# Investigating memory development in children and infantile amnesia in adults

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**Abstract**

Although many researchers have worked on memory development, still little is known about what develops in memory development. When one reviews the literature about memory, she encounters many types of memories such as short term vs. long term memory, working memory, explicit vs. implicit memory, trans-saccadic memory, autobiographical memory, semantic vs. episodic memory, flashbulb memory, verbal memory, and so many other types of memory which are intended to describe the memory processes. But can all these terms thoroughly explain what goes on in memory? Do these terms imply anything about the capacity of memory or about the role of language in memory development? If we could answer the questions about the memory capacity and the role of such factors as language in memory development, we might be able to find the answers to still more interesting and more challenging questions about memory, i.e., what actually develops in memory development and what causes the enigma of infantile amnesia. The purpose of the present research was, then, to find the solutions to the problem of infantile amnesia.

*Key words:* Infantile amnesia; memory capacity; memory development, retrieval

## 1. Introduction

The literature about memory is full of different classifications of memories (see, for example, Lust, 2006; Lightbown and Spada, 2006; Taylor, 2005; Hunt and Ellis, 2004; Levin, 2004), but none of them fully grasps the total picture of

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memory. For example, Levin (2004) elaborates on different types of memories such as recognition memory, visuo-spatial memory, trans-saccadic memory, object memory, perceptual information vs. conceptual information memory and so on. Furthermore, Goswami (2002) provides a relative comprehensive classification of memories including autobiographical memory, episodic memory, explicit vs. implicit memory, declarative vs. non- declarative, verbal memory, pre-verbal memory, non-verbal memory such as visuo-spatial memory, semantic memory, procedural memory, working memory, eyewitness memory, short-term vs. long-term memory, logical memory, strategic memory, spatial memory, voluntary vs. involuntary memory, serial memory, phonological memory, collective memory, rote memory, and recognition memory.

Although Goswami's classification is relatively comprehensive, but there are too many areas of overlap among the memory terms that she defines, so that distinguishing them from one another is very difficult. For example, Goswami (2002, p.128) first defines autobiographical or personal memory as "memories of specific events or experiences in which the individual has a sense of personal involvement. They make up one's life story or personal past", but then she classifies autobiographical memory as a type of episodic memory and considers episodic memory as a type of explicit memory and contrasts it with semantic memory which is a type of implicit memory; "whereas episodic memory concerns events and experiences that can be consciously retrieved, semantic memory refers to our knowledge of language, rules and concepts. In contrast, implicit or procedural memory represents a variety of nonconscious abilities, including the capacity for learning habits and skills, and some forms of classical conditioning"(Goswami, 2002, p. 239).

Regarding explicit and implicit memories, Nelson's definition is more tenable. According to Nelson (1995, cited in Siegler, 1998, p. 180), "explicit memories are ones that can be described verbally, that are conscious, or that can be visualized as a mental image", while implicit memories are ones that can not

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be detected directly, and that can be detected through physiological reactions without conscious attention.

Another classification of memories is provided by Schneider. Schneider (1999, cited in Goswami, 2002, p. 228) distinguishes between "episodic memory (the conscious recollection of events and experiences), semantic memory (our knowledge of language, rules and concepts), procedural memory (learning our unconscious abilities such as habits and skills), working memory (the ability to hold information to mind and operate on it), and eyewitness memory (the ability to provide accurate testimony)".

But what are all these types of memory for? Probably, they are intended to describe the memory processes. But, what are the memory processes that these terms try to explain? And, can all these terms thoroughly explain what goes on in memory? These are the questions that we seek to find answers for in the following sections.

## 2. Memory processes

For sure, memory is not a master-file to store our experiences to be retrieved later on in the form of a series of photographs or movies. Because if this was the case, the eyewitness in the law court would not have any problem in recounting what happened at the scene of the crime. But the fact is that our memory not only doesn't include all of our previous experiences but also it includes events that never happened. Therefore, we might conclude that our memory is a combination of our experiences and our imagination. But why is it so that we do not remember most of our previous experiences? And why is it so that children even remember less than adults? To answer these two questions, we must know about the three phases of memory, namely; encoding, storage, and retrieval.

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According to Siegler (1998), in the encoding phase we form two types of representations: *verbatim* and *gist*. Verbatim includes the details of the events, e.g. the exact words spoken, but the gist is the essence of the events, e.g. the meanings of the sentences rather than their exact words, and is, therefore, more durable in the memory than the verbatim. Siegler (1998) further reasons that adults don't remember their childhood because when they were encoding the information in their childhood, they paid more attention to the verbatim information than to the gist, and since verbatim is less durable in the memory they don't remember it anymore.

In the second phase, storage, after a child has successfully encoded and stored the information, some factors may cause her to forget the information, such as: 1. *Suggestibility*; when we ask children below six, leading (or sometimes misleading) questions they change their recall in directions consistent with the implications of the questions and forget their original information, 2. *Reality monitoring*; preschoolers can't distinguish what they imagined from what they really happened, and 3. *Time*; after one to two years, the accuracy of children's recall deteriorates considerably. (Siegler, 1998, pp. 176-7)

Siegler (1998) believes that in the third phase of memory, retrieval, the conditions under which children are asked to retrieve the information influences what they remember. For example, when a child is asked to *recall* the information from memory by asking such questions as "*where did you go last summer vacation?"* she might remember less than when she is asked *recognition* questions such as "*did you go to France last summer vacation?"* Also, repeating the same question from a child, often elicits different answers.

Now, by knowing the different phases of memory, how can one justify the difference between adults' and children's memories? This is the topic of the next section.

**3. The difference between Adults' and Children's Memories**

It is generally believed that adults can remember more accurately than children. According to Siegler (1998) there are at least four possible justifications for the difference between adults' and children's memories:

**1.** Adults have superior basic processes and capacities;
**2.** Adults know a greater variety of memory strategies;
**3.** Adults have greater meta-cognitive knowledge; and
**4.** Adults have greater content knowledge.

One important issue about memory is the capacity of working memory. Conway et al. (2003) claim that Working memory capacity and general intelligence are highly correlated. Others believe that memory capacity increases with age. For example, in an experiment, Bauer et al. (2000, cited in Goswami, 2002, p. 137) found that older children remembered more than younger children. In another experiment conducted by Pascual-Leone (1970, cited in Siegler, 1998), 5-year-olds could recall lists of four digits, whereas adults could recall lists with seven digits. That’s why Pascual-Leone (1970) proposes that "the absolute number of symbols that people can hold in working memory more than doubles from infancy to adulthood" (cited in Siegler, 1998, p. 188). However, Siegler (1998) believes that the absolute capacity of working memory is the same for young children and adults, but because of their greater knowledge about numbers and memory strategies such as rehearsal, adults can recall more digits.

Age is an important factor that not only influences working memory capacity but also affects long-term memory performance and causes the information to be retained longer in long term memory at older ages. According to Bauer (2008) in infancy, encoding and storage processes can account for age-related variance in long-term declarative memory. While in older ages, the age-related variability in long-term memory can be explained by storage and retrieval processes.

Hartshorn et al.'s (1998) research shows that the duration of retention increases monotonically between 2 and 18 months of age. Therefore, according to Hartshorn et al (1998) the capacity of memory increases with age.

Siegler (1998) asserts that children use strategies in encoding, storage, and retrieval phases even before their 2nd birthday. But why don't children use some helpful strategies such as rehearsal? According to Siegler (1998) there are at least two possible reasons: 1. Meditational deficiency; children don't use rehearsal strategy because using it doesn't lead them to recall more, and 2. Production deficiency; children don't choose to use rehearsal strategy even though it helps their memory. Because of these two deficiencies, training children to use strategies can not guarantee their continued use. Here, a reflective person might ask how, then, children decide which strategy to use?

Siegler (1998) claims children rely on their metacognitive knowledge to make such decisions. Beyond pre-school age, children possess explicit knowledge about memory. For example, they know that their memory is fallible and that they forget. But before school age, they have a kind of over-optimism about their memory capacity. For example, if you show a 4-year-old, ten pictures and ask her how many of them she can remember, she would say she can remember all of them.

According to Siegler (1998), toddlers and pre-schoolers possess implicit knowledge. For example, a 2-year-old child can monitor her use of language by correcting her mistakes in pronunciation, grammar, and naming of objects.

However, regarding the teachability of basic processes and metacognitive knowledge, Siegler (1998) contends that contrasted with basic processes which are difficult to change, metacognitive knowledge and skills are easily teachable; you can teach children rehearsal for rote memorization, or you can teach them how to monitor their comprehension. Besides, the more the children know about the content they are trying to remember, the more material they can

maintain in their working memory. Hambrick and Engle (2002) also found that preexisting knowledge has a strong facilitative effect on memory performance.

Goswami (2002, p. 239) asserts that "changes in basic memory strategies, metacognitive knowledge, and domain knowledge all contribute to developmental changes in memory performance". According to Siegler (1998), basic memory processes are present at birth, memory strategies appear later than basic memory capacities in the second year of life, rehearsal strategy appears between the ages of 5 and 7, implicit metacognitive knowledge is evident quite early among toddlers, while explicit knowledge about memory appears between the ages of 5 and 15, and content knowledge develops from infancy onward. But, if all these memory processes are present from early childhood, why don't adults remember most of their childhood experiences? Many factors may contribute to the retrieval and forgetting of our previous experiences. They will be discussed in the following sections under the titles of the "factors influencing retrieval" and "The enigma of infantile amnesia and its solution".

## 4. Factors influencing retrieval

Findings from different research show that the content of one's earliest autobiographical memories is influenced by a wide variety of factors including one's age, gender and culture, reinforcement and reminders.

In a study, Peterson et al. (2005) found that verbal memory is accessible from very early childhood but it disappears at later ages. Also, they found a difference between the type of memories that girls could retrieve and the type of the memories that boys could retrieve. In their experiment, girls recalled traumatic or transitional events while boys recalled play events.

About the role of gender in retrieval, MacDonald et al. (2000), comparing the memories reported by a group of men and women, found that women

retrieve more information. MacDonald et al. (2000) also found that culture is an influential factor in retrieving the information.

Another experiment conducted by Bauer et al. (2007) on a group of seven-to-ten year olds has shown that girls provided more complete narratives than boys. It has also shown that our early autobiographical memories may change in the course of time. Nevertheless, comparing the early and later memories, West and Bauer (1999) found few objective differences between the early and later memories of women and men.

Bauer et al.'s (2007) finding regarding transience of memory is consistent with Schmolck et al.'s (2000) findings that show original memory continues to change about one year after an experience. Schmolck et al.'s (2000) examined flashbulb memories in American students and fund that the quality of recollections of memory after 32 months was significantly different from the quality of recollections of memory after 15 months with many errors creeping into the memory accounts.

According to Neisser (1982), one of the factors that helps to have enduring memories is reinforcing the memories; fore example, flashbulb memory of the attacks on the world trade center is long lasting because it is constantly reinforced by the media.

Reminders are beneficial to retaining information in long-term memory for a longer period of time. Hayne (1990) after conducting a series of experiments on the effect of multiple reminders on long-term retention found that infants receiving a single reminder treatment forget the information after 7 days, but infants receiving two reminder treatments retain the information in their long-term memory for at least 14 days. When infants received three reminder treatments, although retention was excellent when infants were tested 1 day after the third reminder, retention after longer intervals was no better than that observed after a single reminder treatment.

Morgan and Hayne (2006) examined the effect of a single reactivation treatment on retention by 1- and 2-year-old human infants who were tested in the visual recognition memory paradigm. In their experiment, infants were familiarized with a visual stimulus and were tested after a delay. Without a reactivation treatment, infants of both ages forgot the visual stimulus but exposure to a reactivation treatment alleviated forgetting after the same delay.

According to Hsu et al. (2005) exposing individuals to an isolated component (a prime) of a prior event alleviates its forgetting. In their experiment, infants learned an operant task, forgot it, were exposed to the prime, and later were tested for retention. The data from their research reveal that the minimum effective prime duration equates the accessibility of forgotten memories.

Boller and Rovee-Collier (1994) found that reactivated memory is resistant to revision in new contexts after long delays. Accordingly, Hildreth and Rovee-Collier (2002) found that a reactivation treatment alleviates forgetting and doubles the life of the memory.

Hill et al (1987) tested fifty-five 6- to 7-month-old human infants' retention in a simple forgetting paradigm or in a reactivation paradigm. The results of their findings revealed that the efficacy of a reminder is predicted by the efficacy of that same stimulus in cuing the original memory 24 hours following training based on an operant conditioning procedure. Although the 6-month-olds learned more rapidly and remembered longer than infants half their age, their memory processing was described by the same basic principles.

Hildreth and Hill (2003) found that although increasing the training-reactivation interval enhances retention in 6-month olds, younger infants benefit more from memory reactivation. However, the data gathered by Hildreth and Hill (2003) reveals that increasing retrieval difficulty affects infants' retention of newly acquired and reactivated memories differently.

**5. The enigma of infantile Amnesia and its solution**

Infantile amnesia is defined in the encyclopedia of psychology (2001) as "the inability of human adults to retrieve genuine memories for events that occurred before about three years of age". (Cited from http://www.encyclopedia.com/doc/1O87-infantileamnesia.html). Goswami (2002, p.141) characterizes infantile amnesia by "(a) a relative paucity among adults of memories of events that happened before their third or fourth birthday…, and (b) a smaller number of verbally accessible memories from the years of 3 to 7 than would be expected based on forgetting alone".

There are different reasons for infantile amnesia or the lack of memory of our early years. One of the reasons mentioned by Hunt and Ellis (2004) is that in amnesia, episodic memory is impaired, while semantic memory is spared. Another justification is proposed by Siegler (1998) who mentions four causes for infantile amnesia: 1. passage of time, 2. immaturity of the frontal lobes of the brain which are responsible for memory; frontal lobes of the brain start to develop very late toward the end of the first year and during the first year they can only support implicit memories which don't require conscious thought and verbal descriptions, 3. having little social interaction during childhood, and 4. Incompatibilities between the ways in which infants encode information and the ways in which adults retrieve it; for example, adults try to retrieve the names of things they saw, while when they were infants they didn't tend to encode the information verbally. Still another reason mentioned by Howe and Courage (1993, 1997, cited in Goswami, 2002, p. 43) is the lack of a cognitive self-concept before the age of two.

Freud (1966, cited in Goswami, 2002, pp. 141-142) proposes that the memories formed by very young children are qualitatively different from those created by older children and adults, and asserts that childhood amnesia exists because adults fail to assemble fragments of events into a consistent narrative.

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According to Rovee-Collier and Hayne (1995), globality or locality of the information is a significant factor in retrieving it. Based on their study, local details are retrieved later than the global features. Furthermore, their study shows that memory retrieval is highly sensitive to the conditions present at the time of original encoding. Also, they reported a relationship between encoding and retrieval context, that is, changes in the context disrupt retrieval of the original memory.

According to Butler and Rovee-Collier (1989) changing the context disrupts retention in infants after 3 and 5 days. The results of their research revealed that not only contextual information is incorporated into the memory representations of very immature infants but also memory retrieval is highly specific to the context in which an event was originally encoded. This specificity buffers against generalized memory retrieval after long retention intervals.

In the studies with 3-month-old infants, Rovee-Collier and Dufault (1990) found that retention is disrupted when infants are trained in one context and tested in another, but not when they are trained in multiple contexts prior to testing in a novel context. Accordingly, Rovee-Collier and Dufault (1990) proposed that the contextual dependence of memory retrieval among adults can be alleviated by training in multiple contexts. The retention advantage of multiple learning contexts was observed after 3 days in a simple forgetting paradigm and after 14 days in a reactivation paradigm. However, their findings demonstrated that although the setting in which an event occurs is an important determinant of memory retrieval at 3 months, its protective function can be overridden by common experiences in varied settings.

According to Neisser (2003), there is no single developmental moment at which memory-relevant encoding begins, and remembering a childhood experience depends on the nature of the experience.

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Similarly, Usher and Neisser (1993) claim that the offset of childhood amnesia (the earliest age of recall) differs based on the type of the memory recalled. They found, for example, that the offset of childhood amnesia for hospitalization and sibling birth is age 2 while it is the age of 3 for death and move.

Usher and Neisser's (1993) claim is consistent with Bruce et al.'s (2005) research in that they observed that adults described and dated the first fragment memories (memories in the form of an image, a behavior or an emotion) substantially earlier in life than first event memories (episodic memories) – approximately $3\frac{1}{3}$ years of age for the first fragment memories versus roughly 4 years of age for the first event memories. Bruce et al. (2005) further contend that the end of the childhood amnesia is marked by the earliest remembered fragment memories, not by the earliest event (episodic) memories.

One important issue in measuring the children's memory is the consistency of different measures used by different researchers. How much the measures gained through different procedures are consistent with each other? The procedures that researchers adopt to measure infant memory may yield different results. In a series of experiments, Gross et al. (2002) systematically compared 6-month-old infants' performance across three procedures, i.e., mobile conjugate reinforcement, deferred imitation, and visual attention paradigms. They found that measures of memory obtained using the mobile conjugate reinforcement and deferred imitation paradigms were more similar than those obtained using the deferred imitation and visual attention paradigms.

Another important factor that influences retrieval of the information in the experiments conducted by different researchers is the way the researchers ask questions from the participants in the experiments. For example, Jack and Hayne (2007) show that the nature of the question used to elicit early memories influences the age from which memories are retrieved, and thus influences the boundary of infantile amnesia.

Brown and Kulik (1977) coined the term *flashbulb memory* to refer to one's personal memory for the details of a consequential and emotionally arousing event that are vividly recalled after a long time. For example, many American people can remember where they were when they heard of the attacks on the world trade center (cited from: http://en.wikipedia.org/wiki/Flashbulb_memory). Similarly, many Iranian people can remember what they were doing about 20 years ago when they heard of the death of the leader of Iran, Ayatollah Khomeini.

Recent studies on memory, largely conducted by biologists, emphasize the role of neurobiological mechanisms in infantile amnesia and also in retrieval. This group of biologists asserts that "the hormone cortisol, which is released in response to stressful incidents, cooperate with epinephrine (adrenaline) to cause the formation of flashbulb memories by the brain, functioning to help remembering things to avoid in the future" (cited from http://en.wikipedia.org/wiki/Flashbulb_memory).

Nelson (1998) in his paper namely "the nature of early memory" elucidates the neurobiological mechanisms that cause changes in memory and reasons that maturation of cortical areas in the temporal and frontal cortices that happens between the ages of 1 and 4 is likely responsible for infantile amnesia or for the lack of access to one's earliest memories.

Johnston (1997) reviews the literature about memory and mentions at least six possible factors that may cause infantile amnesia: 1. Repression of distasteful memories; 2. Neurological immaturity; 3. Lack of memory abilities in infancy; 4. Lack of ability to tell stories in infancy; 5. Lack of sense of self in infancy; and 6. Lack of a theory of mind in infancy.

Another factor which is believed to play a pivotal role in infantile amnesia is language development. Infants are thought to have nonverbal or preverbal memories. Simcock and Hayne (2002) conducted an experiment to test whether children could report their preverbal memories with the words that they learned

afterwards. But they found that children fail to translate their personal preverbal memories into language. Therefore, it can be concluded that since children encode the information in nonverbal mode, they can not retrieve in a verbal mode.

Although many of the causes of the problem of infantile amnesia and some of the solutions to this problem are known to us still more research is needed to uncover the mystery of the infantile amnesia and to provide us with a thorough understanding of all the possible solutions to the problem of infantile amnesia, and a complete appreciation of the mechanisms of the memory development and memory attrition.

## 6. Conclusion

Although diverse classifications of memory have been proposed by different researchers to account for different memory processes, none of them have fully grasped the total picture of the memory development in children and infantile amnesia in adults. However, it has been found that there are a number of areas in which children's memories are different from adults' memories: 1. working memory capacity; 2. long-term memory capacity; 3. data encoding procedures; 4. duration of data retention; 5. data retrieval procedures; 6. basic procedures and capacities; 7. variety of memory strategies; 8. meta-cognitive knowledge; and 9. content knowledge.

Furthermore, retrieving the content of our earliest memories is influenced by a wide variety of factors including age, gender, culture, reinforcement, reminders, reactivation interval, etc. Accordingly, there are different reasons for infantile amnesia such as: 1. passage of time; 2. immaturity of the frontal lobes of the brain which are responsible for memory; 3. having little social interaction, 4. incompatibilities between the ways in which infants encode the information and the ways in which adults retrieve it; 5. lack of the ability to

translate preverbal memory into verbal memory; 6. lack of the ability to assemble fragments of events into a coherent narrative; 7. locality of the information; 8. sensitivity to the condition present at the time of original encoding; 9. the difference between encoding and retrieval contexts; 10. the nature of the questions used to elicit early memories; 11. absence of reinforcement; 12. maturation of temporal and frontal cortices between the ages of 1 and 4; 13. repression of distasteful memories; 14. lack of sense of self; 15. lack of a theory of mind; and 16. lack of the ability to tell stories.

Seeking to solve the problem of infantile amnesia, experts in the field of memory proposed the followings as the possible solutions to this problem: 1. the physiological maturation of the frontal lobes of the brain, 2. hearing and producing stories about past events, 3. improved encoding of the gist of the events, 4. frequent reinforcement or reactivation of the past events, and 5. the release of the hormone cortisol.

However, more research is needed in this field to identify the other solutions to the problem of infantile amnesia and to elucidate the mechanisms of memory development and memory attrition.

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