer quickly and have mixed between “stand up” and “sit down”. For statement 8, they were confused, because for them farida can leave the water tap open, since it is clear that they do the same when brushing their teeth.

Item 16: The pupils were required to identify the morality of the story (a strip cartoon). 63% of them succeeded to give the answer. It was not obvious for the pupils to isolate the aim from the general idea and some of them mixed the "morality of the story" with the concept of the title.

4.4. Memory links to intelligence:

As it has been exposed in chapter III, Scientists have shown that for one person the tests scores are correlated. The "correlation coefficient ", called "r" measures or estimates the degree of relationship between the two sets of scores. The value of "r" helps to know how well one of the tests can be used to predict the other.

4.4.a) Correlation between memory items and intelligence items

To analyse the correlation between the memory items and the intelligence items, we used Spearman rank correlation coefficient (c.f. Appendix:3).

This coefficient is given here:

$$r(X,Y)=1-(6^* \sum_{i=1,N}[rank(Xi)-rank(Yi)]^2)/(N^3-N),$$

X and Y are the observations (here the items)

N is the number of individuals that have been tested. In our tests N =60 (the number of pupils). and the general formula for the coefficient of correlation is:

$$r(x,y) = \sum_{x\,y} /(N^* \sum_x \sum_y)$$

where x = deviation of an x score from the mean score.

y = deviation of a corresponding y from the mean of the y scores

$\sum$ xy = sum of all products of deviations each x deviation times its corresponding y deviation

$\sum x \sum y$ = standard deviations of the sample distributions of x and y scores.

Alternatively, the Spearman ρ (rank) coefficient of correlation:

$6* \sum D^2/ [N (N^2 - 1)]$,

where 6 stands for the six steps in ranking and $\sum D^2$ = sum of the squared differences between ranks and N = number of squared measurements in the data.

From that we have the following tables:

	Item. 1.i	Item2i	Item3i	Item4i	Item5i	Item6i	Item7i	Item. 8i
Item1	0.7066	0.3914	0.5015	0.3944	0.4969	0.5796	0.5635	0.4678
Item2	0.6399	0.2423	0.3515	0.2494	0.3302	0.5588	0.4551	0. 2678
Item3	0.7753	0.4569	0.5286	0.3716	0.4248	0.6657	0.6789	0.5366
Item4	0. 6353	0.2585	0.4086	0.1965	0.3764	0.4177	0.5189	0.3207
Item5	0. 8454	0.6553	0.6454	0.4977	0.5966	0.6712	0.7057	0.6408
Item6	0. 5777	0.2573	0.3060	0.2007	0.3234	0.4212	0.4714	0.3190
Item7	0. 5184	0.3056	0.2845	0.1629	0.1819	0.4469	0.4861	0.3046
Item8	0. 5583	0. 3142	0. 3140	0. 2640	0. 2981	0. 4798	0.4409	0.3904
Item9	0. 5787	0.5360	0.3628	0.5882	0.2946	0.5074	0.2878	0.5571
Item10	0. 5589	0.4975	0.4913	0.6612	0.30	0.4564	0.3384	0.4782

Table 4.1.a Intercorrelation Matrix : *Correlation between Memory and intelligence items*

	Item.9i	Item10i	Item11i	Item12i	Item13i	Item14i	Item15i	Item16i
Item1	0.6173	0.4998	0.4148	0.7187	0.7187	0.5288	0.3677	0.4404
Item2	0.2972	0.2665	0.2481	0.6353	0.6353	0.3779	0.3085	0.2496
Item3	0. 5985	0. 4852	0.4336	0. 7916	0.7416	0.5276	0. 3939	0. 4517
Item4	0. 3318	0.2752	0.3102	0.6316	0.6316	0.4250	0.2922	0.1699
Item5	0. 6535	0. 6086	0.6286	0. 8649	0.8649	0. 6784	0. 5082	0. 6509
Item6	0. 4570	0. 2943	0. 2884	0. 5915	0.5915	0. 4576	0. 2736	0. 3201
Item7	0. 5523	0. 2501	0.1491	0. 5367	0.5250	0. 4069	0. 3091	0. 3849
Item8	0. 3136	0. 214	0.3148	0.5620	0.5620	0. 4310	0. 3095	0. 3909
Item9	0. 2977	0. 2836	0.2421	0.5992	0.5992	0.5120	0.4946	0.4342
Item10	0. 2874	0. 2854	0. 1705	0. 5827	0.5726	0. 4090	0.5588	0.3018

Table 4.1. b Intercorrelation Matrix : *Correlation between Memory and intelligence items*

Rationale

-From table 4, we can give some explanation and analyse these results on the basis of the score of the correlation coefficient “r”.

In order to do that, we first have to point out to the fact that r(X,Y) varies between –1 and +1, the interpretation of "r" values is given as follows:

- if "r" is close to 0, there is no correlation between X and Y
- if "r" is close to –1, there is a strong negative correlation between X and Y
- if "r" is close to 1, there is a strong positive correlation between X and Y

When we say that there is a strong correlation between X1 and Y1, this means that almost all the individuals who have had a good score in X1 have also succeeded to answer Y1.

Discussion and analysis:

- Intelligence **item 3i** which corresponds to "the retrieving of similarities and differences between the dog and the fox" is highly correlated with memory Items 3 and 5 (r:= 0. 5286 and 0. 6454). At 0.05 significance level,two-tailed test, the critical value of r with a number of 60 (the sample) is:0.26. since the obtained (observed) rs of 0.53 and 0.64 are much higher than the required r for significance,item 3i (intelligence) is highly correlated with memory items 3 and 5. It means that most of the pupils that succeeded in item 3i, did well in the memory items 3 and 5. The pupils' memory performance in these two tasks (ie: identifying the square in a set of forms and saying if there was an eagle or a car in an other set of pictures) are attributed to their good appreciation of the semantic features of the items and their ability to generate suitable and compatible cues for retrieving the contents of memory in a short time. This helps also to notice that their good semantic organization of information helps them to an easy identification of similarities and difference between the dog and the fox ant it is what has been exposed by theory in chapter 3.

- **Item 4i** (ie: link the verb with the right subject), is strongly correlated with memory item 9 (r = 0.58) and very highly correlated with item10 (r = 0.66). Both items are relative to the recall of story (The story was told with images). The comprehension of the text of the teller depends on different factors, namely those relative to the pupils' linguistic knowledge and those relative to the structure of the text. That is why it seems clear that most of the pupils who succeeded to link the right verbs with the right subjects have understood quickly the meaning of the words, which really helps when you listen to a story. It seems obvious that when there is no linguistic limitation the children perform well to understand and retain new information. It is also well correlated with memory item 5 (r = 0.4977 i.e., 0.50) since the children used the organisation of their memory when searching for the different concepts representing the subjects or the verbs they have to link.

- **Item 5i** (choose the letters of the word "cat" in a set of letters) is highly correlated with memory item 5 (r = 0.59), where the pupils had to say if there was an eagle or a car on the board. In fact, the pupils of this stage as it has been shown by Piaget and other scientists (see chapter 2) use successfully and almost systematically symbolic representation of concrete objects. Then they can hold in their mind a word and manipulate it. Here, they were asked to dissociate all the letters of the word while maintaining it by implicit rehearsal in their working memory. In **Item 5i**, they also used the same technique, they tried their best to remember by rehearsal all the pictures of the animals previously stuck on the board and when asked if there was an eagle or a car (verbal information), they brought from long-term memory the description (concepts) of these words and compared them with those already present in their working memory.

- **Item 6i**: recalling that the concrete stage children move from simple classification to multiple classification and class inclusion, the notion of a set of elements is also acquired at this stage. That's why most of them succeeded in this item. This item is highly correlated with memory items 2(r =0.56) , 3(r =0.67) and has a positive correlation with item 5 (r = 0.67). It seems that the children that have performed well in memory items 2, 3 and have a good observation faculties, they pay attention to small details and integrate quickly new information (since there was a new information in item 2, namely the colours of the circles). Another link with memory item 3 is that they manipulate the same objects, the geometric forms.

- **Item 7i**: This item concerns the reordering of 8 numbers (increasing order). At this stage, the children have completely developed a seriation structure, and have understood the development of the number concept. This item has a high correlation with item 4 (r =0.5189 or 0.52). When presented with the different circles (WRWRW) the children, who succeeded to keep in mind the right order (with or without the chunking method), had also performed well in item 7, their knowledge aptitude to deal with the notion of order seems to be strong enough.(all the items between 2 and 8 have positive correlations with item 7i , with 5 having a very high correlation with 7i as r = 0.71.)

- **Item 8i**: This item is highly correlated with item 3 (r =0.54), 5 (r = 0.64) and 9 (r = 0.56). It has been proved that in the first years of primary school when you ask a child to give the multiples of a number, she or he is *not* going to calculate them, but she/ he is aware that he already knows them and she/ he is going to bring them from his long-term memory. When faced with this sequence the pupil is going to remember and not to recalculate the other elements. She/ he will quickly move the information from long-term memory (identification of the multiples of 5) to working memory, as quickly as she/ he can. From the correlation with item 9, the only explanation we can give here is that they have understood that there was a logical link between the elements of the sequence, namely that they are multiple of 5, and that when they remember a story, they also have to quickly find a logical relationship between the sequence of events.

- **Items 9i, 10i and 11i:** For these items, it seems more complicated to give a direct interpretation. The analysis of the correlation shows that there are strong links between these items and item 5 (r = 0.65 for 9i, r =0.61 for 10i and r = 0.63 for 11i), which is a proof, as before, of the link of the performance to resolution of equations and mathematical problems with the organisation of knowledge in memory structure, both declarative and procedural memory. According to us, since the strategies of resolutions have been already seen with the teacher of mathematics, the pupils are relying more on their procedural memory (knowing how to perform an activity, (c.f. Chapter 1). Of course, their capacity to bring the information already stored in their long-term memory to their working memory and to manipulate it in this latter has been of a good help since they succeeded to answer these test items in a short time. That is why the correlation with item 8 (especially for item 9i and 11i, r=~0.31) is somehow positive, except for item 10i (r = 0.21).

- **Item 12i and 13i** are highly correlated with almost all the memory items (c.f.table 4.1.b). Since 59 pupils have given the right answers (a good appreciation of a simple situation). The children who succeeded in the different memory items are among these 59 pupils, that is why the correlation coefficients are high.

- **Item 14i:** It is highly correlated with item 5 (r = 0.68) and the reasons are the same as previously. It is also highly correlated with item 9 (r=0.51). The pupils who knew how to organize the links between the text of the teller and the images on the board, and then recall the story proved that their understanding of the story, relying on the good interpretation of the images on the board could help them to recall the story on the basis of what they kept in their mind, and the causal links were also able to link the sentences to figures.

- **Item 15i:** It has a good correlation with items 9 (r = 0.49) and 10 (r = 0.56). Of course, to identify the wrong and right situations, pupils have to remember, ie: bring from their long-term memory, the right concepts and description of events they already stored (in their procedural or declarative memory) to understand and then answer. This procedure is very close to what they did when they remembered a story, since they explored back their long-term memory to remember the story and to reconstruct the events. It is also highly correlated with item 5 (r = 0.51), since the children used for the two the organisation and the speed for the searching of concepts in their memory.

- **Item 16i:** To answer this item, pupils relied on their already acquired knowledge and previous experiences to give the morality of the story (strip cartoon). This item is correlated with item 5 (r = 0.65), but it is not only a matter of information organizing, it is also a matter of processing information abilities. Since the children after having understood the story had to isolate the main idea and keep in mind the most important concepts. In fact, we can notice that the children have not really understood the word"morality".

There are only two values of r (item 2 and 4) which are not positive, all the others 1, 3,5,6,7,8,9 and 10 have from only positive to good correlation.

This can be explained by the fact that items 2 and 4 are relying on categories that are not of the same level of those necessary to understand the morality of the story. In other words the colour of the objects used in both items 2 and 4 was of a major importance since it was the task required (finding the number of colours or giving the order of colours). In the strip cartoon the colours of the objects was useless to understand the morality of the story.

4.4.b) Links between memory and intelligence global scores

On the basis of the results of all the pupils in the two sets of items, we have decided to take a random sample of 10 pupils to analyze the relation between memory and intelligence.
The pupils selected (randomly) are : p3, p6, p11,p18,p26,p35,p40,p45,p48,p55

	p3	P6	p11	p18	p26	p35	p40	p45	p48	p55
Global memory Score	**19,5**	**15.75**	**15**	**17**	**12.25**	**16.25**	**12.5**	**4.75**	**14**	**18.5**
Global intelligence score	**15.75**	**13**	**12.5**	**15.25**	**10.5**	**17**	**11**	**5.25**	**11.5**	**16.25**

Table 4.2. *Memory and intelligence score for a random pattern of 10 pupils*

From the previous table, we can make different observations.

In General there is a strong correlation between the scores obtained by the pupils in the two sets of items. High scores in memory span tasks seem to predict some high scores in intelligence tasks. (except for pupil 45)

However, it is not because a pupil gets higher memory score than another one that we have to expect that the first one will have also a higher score in intelligence tests. See for example, pupils p3 and p35.But the general tendency is that there are strong correlations between global memory scores and global intelligence scores (c.f. table 4.2) In fact, memory abilities help to achieve the goal of intelligence tasks, but there is rarely a linear relationship between the two scores.

The result depends on the capacity of a test taker to solve the problem and it is not just a matter of information organizing, but it is also a matter of processing information abilities, which in general is helped by the already acquired knowledge and previous experiences.

SUGGESTIONS FOR PEDAGOGICAL IMPLICATIONS

After examining the results obtained in the experimental study designed in our research, and which put focus on the importance of memory in thinking and on the role of intelligence in our ability to store retain and retrieve data when needed, we can propose the following general suggestions:

Children, especially those who have difficulties in remembering the material studied at school, should be given the opportunity to rehearse it in the classroom through activities proposed by the teacher in a certain manner that they entail a kind of intelligent repetition to store better even the details. In other terms, teachers should rely on elaborative and deep rehearsal.

Since in many cases, different problems are concerned with the organisation of our knowledge in memory structure, for both declarative and procedural memory**,** teachers have to help the children to learn how to organise and structure the information they are faced with. They have to understand how they can structure their knowledge, using hierarchical and causal organisation.

When a new concept is studied, teachers may try to present it to the children by different ways, first a theoretical work followed by practical experiments. Then**,** they can ask the pupils to make some research on the subject and present a personal work in the classroom. This will improve and complete the definition of the concept and strengthen the different levels of their semantic and procedural memory.

Commentaire [NS1]: !:

The children have to enhance their vocabulary to reinforce their knowledge; this will help them to understand the texts and the terms used in the problems presentation. Teachers can give them as much as possible printed texts or stories, they have to read them and give their own interpretation of what they have read. It will make them explore back their long-term memory to remember the story and to reconstruct the events when discussing about the text

For concrete operational children, they have to understand system modelling as soon as possible since there is age related use of information in hierarchical and causal modelling. This cannot be explored with young children (less than six years).

The syllabus has to be renewed and should contain topics that motivate pupils. In addition to that, teachers should bear in mind that a moderate level of arousal (motivation) leads to a better result than too much motivation (a high level of arousal) or too less motivation (a low level of arousal).

- The syllabus should be highlightened ; given more time and less material, pupils would be able to make a better use of selective attention.

We hope that our suggestions could be a helpful hand for the pupils. Of course, teachers should adjust them to the learners and the learning situations.

GENERAL CONCLUSION

This study has been devoted to the investigation of cognitive development in Algerian children of ten and eleven years old. We have namely focused our analysis on their memorization and thinking capacities. The question that has been clearly asked here was: Do children who possess high mental abilities, in other words who are considered to be intelligent, own effectively good memorizing aptitudes?

To analyze the possible links between memory and intelligence, we have first presented the theoretical foundations and results on memory and intelligence studies that have been reported in the literature with some of the new findings on the links between these capacities. As we have said previously, we were not interested in the measurement of the intellectual quotient (IQ) of our children, but we have tried to find out if there exists a given relation between their capacity for memorization and their abilities to think.

For this purpose, we worked on the findings of some batteries of tests on memory and intelligence investigations on a group of sixty pupils of an Algerian primary school. The two random sub-groups of the same instructional level and of an equal size are constituted of boys and girls.

From the analysis of multiple correlation results between the two series of memory and intelligence items, we have derived some conclusions and remarks, which are in accordance with what was expected by theoretical studies.

Actually, intelligence performances seemed to have a strong relation with memory performances if we consider that: children who have a good semantic organization of information and a good organization of knowledge in memory structure, in both declarative and procedural memory, have performed well in many intelligence items.
But, for some other intelligence items, a good ability to generate suitable and compatible cues for retrieving the contents of memory in a short time was needed. That is to say, children who performed well in these items had good speed reaction, linked to their abilities to move the information quickly from their Long Term Memory to their Working Memory. It appears clearly that for some problem solving it is not just a matter of information organisation, but it

is also a matter of processing information abilities, which in general is helped by the already acquired knowledge and previous experiences.

To conclude, we can say that, in general, memory abilities help to achieve the goal of intelligence tasks, but there is no established linear relationship between children memory and intelligence scores.

This problem is still a wide open area for investigation. We tried to do our best with the present study to clarify as clear as possible the relationship between memory and intelligence for children of average ten years old. We hope that this small piece of research will be of some significance to investigation in the area. Our main concern was to bring some useful clarifications and we wish that the target objective has been reached.

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Appendix 1: Images used for memory and intelligence items

The following images have been used for the memory and intelligence tests

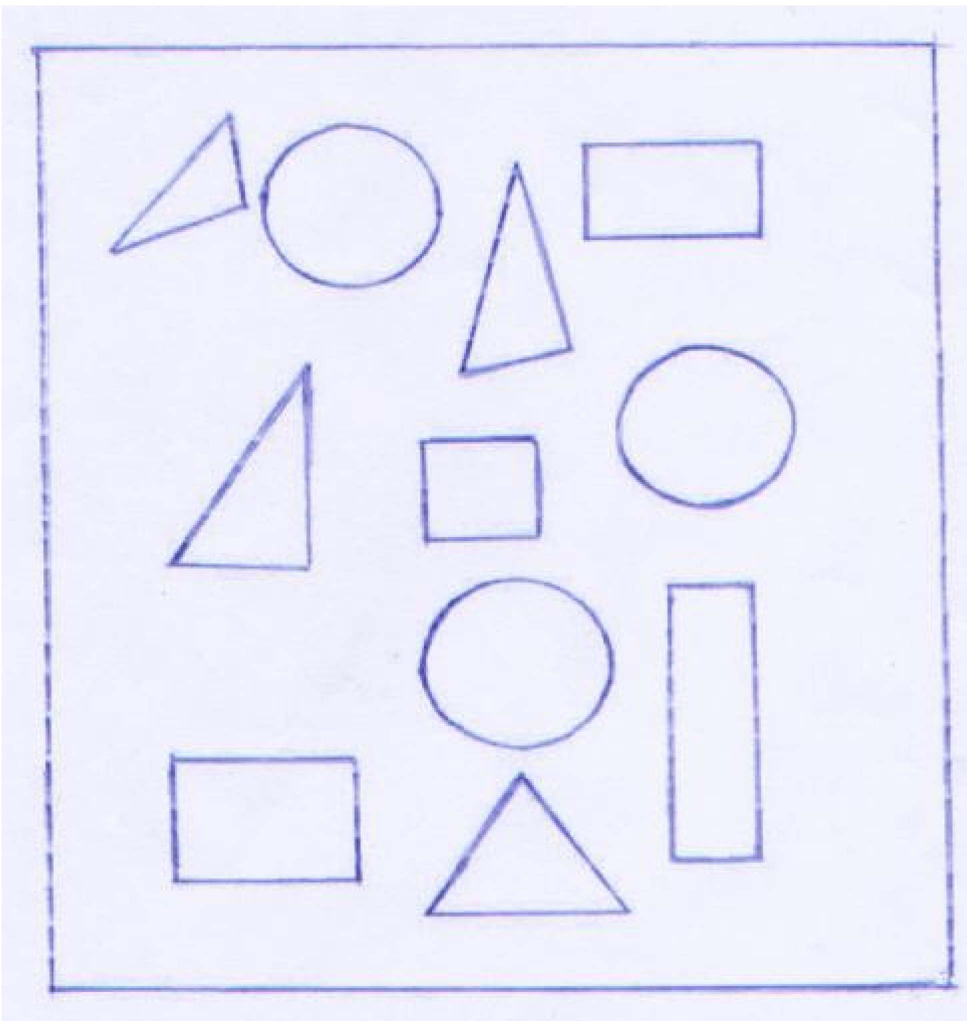

Figure Ap.1 : *Different geometric forms (memory item 3)*

Figure Ap.2 : *Images of different things and animals (memory item 5)*

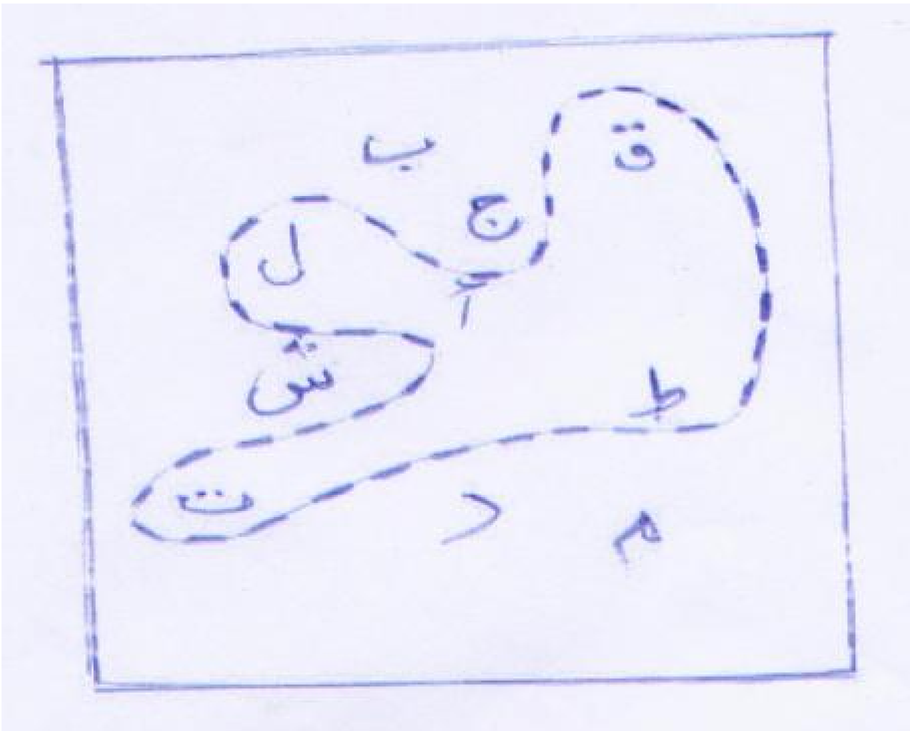

Figure Ap.3 : *Finding the letters of the word cat in a set of letters (intelligence item 5)*

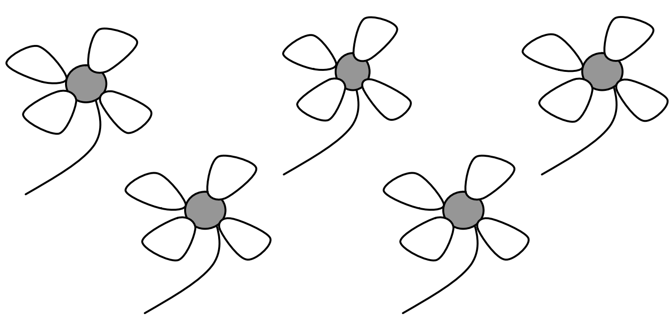

Figure Ap.4 *: The five flower (intelligence item 10)*

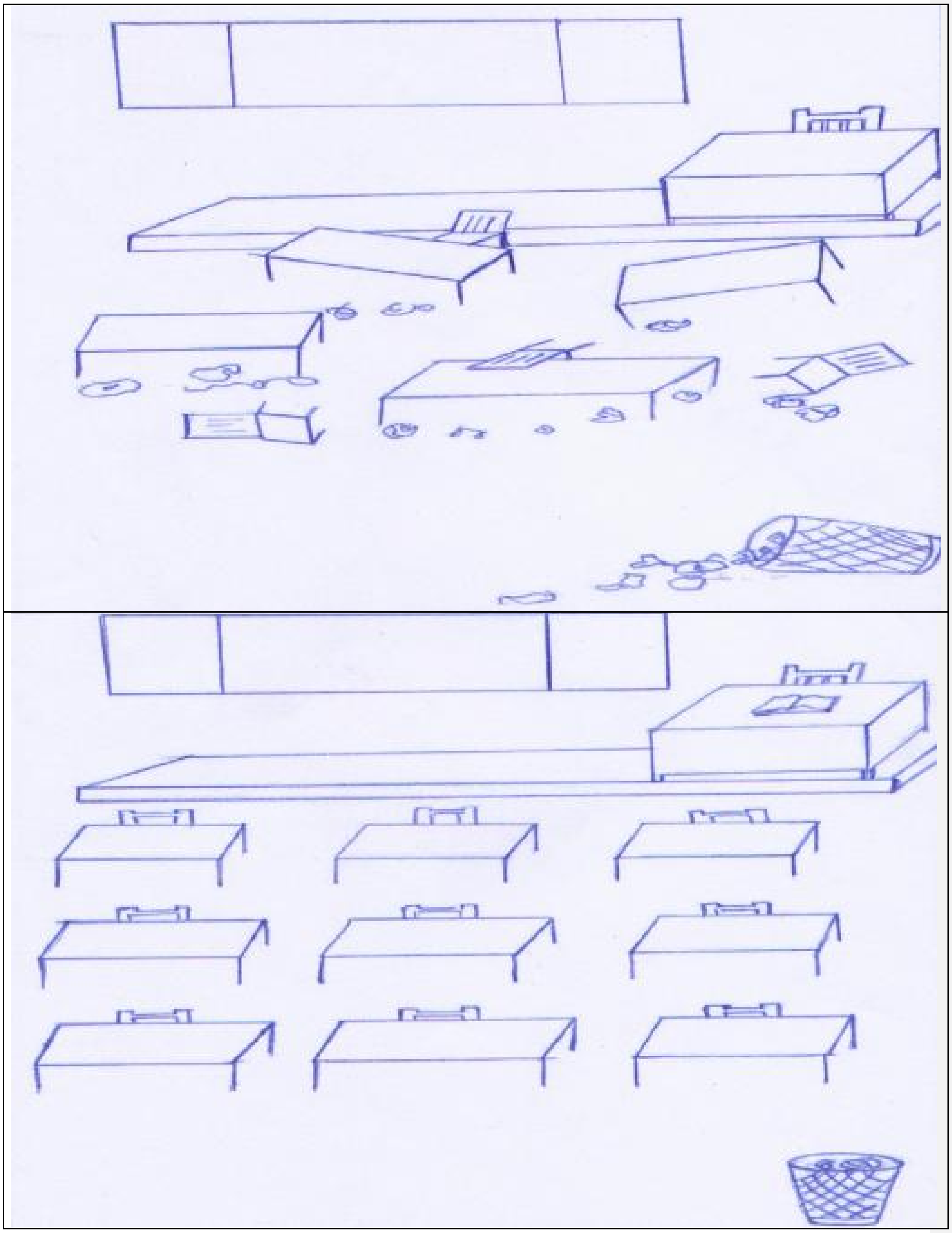

Figure Ap.5: *Choice of the classroom (Intelligence item 12)*

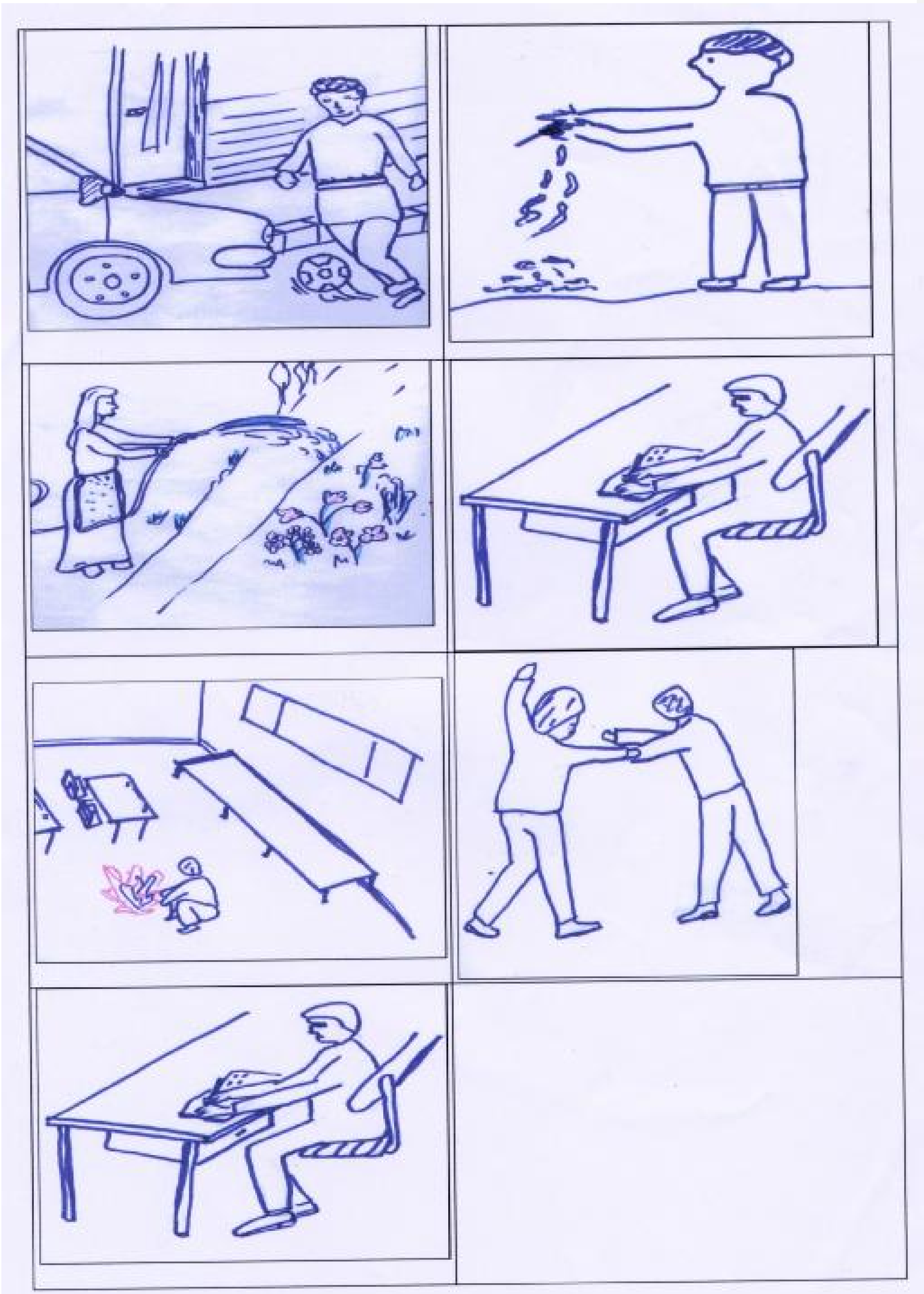

Figure Ap. 6 : Identifying the normal or the abnormal situations (intelligence item 13)

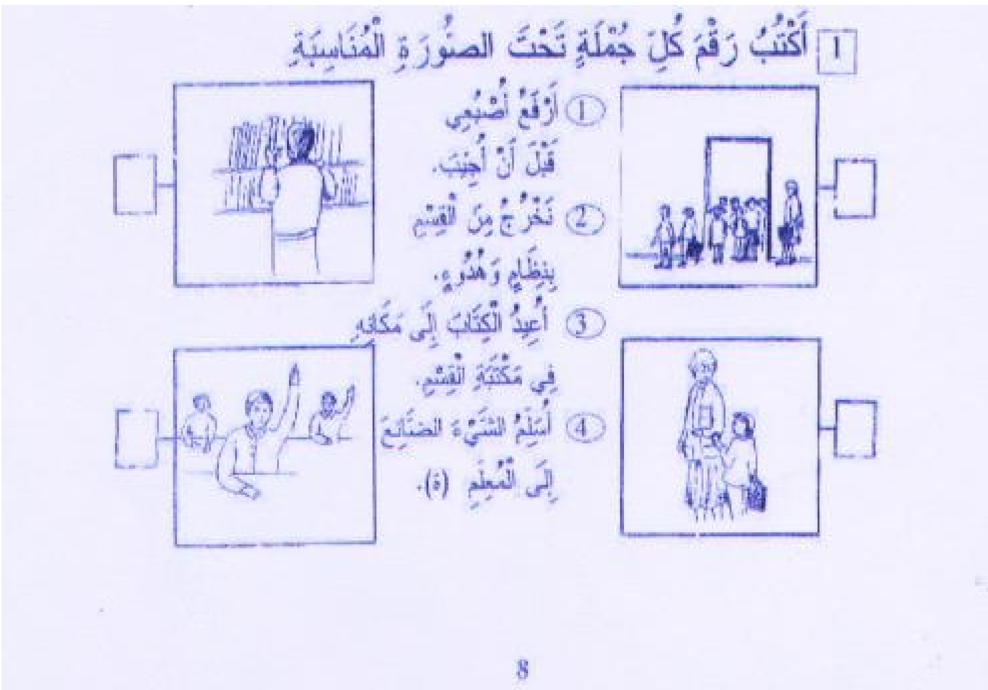

Figure Ap.7 *: Link the figures and the sentences (intelligence items 14)*

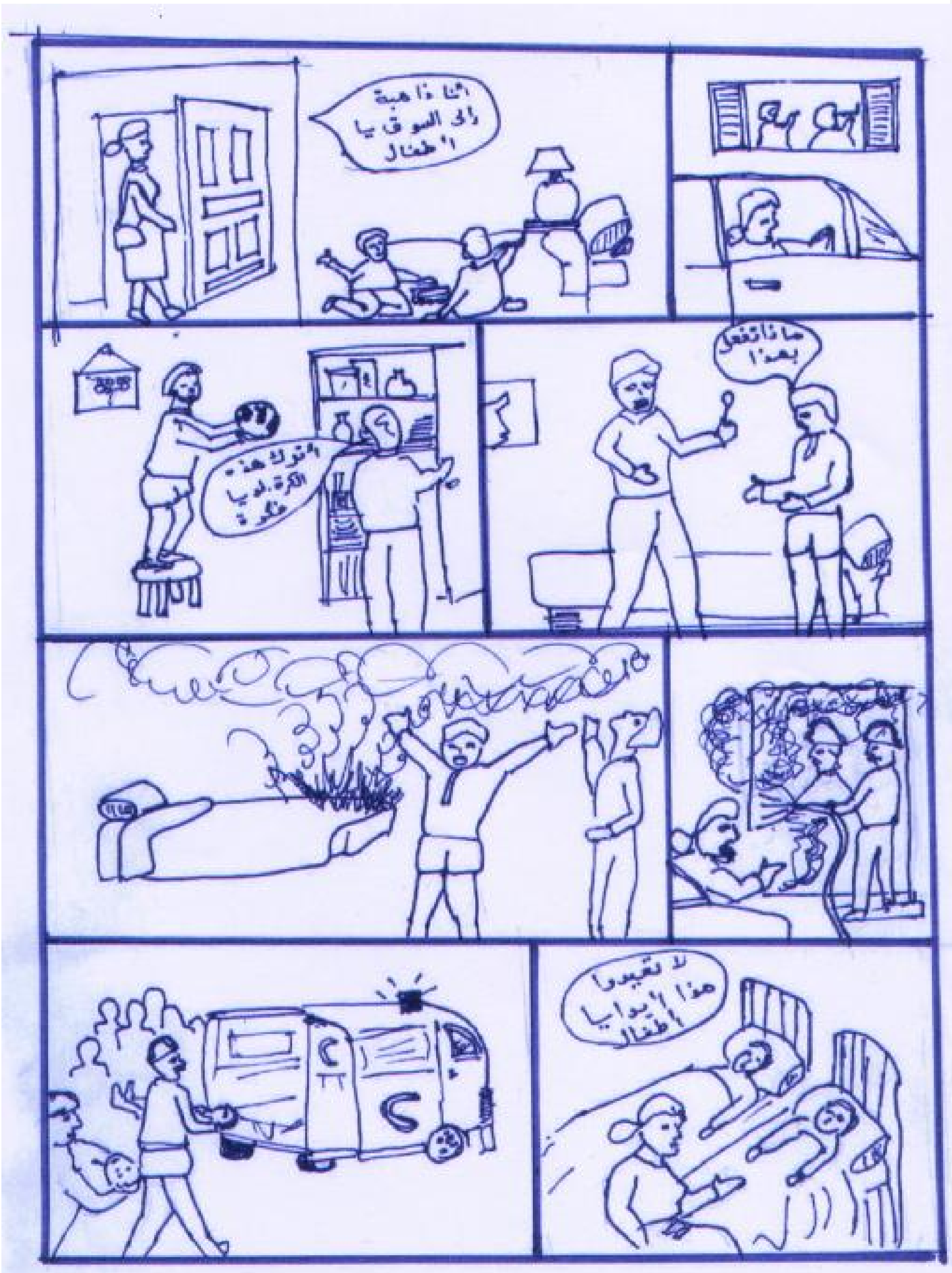

Figure Ap.8: Identifying the morality of the story (the strip cartoon: intelligence item 16)

Story 1: Little Tom Thumb (translated into Arabic) Once upon a time, there lived a very poor woodcutter and his wife; they had seven boys. The youngest was very little, and when born no bigger than one's thumb. They called him Little Thumb (petit Poucet).

One year, the woodcutter said to his wife, " I am resolved to lose them in the woods tomorrow; for, while they are busy, we can leave them." Little Thumb heard every word. He got up early and filled his pockets with small white pebbles, and returned home. They went into a thick forest. Their parents, slipped away from them without being seen, and returned home. When the children saw they had been left alone, they began to cry. Little Thumb said, "Don't be afraid, brothers. Father and mother have left us here, but I will lead you home again. Just follow me."

When they arrived home, their parents were extremely glad to see them, but when the money was all gone, they resolved to take them much deeper into the forest than before. Although they tried to talk secretly about it. Their father gave each of them a piece of bread, he fancied he might make use of this instead of the pebbles, by throwing it in little bits all along the way; and so he put it into his pocket. Their parents took them into the thickest part of the forest, then, they left them there. Little Thumb thought that he could easily find the way again by means of his bread, which he had scattered along the way; but he could not find it. The birds had come and had eaten every bit of it up.

Night now came on, and there arose a terrible high wind, which made them dreadfully afraid. Little Thumb climbed to the top of a tree, to see if he could discover anything. He saw at last a light, like that of a candle, but a long way from the forest. However, after walking he had seen the light, he perceived it again as he came out of the woods. They came at last to the house, they knocked at the door, and a woman opened it. Little Thumb told her they were poor children who had been lost in the forest. The woman, said to them, "Alas, poor babies, where are you from? Do you know that this house belongs to a cruel ogre who eats up little children?" "Ah! dear madam," answered Little Thumb "what shall we do? If you refuse to let us sleep here then the wolves of the forest surely will devour us tonight. We would prefer the gentleman to eat us, but perhaps he would take pity upon us, especially if you would beg him to." The ogre's wife, who believed she could hide them from her husband until morning, let them come in, and had them to warm themselves at a very good fire.

When he came in, the ogre asked if supper was ready and then sat down at the table. He sniffed, saying, "I smell fresh meat." His wife said, "You can smell the calf which I have just now killed and flayed." . "I smell fresh meat, I tell you". He got up from the table and went directly to the bed. "Ah, hah!" . With that, he dragged the children out from under the bed, one by one. He then took a large knife, sharpened it on a large whetstone which he held in his left hand. His wife said to him, "Why do it now? Is it not tomorrow soon enough?" you have so much meat already" . "That is true," said the ogre. "Feed them so they don't get too thin, and put them to bed." The woman offered them a good supper. The ogre, drank and went to sleep.

The ogre had seven little daughters. They had been put all seven in a large bed early, and each of them wearing a crown of gold on her head. The ogre's wife gave the seven little boys a bed just as large and in the same room. Little Thumb, who had observed that the ogre's daughters had crowns of gold upon their heads got up about midnight, and, taking his brothers' caps, put them on the heads of the little ogresses, after having taken off their crowns of gold.

The ogre awakened about midnight, he picked up his large knife. He then went, into his daughters' room. He came to the bed where the little boys lay. Feeling the crowns, he said, "That would have been a terrible mistake. Then he went to the bed where the girls lay. Finding the boys' caps on them, he cut all seven of his daughters' throats and he went to bed again to his wife. As soon as Little Thumb heard the ogre, he wakened his brothers and told them to follow him.. They kept running nearly the whole night, and not knowing which way they were going.

When he awoke, the ogre, went upstairs and asked his wife to follow him. "What have I done?" he cried. "Those wretches shall soon pay for this!". "Bring me my seven-league boots at once, so that I can catch them." .He went out, and ran this way At last he came to the very road Little Thumb hid himself and his brothers in a nearby rock, all the while keeping watch on the ogre.

The ogre was very tired and decided to take a rest. However, Little Thumb told his brothers that they immediately should run away towards home while the ogre was asleep . They took his advice, and soon reached home. Little Thumb pulled off the ogre boots gently and put them on his own feet. The boots were enchanted, they became little to fit the person who was wearing them. He went to the ogre's house and said :"Your husband," said Little Thumb, "is in very great danger. He has been captured by a gang of thieves You should give me everything he has of value, without keeping back anything at all, for otherwise they will kill him without mercy. The good woman, being sadly frightened, gave him all she had, for although this ogre ate up little children, he was a good husband. Thus Little Thumb got all the ogre' s money. He returned with it to his father's house, where he was received with great joy.

Story *2*: The Pied Piper of Hamelin (translated into Arabic)

Once upon a time, there was a small town called Hamelin where people were living in peace and happiness. One day, people there started to find rats in their houses. Soon later the rats were every where. They bit sleeping babies and stole all food. People became angry and asked the Mayor to solve the problem. While they were talking, a strange young man came into the room. He was carrying a pipe. He said to them, "If you give me a thousand guilders I will take away the rats away from Hamelin". Then, the Piper stepped into the street and began to play an unusual tune. At once, there was a noise like a marching army, and the rats came out of all the houses to follow the man. He took them to the river. There the Piper stopped but the rats ran into the river and died. When the young man asked for his money, the Mayor laughed and said: " We saw the rats drown; and what is dead cannot come to life again" . The Piper who was very angry replied: " If you don't pay me, you will hear another tune". All started to laugh. The young man stepped at the street again and started to play a soft sweet tune. All the children came running out of their houses to follow him happily. No one could stop them. The Piper took the kids to high hill where there was a wonderful door. When it opened, the Piper walked through the big door and the children follow him, and when they were all inside the door the mountain shut once more. The Mayer sent men north, south, east, west to pay the Piper as much money as he wanted if he brought the children back to Hamelin. But the young man and the children had gone for ever, and they were never seen again.

Appendix 2: Global Memory and Intelligence scores

PARTIAL AND GLOBAL MEMORY SCORES											
	Item1	**Item2**	**Item3**	**Item4**	**Item5**	**Item6**	**Item7**	**Item8**	**Item9**	**Item10**	**Global score**
p1	0,5	0,75	1,25	0	1,5	1,5	2,5	3	3,5	2,5	**17**
P2	0,5	0,75	1,25	1,5	1,5	2	2,5	2	1,5	2	**15,5**
P3	0,5	0,75	1,25	1,5	1,5	2	2,5	2,5	3,5	3,5	**19,5**
p3	0,5	0,75	1,25	1,5	1,5	2	2,5	2	1,5	2	**15,5**
p4	0,5	0,75	1,25	1,5	1,5	2	2,5	3	3,5	3,5	**20**
p5	0,5	0,75	1,25	0	1,5	2	2,5	1,5	3,5	3,5	**17**
p6	0,5	0	1,25	0	1,5	2	2	3	3,5	2	**15,75**
p7	0,5	0,75	1,25	1,5	1,5	2	2	1,5	2	0,5	**13,5**
p8	0,5	0,75	1,25	1,5	1,5	2	2	3	3,5	2	**18**
p9	0,5	0,75	1,25	1,5	1,5	2	1,5	1,5	3,5	3,5	**17,5**
p10	0,5	0,75	1,25	1,5	1,5	2	1,5	1,5	1	0,5	**12**
p11	0,5	0,75	1,25	0	1,5	2	1	3	2,5	2,5	**15**
p12	0,5	0,75	1,25	0	1,5	2	1	3	3,5	2	**15,5**
p13	0,5	0,75	1,25	0	1,5	2	1	3	3,5	2	**15,5**
p14	0,5	0,75	1,25	1,5	1,5	2	1,5	2	2	3,5	**16,5**
p15	0,5	0	1,25	0	1,5	2	1,5	1,5	1	2	**11,25**
p16	0,5	0,75	1,25	0	1,5	2	1	3	2	0,5	**12,5**
p17	0,5	0,75	1,25	0	1,5	1,5	2	1,5	1	2,5	**12,5**
p18	0,5	0,75	1,25	1,5	1,5	2	1,5	2,5	2	3,5	**17**
p19	0,5	0,75	1,25	1,5	1,5	1,5	1,5	3	3,5	3,5	**18,5**
p20	0,5	0	1,25	1,5	1,5	1,5	1,5	2	3	3,5	**16,25**
p21	0,5	0	1,25	0	1,5	1,5	1	3	1	2	**11,75**
p22	0,5	0	1,25	0	1,5	1,5	1	2,5	1	2	**11,25**
p23	0,5	0	1,25	1,5	1,5	2	2,5	3	3,5	2	**17,75**
p24	0,5	0	1,25	0	1,5	2	2	1,5	3,5	3,5	**15,75**
p25	0,5	0	1,25	1,5	1,5	2	2,5	3	3,5	3,5	**19,25**
p26	0,5	0	1,25	1,5	1,5	2	2,5	1,5	1	0,5	**12,25**
p27	0,5	0	1,25	0	0	2	1	3	0,5	3,5	**11,75**
p28	0,5	0	1,25	1,5	1,5	2	2,5	3	2,5	3,5	**18,25**
p29	0,5	0,75	1,25	1,5	1,5	1,5	2	3	1	2	**15**
p30	0,5	0,75	1,25	1,5	1,5	1,5	1	2	0	3,5	**13,5**
p31	0,5	0	1,25	1,5	1,5	2	2	3	1	0,5	**13,25**
p32	0,5	0	1,25	0	1,5	1	1	2,5	3,5	3,5	**14,75**
p33	0,5	0	1,25	0	1,5	1	2,5	3	3,5	3,5	**16,75**
p34	0,5	0,75	1,25	1,5	1,5	2	2,5	3	3,5	3,5	**20**
p35	0,5	0,75	1,25	0	1,5	2	0,75	2,5	3,5	3,5	**16,25**
p36	0,5	0	1,25	0	1,5	2	0,75	1	0	0,5	**7,5**
p37	0,5	0	1,25	0	1,5	2	2	2,5	2	2	**13,75**
p38	0,5	0	1,25	0	1,5	2	2	3	2	3,5	**15,75**
p39	0,5	0	1,25	0	1,5	1,5	0,5	3	3,5	0,5	**12,25**
p40	0,5	0,75	1,25	0	1,5	1,5	0,5	3	1,5	2	**12,5**
p41	0,5	0	0	0	1,5	1,5	0,25	1,5	3,5	3,5	**12,25**

p42	0,5	0	1,25	1,5	1,5	1,5	0,5	3	1	0,5	**11,25**
p43	0,5	0	1,25	1,5	1,5	1,5	0	1,5	3,5	2,5	**13,75**
p44	0,5	0	1,25	0	1,5	2	2,5	3	3,5	3,5	**17,75**
p45	0	0	1,25	0	0	1	0,5	1,5	0	0,5	**4,75**
p46	0	0	0	0	0	1	0,75	0,5	3,5	3,5	**9,25**
p47	0	0	0	0	0	1	0,25	1,5	3,5	3,5	**9,75**
p48	0	0	1,25	0	1,5	1	0,75	2,5	3,5	3,5	**14**
p49	0	0	0	0	0	1	0,25	1,5	0	0	**2,75**
p50	0	0	0	0	1,5	1	0,5	1,5	0	0,5	**5**
p51	0	0	0	0	1,5	1,5	0,5	3	3,5	3,5	**13,5**
p52	0	0,75	0	0	1,5	1,5	0	1	3,5	3,5	**11,75**
p53	0	0	0	1,5	1,5	1,5	1	3	3,5	3,5	**15,5**
p54	0	0	0	1,5	1,5	1	0,5	3	2	2	**11,5**
p55	0	0,75	1,25	1,5	1,5	2	2,5	3	3,5	2,5	**18,5**
p56	0	0	0	0	1,5	0,5	0	0,5	3,5	2,5	**8,5**
p57	0	0	0	0	0	1	0,25	0,5	3,5	3,5	**8,75**
p58	0	0	1,25	0	0	1	0,5	1	0	0	**3,75**
p59	0	0	1,25	0	1,5	1	1	2	3,5	2,5	**12,75**
p60	0	0	1,25	1,5	1,5	1,5	2	3	3,5	3,5	**17,75**

TableAp.1 .*Memory Scores*

PARTIAL AND GLOBAL INTELLIGENCE SCORES

	Item1	Item2	Item3	Item4	Item5	Item6	Item7	Item8	Item9	Item10	Item11	Item12	Item13	Item14	Item15	Item16	**Score global**
p1	0,5	0,75	0,5	1,5	2	0,5	0,5	1	1,5	1,75	1	0,5	1,75	1,5	1	2	**18,25**
p2	0,5	0,5	0,5	1,5	2	0,5	0,5	1	1,5	1,75	2	0,5	1,75	1,5	1	2	**19**
P3	0,5	0,5	0,25	1	1	0,5	0,5	0,75	1,5	1,75	2	0,5	1,75	1,5	0,75	1	**15,75**
p4	0,5	0,5	0,5	1,5	1,75	0,5	0,5	1	1	1,75	2	0,5	1,75	1,5	1	2	**18,25**
p5	0,5	0,5	0,25	1,5	2	0,5	0,5	1	1,5	1,75	1	0,5	1,75	1,5	1	2	**17,75**
p6	0,5	0,5	0,5	1,5	2	0,5	0	0,25	0	0	1	0,5	1,75	1,5	0,5	2	**13**
p7	0,5	0,5	0,25	1,25	2	0,25	0,5	0,75	1,5	1,75	1	0,5	1,75	1,5	0,75	2	**16,75**
p8	0,5	0,5	0,25	1,5	1,75	0,5	0,5	1	1	0	0	0,5	1,75	1,5	0,75	0	**12**
p9	0,5	0,75	0,5	1,5	2	0,5	0,5	1	1,5	1,75	1	0,5	1,75	1,5	1	0	**16,25**
p10	0,5	0,5	0,5	1,25	2	0,5	0,5	0	1,5	1,75	2	0,5	1,75	1	0,5	2	**16,75**
p11	0,5	0,25	0,5	1,5	2	0,5	0	1	0,5	0	1	0,5	1,75	1,5	1	0	**12,5**
p12	0,5	0,5	0,5	1,5	2	0,5	0,5	1	0,5	1,75	2	0,5	1,75	1,5	1	2	**18**
p13	0,5	0,5	0,25	1,25	1,5	0,5	0,25	1	0,5	1,75	2	0,5	1,75	1,5	0,75	2	**16,5**
p14	0,5	0,75	0,5	1,5	2	0,5	0,25	0,75	0	0	1	0,5	1,75	1,5	1	0	**12,5**
p15	0,5	0,5	0,5	0,75	1,5	0,5	0,5	1	1,5	1,75	2	0,5	1,75	1,5	1	2	**17,75**
p16	0,5	0,5	0,5	1	2	0,25	0,5	1	1,5	1,75	2	0,5	1,75	1,5	1	2	**18,25**
p17	0,5	0,5	0,5	1,5	1,5	0,5	0,5	1	1,5	1,75	2	0,5	1,75	1,5	1	2	**18,5**
p18	0,5	0,5	0,5	1,25	2	0,5	0,5	0,75	0,5	1,75	2	0,5	1,75	1,5	0,75	0	**15,25**
p19	0,5	0,5	0,5	1,25	2	0,5	0,5	1	0,5	0	0	0,5	1,75	0	1	0	**10,5**
p20	0,5	0,75	0,5	1,5	2	0,25	0,25	1	1,5	1,75	2	0,5	1,75	1,5	0,75	2	**18,5**
p21	0,5	0,5	0,25	1	1	0,5	0,5	1	1,5	1,75	2	0,5	1,75	1,5	1	2	**17,25**
p22	0,5	0,5	0,5	1,25	2	0,5	0,5	1	1,5	1,75	1	0,5	1,75	1,5	0,75	2	**17,5**
p23	0,5	0,75	0,25	1,25	1,5	0,5	0,5	1	1,5	0	1	0,5	1,75	1,5	1	1	**14,5**
p24	0,5	0,5	0,5	1,5	2	0,5	0,5	1	1,5	1,75	2	0,5	1,75	1,5	1	2	**19**
p25	0,5	0,5	0,5	1,5	2	0,25	0,5	1	1,5	1,75	1	0,5	1,75	1,5	1	2	**17,75**
p26	0,5	0,5	0,5	1,25	2	0,5	0,5	1	0	0	0	0,5	1,75	0,5	1	0	**10,5**
p27	0,5	0,5	0,5	1,5	2	0,25	0,5	0,75	0	1,75	0	0,5	1,75	1,5	1	1	**14**
p28	0,5	0,75	0,5	1,5	1	0,5	0,5	1	1,5	1,75	1	0,5	1,75	1,5	1	2	**17,25**
p29	0,5	0,5	0,5	1	2	0,5	0,5	0,75	0	1,75	1	0,5	1,75	1,5	1	2	**15,75**
p30	0,5	0,5	0,5	1,5	2	0,5	0,5	1	0,5	0	2	0,5	1,75	0	1	1	**13,75**
p31	0,5	0,5	0,5	1,25	2	0,5	0,5	1	1,5	1,75	2	0,5	1,75	1,5	0,75	2	**18,5**
p32	0,5	0,75	0,5	1,5	2	0,5	0,5	1	1,5	1,75	2	0,5	1,75	1,5	0,75	2	**19**
p33	0,5	0,75	0,5	1,5	2	0,5	0,5	1	1,5	1,75	1	0,5	1,75	1,5	1	2	**18,25**
p34	0,5	0,5	0,5	1,5	1,5	0,5	0,25	0,75	1,5	1,75	1	0,5	1,75	1,5	0,75	2	**16,75**
p35	0,5	0,75	0,5	1,5	2	0,5	0,5	1	1,5	0	2	0,5	1,75	1	1	2	**17**
p36	0,5	0,5	0,5	1,5	2	0,25	0,5	1	0	1,75	1	0,5	1,75	1,5	0,5	0	**13,75**
p37	0,5	0,75	0,5	1	2	0,5	0,5	1	1,5	1,75	2	0,5	1,75	1,5	1	2	**18,75**
p38	0,5	0,75	0,25	1,5	2	0,5	0,5	1	0,5	1,75	1	0,5	1,75	1,5	1	2	**17**
p39	0,5	0,75	0,25	1,5	2	0,5	0,25	1	0	1,75	2	0,5	1,75	1,5	1	2	**17,25**
p40	0,5	0,5	0,5	1,5	2	0,5	0,5	0,75	0	0	1	0,5	1,75	0,5	0,5	0	**11**
p41	0,5	0,5	0,5	1,5	2	0	0,25	1	1,5	1,75	2	0,5	1,75	1,5	1	2	**18,25**
p42	0,5	0,5	0,5	1,25	2	0,5	0,5	1	1,5	1,75	2	0,5	1,75	1,5	0,75	2	**18,5**
p43	0,5	0,5	0,5	1,5	2	0,5	0,5	1	0,5	1,75	2	0,5	1,75	1,5	1	0	**16**
p44	0,5	0,75	0,5	1,5	2	0,5	0,5	1	1,5	1,75	2	0,5	1,75	1,5	1	2	**19,25**
p45	0,5	0	0,25	1	1,5	0,25	0	0	0	0	1	0,5	0	0	0,25	0	**5,25**

p46	0,5	0,5	0,5	1,5	2	0,5	0	1	0	0	0	0,5	1,75	1,5	1	0	**11,25**
p47	0,5	0,5	0,5	1,5	1,5	0,5	0,5	1	0	1,75	2	0,5	1,75	1,5	1	0	**15**
p48	0,5	0,75	0,5	1,5	0,5	0,5	0,5	1	1	0	0	0,5	1,75	0,5	1	1	**11,5**
p49	0,5	0	0,25	0,75	2	0	0,25	0,75	0	0	0	0	1,75	1,5	1	1	**9,75**
p50	0,5	0,5	0,5	1,25	2	0	0	0	0	1,75	1	0,5	1,75	1,5	0,5	1	**12,75**
p51	0,5	0,75	0,5	1,5	2	0,25	0,5	1	1,5	1,75	2	0,5	1,75	1,5	0,75	2	**18,75**
p52	0,5	0,75	0,25	1,25	1,5	0,5	0,5	1	0	1,75	0	0,5	1,75	1,5	1	2	**14,75**
p53	0,5	0,5	0,25	1,5	2	0,25	0,5	1	0	0	2	0,5	1,75	1,5	1	2	**15,25**
p54	0,5	0,5	0,5	1,5	2	0,5	0,5	1	0	1,75	2	0,5	1,75	1,5	1	0	**15,5**
p55	0,5	0,75	0,5	1,25	2	0,5	0,5	1	0,5	0	2	0,5	1,75	1,5	1	2	**16,25**
p56	0,5	0,75	0,5	1,25	2	0	0,25	0	0	1,75	1	0,5	1,75	1,5	0,75	2	**14,5**
p57	0,5	0,5	0,5	1,5	2	0,5	0	1	0	1,75	0	0,5	1,75	1,5	1	2	**15**
p58	0,5	0,5	0,25	1,25	1,5	0	0,5	1	0	1,75	0	0,5	1,75	1,5	0,5	0	**11,5**
p59	0,5	0,5	0,5	1,5	1,5	0,5	0,5	1	0,5	1,75	2	0,5	1,75	1,5	1	2	**17,5**
p60	0,5	0,5	0,5	1,25	2	0,5	0,5	1	1,5	1,75	2	0,5	1,75	1,5	1	2	**18,75**

TableAp.2. *Intelligence Scores*

Appendix 3: Correlation analysis

The use of the rank correlation coefficient of Spearman is justified by the fact that this coefficient has been proved to be adapted to situations where the relation between the observations X and Y seems to be non-linear (and monotone) with exceptional values.

This coefficient is given here:

$$r(X,Y)=1-(6* \sum_{i=1,N}[Rank(Xi)-Rank(Yi)]^2)/(N^3-N)$$

Rank(Xi) : is the rank of Xi in the distribution X1.. XN

Rank(Yi) : is the rank of Yi in the distribution Y1.. YN

N is the number of individuals that have been tested.

The rank correlation coefficient vary between –1 et 1. The sign of “r ”give the direction of the relation between X and Y. Its absolute value give the intensity of the relation between X and Y. It means our capacity to predict the values of Y knowing those of X. Given the following example:

Child	**X**	**Y**	**Rank(X)**	**Rank(Y)**	**Rank(X)- Rank(Y)**	**[Rank(X)- Rank(Y)]^2**
A	31	50	1,5	1	0,5	0,25
B	31	55	1,5	3	-1,5	2,25
C	32	52	3	2	1	1
D	33	56	4,5	4	0,5	0,25
E	33	63	4,5	5	-0,5	0,25
F	34	65	6	6	0	0
G	35	69	7	7	0	0
H	36	90	8	8	0	0
I	37	110	9	9	0	0
J	38	150	10	10	0	0
$\sum$						4

The value 31 is repeated 2 times and occupies the rank 1 and 2 for X, then the rank of 31 is (1+2)/2=1,5

The value 33 appears 2 times and occupies the ranks 4 and 5 then the rank of 33 is (4+5)/2=4,5

Since the square of ranks differences is +4 and the number of individuals is 10 then we deduce the value of the Spearman correlation coefficient. All the calculations of the correlations are in a disc. You can consult this disc, if you feel the need to. r=1-[(6*4)/(1000-10)]= +0,98. We give in Table Ap.1 an example of calculation of the correlation between the memory item 1 and intelligence items (item.i.1 and item.i.2) .

pupil	Item 1	Rank1	Item. I.1	Rank2	Item.I.2	Rank3	$(Rank1-Rank2)^2$	$(Rank1-Rank3)^2$
p1	0,5	38,5	0,5	30,5	0,75	51,5	64	169
p2	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p3	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p4	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p5	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p6	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p7	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p8	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p9	0,5	38,5	0,5	30,5	0,75	51,5	64	169
p10	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p11	0,5	38,5	0,5	30,5	0,25	3	64	1260,25
p12	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p13	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p14	0,5	38,5	0,5	30,5	0,75	51,5	64	169
p15	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p16	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p17	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p18	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p19	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p20	0,5	38,5	0,5	30,5	0,75	51,5	64	169
p21	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p22	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p23	0,5	38,5	0,5	30,5	0,75	51,5	64	169
p24	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p25	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p26	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p27	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p28	0,5	38,5	0,5	30,5	0,75	51,5	64	169
p29	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p30	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p31	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p32	0,5	38,5	0,5	30,5	0,75	51,5	64	169
p33	0,5	38,5	0,5	30,5	0,75	51,5	64	169
p34	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p35	0,5	38,5	0,5	30,5	0,75	51,5	64	169
p36	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p37	0,5	38,5	0,5	30,5	0,75	51,5	64	169
p38	0,5	38,5	0,5	30,5	0,75	51,5	64	169
p39	0,5	38,5	0,5	30,5	0,75	51,5	64	169
p40	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p41	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p42	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p43	0,5	38,5	0,5	30,5	0,5	23	64	240,25
p44	0,5	38,5	0,5	30,5	0,75	51,5	64	169
p45	0	8,5	0,5	30,5	0	1,5	484	49
p46	0	8,5	0,5	30,5	0,5	23	484	210,25
p47	0	8,5	0,5	30,5	0,5	23	484	210,25
p48	0	8,5	0,5	30,5	0,75	51,5	484	1849
p49	0	8,5	0,5	30,5	0	1,5	484	49
p50	0	8,5	0,5	30,5	0,5	23	484	210,25
p51	0	8,5	0,5	30,5	0,75	51,5	484	1849

p52	0	8,5	0,5	30,5	0,75	51,5	484	1849
p53	0	8,5	0,5	30,5	0,5	23	484	210,25
p54	0	8,5	0,5	30,5	0,5	23	484	210,25
p55	0	8,5	0,5	30,5	0,75	51,5	484	1849
p56	0	8,5	0,5	30,5	0,75	51,5	484	1849
p57	0	8,5	0,5	30,5	0,5	23	484	210,25
p58	0	8,5	0,5	30,5	0,5	23	484	210,25
p59	0	8,5	0,5	30,5	0,5	23	484	210,25
p60	0	8,5	0,5	30,5	0,5	23	484	210,25
Corr « r »							**0,7066**	**0,3914**

TableAp.3. *Correlation between the memory item 1 and intelligence items (item.i.1,2)*

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RESUME

Dans le domaine de la psychologie cognitive, la mémoire et l'intelligence ont fait l'objet de recherches très avancées depuis le début du $20^{ième}$ siècle. Le modèle modal de la mémoire, donné par Atkinson and Shiffrin en 1968, présentant cette dernière comme divisée en trois sous-systèmes principaux (Le Registre Sensoriel, la Mémoire à Court Terme et la Mémoire à Long Terme) représente une des conceptions dominantes de la mémoire humaine dans le domaine, dès les années 1960. Néanmoins, les limites de ce modèle ont été dépassées quand les scientifiques ont reconnu à la Mémoire à Court Terme un rôle dominant dans l'apprentissage. En effet, c'est ainsi qu'est apparu avec Craik and Lockhart (1972), la notion de mémoire de travail décrite comme une partie spécialisée de la mémoire à long terme. Les études de A. Baddeley et G. Hitch, sur la mémoire de travail, ont apporté une description plus précise de ses différentes fonctionnalités.

L'intelligence, reconnue comme la capacité de l'être humain à apprendre et s'adapter à son environnement, apparaît comme étant en relation directe avec la mémoire. Si elle se manifeste par notre capacité à créer des liens entre des éléments, anciens ou nouveaux, les informations décrivant conceptuellement ces différents éléments se trouvent bien dans notre mémoire.

Le problème que nous nous sommes posé dans ce travail est le suivant : Quel est le lien entre la mémoire et l'intelligence ? Sommes-nous plus intelligents si nous avons de plus grandes capacités de mémorisation. Plus précisément, les élèves Algériens des écoles primaires sont-ils plus intelligents s'ils ont une bonne mémoire. Pour répondre à cette question nous avons mené un travail expérimental sur deux groupes de 30 élèves de 11 ans. En général, les résultats montrent qu'il y a une forte corrélation entre les notes obtenues par les élèves dans les deux jeux de tests de mémoire et d'intelligence. Des notes élevées dans les tests de la mémoire semblent prédire des notes élevées dans les tests d'intelligence. Cependant, il n'y a pas de relation linéaire entre les notes obtenues même si les capacités de mémorisation semblent faciliter grandement la réussite dans certains tests d'intelligence.

ملخص

تتناول هذه الأطروحة دراسة العلاقة بين الذكاء (القدرة علي التفكير و الاستيعاب) والذاكرة (القدرة علي التذكر و تخزين المعلومات) في اللغة الانجليزية ، وأهم العوامل المؤثرة علي ذلك فيما يخص تلاميذ المدرسة الابتدائية الذين تتراوح أعمارهم بين 10و11 سنة . اعتمدت الدراسة على وسيلة واحدة: تمرينين تطبيقيين (سلسلة تمارين حول الذكاء و مجموعة تمارين حول الذاكرة). نتائج البحث أكدت على وجود علاقة متينة بين الذاكرة و الذكاء و أن العوامل المؤثرة متمثلة في قدرة التلاميذ على تنظيم المعلومات في الذاكرة و استرجاعها لاستعمالها وقت الحاجة و إيجاد حلول لمسائل مختلفة في أقصر وقت ممكن.