

# *A 2-year-old Child's Memory of Hospitalization During Early Infancy*

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A child who had had surgery at 5 months of age, and who had been treated at the time for post-traumatic symptoms (reported in a previous paper by the author), was interviewed 2 years later and almost 3 years later to test for possible verbal recall of his hospitalization. He appeared to have some memories of the experience at 29 months of age, and he was able to superimpose verbal labels onto the preverbal memories. At 40 months of age, however, the memories were no longer verbally accessible. The results are discussed in the context of different theories of encoding, storage, retrieval, and loss of early memories. The findings from this study support other findings indicating that there appears to be some form of long-term memory in place early in life, at least for highly salient, traumatic events. There may be one memory system for traumatic memories, fully functional at birth, and a later developing, different system for neutral memories. It is further hypothesized that there may be a sensitive period around 2–3 years of age for the recall of early traumatic memories, and that verbal recall is more likely to be present in verbally precocious children during that period. Copyright © 2008 John Wiley & Sons, Ltd.

*Key words:* early trauma; early memory development; early language development

## INTRODUCTION

It was formerly believed that long-term memory was primarily verbal and that experiences occurring during the preverbal period could not be encoded in any retrievable form. However, there is considerable evidence from both experimental and naturalistic studies that memory does occur in the absence of language and is functional from very early in life.

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Experimental studies of preverbal memories have used several different paradigms in which infants are exposed to a laboratory event and later tested for recall at various time intervals. The paradigms include operant conditioning, novelty preference, behavioural recognition, deferred and elicited imitation, and speed of learning or relearning (Bauer, 2005, 2006; Hartshorn *et al.*, 1998; Herbert, Gross, & Hayne, 2006; Hill, Borovsky, & Rovee-Collier, 1988). These studies have found an age-related increase in infants' retention of laboratory events. By 12 months of age, recall of an observed action sequence, measured by deferred imitation, lasts for several months (Bauer, 2005, 2006).

The naturalistic studies involve the recall of traumatic incidents that occurred during the preverbal period, and the durations of recall reported are generally longer than those for laboratory events (Drell, Siegel, & Gaensbauer, 1993; Gaensbauer, 1995, 2002; Terr, 1988). For example, a child who suffered from symptoms of post-traumatic stress disorder (PTSD) because of an auto accident at 9 months of age was able to reenact the accident accurately through play during therapy sessions at 22 months of age (Drell *et al.*, 1993). In another study, a 35-month-old girl accurately reenacted with dolls the sexual abuse she had experienced before 6 months of age (Terr, 1988). Although play resembling earlier trauma is not proof of memory, the authors interpreted these play sessions as indicating possible memory of the events. In a study using recognition distress as an indication of recall, an infant who had been abused by his father between the ages of 3 and 10 weeks showed distress at the sight of men, but not of women, for many months thereafter (Gaensbauer, 2002).

Of particular theoretical and clinical interest is the question of later verbal accessibility of preverbal events. Several studies have found limited verbal accessibility. In one study, children were exposed to a specific laboratory event at 27, 33, or 39 months of age, and their language abilities were also assessed. In tests of verbal recall 6 and 12 months later, none of the children were able to describe the event with language that had not already been part of their vocabulary at the time of encoding, although they showed evidence of non-verbal recall (Simcock & Hayne, 2002). In a study of 20 children who had been traumatized before 5 years of age, verbal recall was not present for traumas occurring before 2½ years of age even though the children had behavioural memories, as evidenced by their post-traumatic play and trauma-specific fears (Terr, 1988). In studies of children who had been to the emergency room, and who were interviewed several years later, researchers have found very limited verbal accessibility of memories for visits that occurred before 2 years of age (Howe, Courage, & Peterson, 1994; Peterson & Parsons, 2005; Peterson & Rideout, 1998).

Other studies seem to contradict these results. Children exposed to several multi-step behavioural sequences at 20 months of age demonstrated verbal recall of the events at age 3 under certain conditions, and language skills at the time of exposure to these laboratory events were not predictive of later verbal report (Bauer, 2004; Bauer, Wenner, & Kroupina, 2002; Cheatham & Bauer, 2005). Factors that enhanced later verbal report included reinstatement and the use of physical props. However, there was no later verbal recall in children who had been younger than 20 months of age at initial exposure. In another study, 2-year-old children were able to use newly acquired colour labels to describe a laboratory event experienced before these words had been taught, indicating that verbal labels can be applied to preverbal memories (Morris & Baker-Ward, 2007).

There are also anecdotal reports of verbal recall for preverbal experiences. A striking example is the case of a verbally precocious 28-month-old girl who was able to verbally recall details of a painful hospital procedure carried out at 3

months of age. This memory was triggered by the sound of pounding next door, which apparently reminded the child of construction work going on in the hospital during her procedure (Bernstein & Blacher, 1967). Nelson and Ross (1980) reported instances in which 21- to 27-month-olds verbalized about events or objects they had experienced well before they were able to label them. Gaensbauer (1995) described memory for traumatic incidents that occurred in five children between 7 and 15 months of age. After the children's language abilities had developed sufficiently, they were able to superimpose verbal descriptions on the non-verbal representations in the context of therapy for their post-traumatic symptoms. There are also reports of young children verbally describing details of their own birth as soon as they acquire sufficient verbal skills, around 2–3 years of age (Chamberlain, 1998). These memories are eventually lost, but appear to be retrievable later on under hypnosis in older children and adults (Chamberlain, 1986), although this does not constitute proof of memory.

A problem with these anecdotal reports is that there is no way of knowing how much information the children have been given about the events. It is conceivable that some of these memories are reinstated ('kept alive') or even created by family members discussing the events with the children. If these reports are accurate, however, they indicate that verbal encoding is not a necessary prerequisite for later verbal accessibility, and that certain salient memories from very early in life can indeed 'cross the language barrier'.

Two different memory systems have been proposed (Mandler, 1990; Schacter, 1987). The implicit (non-declarative) memory system encodes and retrieves non-verbal perceptual and motor skills, while the explicit (declarative) memory system is responsible for the conscious recall of facts and events (Carlson, 1998). Explicit memory has been further divided into semantic memory (for facts) and episodic memory (for personally experienced events) (Bauer, 2007; Tulving, 2005). Studies of adults with brain lesions indicate that these various memory systems may have distinct neurological substrates (Carlson, 1998; Tulving, 2005).

The implicit memory system is hypothesized to develop first and to be functional during early infancy. Studies with infants have found that the explicit memory system begins to develop around 9 months of age and is fairly robust by the end of the second year (Bauer, 2006). Although the explicit memory system is not dependent on verbal encoding, it has generally been assumed that the ability to verbally recall either facts or personal events later on would be impossible unless the child had encoded them conceptually as an explicit memory (Bauer, 2006; Mandler, 1990; Peterson & Rideout, 1998). Furthermore, it has been argued that mental time travel (of which episodic memory is one aspect) emerges only around 3–4 years of age (Suddendorf & Busby, 2005; Tulving, 2005).

These developmental assumptions fail to explain the occasional findings of young children superimposing verbal descriptions on preverbal memories (occurring before 9 months of age) after the children attain verbal fluency. It has been suggested that there may not be a sharp boundary between implicit and explicit memory systems early in life, and that both kinds of memory are present early on (Gaensbauer, 1995, 2002; Howe, 2000; Rovee-Collier, 1997).

Another potentially useful distinction is between neutral and traumatic memories. Neutral, explicit memories are thought to be mediated primarily by neural pathways in the hippocampus, the temporal cortex, and the prefrontal cortex. The typical laboratory events used in memory studies are simple action sequences in settings that are presumably not traumatic for the infants. The

development of recall for these neutral events, as measured by deferred imitation, begins during the second half of the first year, and is associated with more efficient encoding and storage processes in the temporal–cortical network (Bauer, 2002, 2006, 2007).

It has been suggested that traumatic events are encoded and stored more effectively than neutral events, but still with the same memory processes that begin to mature during the second half of the first year (explicit memory) (Bauer, Kroupina, Schwade, Dropik, & Wewerka, 1998). Howe has proposed a continuous theory of memory development in which the mechanisms governing memory in infants are the same as those in older children and adults, and that autobiographical memory would be dependent, not on explicit memory development, but on the development of a cognitive self that emerges around 24 months of age. Specific memories would be enhanced, not by their positive or negative emotional content, but rather by their level of distinctiveness (Howe, 2000). Studies at all ages have shown that events that stand out from the background of one's previous experiences and knowledge are well remembered over time (Howe, Courage, Vernescu, & Hunt, 2000).

Another possibility is that traumatic events are encoded and stored *differently* than neutral events. While a child might not remember details of her day-to-day life during early infancy, highly arousing, traumatic experiences might be stored in a special way that makes them available for later recall. Terr (1988; p. 103) referred to 'burned-in visual impressions' when describing traumatic memories. Animal studies suggest that intense emotional memories are processed outside of the hippocampally mediated memory system and are difficult to extinguish (Van der Kolk, 1994), and studies of the neurobiology of trauma point to the amygdala as playing an important role in the storage of traumatic memories along with their accompanying conditioned fear responses, which account for the typical symptoms of PTSD (Carlson, 1998; Debiec & LeDoux, 2006; Tronel & Alberini, 2007).

## DESCRIPTION OF THE CASE

The present case study is a naturalistic investigation into a child's later verbal recall of surgery and hospitalization during early infancy. The subject, Michael, had been hospitalized for cranial surgery for 3 days at 5 months of age with no subsequent hospital visits. After the surgery, his symptomatic behaviours fit the diagnosis of traumatic stress disorder (TSD) according to the DC:0–3 (Zero to Three: National Center for Infants, Toddlers and Families, 1994). The therapy was implemented by the parents in consultation with the author, who specializes in coaching for parent/child therapy. The approach was based on an exposure therapy model (flooding) using a somatic trauma trigger that occurred spontaneously in the context of a normal care-taking routine (being placed in the supine position). The infant was allowed to have a full-blown emotional response during several treatment sessions with the parents in close physical contact. The outcome was positive, with disappearance of some symptoms of TSD after the first week, and no remaining symptoms after 2 months. His post-traumatic symptoms and treatment are described in a previous paper by the author (Solter, 2007). At the time of this memory study, Michael had no physical or emotional problems and was not in therapy.

This study differed from other investigations of infant trauma memories in that efforts were made from the time of the trauma to prevent the child from

acquiring any additional information about his hospital experience. Because of the author's intention to conduct a later memory study, the child's parents were requested to refrain from mentioning any specific details to him of his hospital experience, and to convey this request to the grandparents.

The original plan was to conduct an interview with Michael at 3 years of age. However, the plan changed because of his verbal precociousness. He uttered his first words at 8 months of age and spoke in complete sentences by 20 months of age. A first interview was therefore conducted when he was 29 months old, exactly 2 years after his hospitalization. A second interview was conducted 11 months later, at 40 months of age (almost 3 years after his hospitalization). After the first interview, the parents were once again requested not to discuss the details of their child's hospitalization with him. The interviews were conducted by the author with the child's mother present.

### *The First Interview*

This first interview took place when Michael was 29 months old (exactly 2 years after his hospitalization). I gave Michael a Curious George hospital set to play with, and we played together for a while, letting him lead the play. There did not seem to be any autobiographical material surfacing in his play. After the newness of the toys had worn off, I began the interview. My questions were guided by my knowledge of the details of his hospitalization and also by his own answers. Michael showed no signs of distress either during or after the interview. His answers were clear, immediate (except where indicated), and very matter-of-fact, as if he were talking about a recent visit to the zoo. Confirmation for Michael's statements was later obtained from his parents. The following is a transcript of the entire interview. The author is referred to as A., and Michael is referred to as M. Explanations in brackets follow his answers.

A.: Do you remember when you were in the hospital?

M.: When was I in the hospital?

[Michael's pronunciation of the word hospital was 'hostibal.' For purposes of clarity, standard spelling, rather than phonetic spelling, is used in the transcripts.]

A.: When you were a baby.

M.: Why was I in the hospital?

A.: You had to have surgery. Do you remember who was with you in the hospital?

M.: [After a brief pause, as if trying to remember.] Grandpa?

[Incorrect. 'Grandpa' refers to his paternal grandfather, who was not present with him in the hospital. He said 'Grandpa' with a clear questioning intonation.]

A.: Was Grandpa with you in the hospital?

M.: No.

[Correct.]

A.: Was Pappy with you in the hospital?

M.: Yes.

[Correct. 'Pappy' refers to his maternal grandfather.]

A.: Was Nanny with you in the hospital?

M.: Yes.

[Correct. 'Nanny' refers to his maternal grandmother.]

A.: Was Grandma with you in the hospital?

M.: No.

[Correct. 'Grandma' refers to his paternal grandmother.]

A.: Were Mommy and Daddy with you in the hospital?

M.: Yes.

[Correct. 'Mommy' and 'Daddy' refer to his parents.]

A.: Could you move when you were in the hospital?

M.: Yes.

[Correct.]

A.: Could you see when you were in the hospital?

M.: I couldn't see.

[On the second post-surgical day, both of his eyes were swollen shut for about 24 h.]

A.: Could you hear when you were in the hospital?

M.: [After a brief pause.] What did the doctor say?

A.: I don't know. I wasn't there. What *did* the doctor say?

M.: I couldn't understand.

A.: You couldn't understand what the doctor said?

M.: I wasn't listening.

A.: Was it a man doctor or a woman doctor?

M.: A man.

[Correct. His surgeon was male, and he did several follow-up visits in the hospital.]

A.: Did you eat or drink anything when you were in the hospital?

M.: I drank milk from my Mommy.

[Correct. He was breast-fed until the age of 11 months. During his hospital stay his only source of nourishment, aside from intravenous feeding, was breast-feeding.]

A.: Did you hurt anywhere? Did your foot hurt? Or did your tummy hurt? Or did your head hurt?

M.: My tummy hurt.

A.: Did you throw up?

M.: What's that?

[I asked Michael's mother to explain the term 'throw up' in a way that Michael would understand, so she explained the concept of vomiting, and sort of demonstrated.]

A.: So did you throw up in the hospital?

M.: I *did* throw up.

[Correct. He emphasized the word 'did.' On the second post-surgical day, Michael vomited after nursing for the first time since the surgery. He later vomited after being fed oral iron.]

A.: Did anything else hurt you? Did anyone hurt you?

M.: I had a shot.

[Correct. He was given several morphine injections in the hospital. Other needle insertions included heel sticks and an intravenous needle. At his 2-year pediatric examination, he had been given a vaccination. His word for that was 'a shot.']

A.: Did anybody sing to you when you were in the hospital?

M.: Pappy sang to me.

[Correct. 'Pappy,' his maternal grandfather, had indeed sung a song to Michael during the first night in the intensive care unit when Michael was very agitated.]

A.: Do you remember what he sang to you?

M.: Holy Night.

[Correct. The song his grandfather sang to him was 'Silent Night,' of which the first words are, 'Silent Night, Holy Night...'. Michael had heard the song since

then at Christmas time, but nobody had told him that his grandfather had sung that song, or any song, to him.]

A.: Was there anyone else?

M.: A woman.

A.: What did the woman look like?

M.: She was a hospital woman.

[Correct. He had been attended by several females in the hospital. During the first night in the intensive care unit, a very friendly and helpful nurse had done several things to make him feel more comfortable, and he had stared intently at her.]

A.: Do you remember what she was wearing?

M.: A red shirt and a scarf.

[Correct. The helpful nurse had indeed been wearing a red blouse and a red neck scarf, probably because of the Christmas season.]

A.: Did she sing to you?

M.: She sang to another baby.

[Unverified.]

A.: Do you remember the surgery? You were asleep so it probably didn't hurt.

M.: I dreamed about it.

A.: Were you happy or sad when you were in the hospital?

M.: I was happy. Sometimes I was sad.

[A period of play followed.]

A.: When we were talking about the hospital, you said that you couldn't see. *Why* couldn't you see?

M.: Because my eyes were closed.

[Correct. Both eyes had been swollen shut on the second post-surgical day.]

A.: Your eyes were closed?

M.: [Tapping on his closed eyelids with his hands.] I closed my eyes because they hurt, in the hospital.

### *The Second Interview*

The second interview took place when Michael was 40 months old (almost 3 years after his hospitalization). Michael's mother was again present. Small figures and other small toys were available. After he had played with the toys for a while, I began the interview with several direct questions, as for the first interview. Contrary to the first interview, Michael did not express any memory of the hospitalization, and he either ignored my questions or stated that he didn't know. At one point, he said, 'What hospital?' After about 15 min of fruitless direct questioning, I introduced a hospital play theme in hopes of triggering a memory, and he became eagerly engaged in the play. Here are some brief excerpts:

A. [Putting a miniature plastic baby in a crib.] Shall we pretend that's you in the hospital?

M. Yeah. Let's take the cars and trucks and get the ambulance, because that's what takes them to the hospital. [Finds a small ambulance.] This is the one who takes them to the hospital.

[He had not been taken to the hospital in an ambulance.]

[He then got caught up in his own fantasies and was easily distracted from the theme. The people who visited him in his play included several who had not been present (an uncle, an aunt, and a cousin), and toys that caught his attention stimulated play themes unrelated to the hospital experience (a fire truck, baby

bottles). When he introduced a hospital woman in his play, I asked the following question]:

A. Do you remember what the woman was wearing?

M. Yeah, look what she was wearing. [Indicates the female figure dressed in pink.]

A. Is this what she's wearing? But in your memory of what was she *really* wearing, do you remember what color she was wearing?

M. You mean when it really happened?

A. Yes. When it really happened. When you were really there. Do you remember what the woman was wearing?

M. No, but I think it was the same color.

[Later, we then had the following conversation]:

A. Did anybody sing to you?

M. No.

A. Last year you told me that Pappy sang to you in the hospital.

M. What did Pappy sing to me again?

A. You tell me. Do you remember what he sang to you?

M. No, he didn't. Nanny sang.

## DISCUSSION

There is a striking difference between the two interviews. In the first one, at 29 months of age, Michael appeared to remember specific details of his hospitalization at 5 months of age. He engaged willingly in the conversation and responded to the questions without any hesitation. His statements referred to multiple sensory modalities, including visual and auditory perceptions, body sensations, and emotional states. He appeared to remember correctly who had been with him, that he had been breast-fed, that he had had a 'shot,' that he had vomited, that he could not see because his eyes had been shut, and that his grandfather had sung a song to him. Perhaps most surprisingly, he correctly named the song that his grandfather had sung and stated the colour of a nurse's clothing.

In the second interview, at 40 months of age, Michael did not verbalize any memories of his hospitalization. He seemed to have forgotten the experience, including the specific details he had mentioned the previous year. Moreover, he seemed much more interested in his own fantasy play than in answering questions.

The hospital memories from 5 months of age appeared to be accurate and verbally accessible for this child at 29 months of age, but not 11 months later, at 40 months of age. These results cannot be attributed to the memories being reinstated by parents or other relatives because nobody had ever discussed the details of his experience with him.

Although there was no verbal reinstatement of the experience, it is possible that it was reinstated non-verbally in the context of everyday life. One of the trauma triggers for Michael was being placed in the supine position, which caused extreme distress. In the hospital, he had experienced several painful post-operative procedures in that position. By 7 months of age, all signs of protest in that position had disappeared. However, being regularly placed in the supine position for diapering could have reinstated the memory on a daily basis throughout infancy. It has been shown that periodic non-verbal



reminders can maintain early memories over significant periods (Rovee-Collier, Hartshorn, & DiRubbo, 1999).

The finding of long-term memory and verbal recall for an event occurring before 6 months of age conflicts with laboratory research indicating very little long-term verbal recall for events occurring before 20 months of age (Bauer, 2004, 2007), although it does support the finding that verbal encoding is not necessary for later verbal recall (Cheatham & Bauer, 2005). On the other hand, this study corroborates naturalistic findings of young children's apparent ability to later recall and verbalize memories of early traumatic events occurring during the first year (Bernstein & Blacher, 1967; Gaensbauer, 1995).

A possible conclusion from these seemingly contradictory results is that traumatic memories may be stored differently and earlier than neutral ones. During the evolutionary process, there would have been a biological advantage for traumatic events to be retained in memory to enhance the vulnerable human infant's survival in dangerous situations. Infants who acted sufficiently frightened when something triggered a trauma memory would have stood a better chance of attracting protective attention from their parents and therefore of surviving. As mentioned in the introduction, findings from the neurobiology of trauma indicate that traumatic memories are stored in a different part of the brain than neutral memories, with the amygdala playing a key role in the storage of traumatic memories (Carlson, 1998; Debiec & LeDoux, 2006; Tronel & Alberini, 2007, Van der Kolk, 1994). Early traumatic memories, because of their intense emotional content, would be readily retrievable as mental images and sensations, thereby rendering them available for later mapping of verbal labels, thus playing the same role as Bauer's use of three-dimensional props to trigger verbal recall (Bauer, 2004).

If one assumes that autobiographical (episodic) memory is dependent on a cognitive sense of self, this case study appears to contradict the assumptions that a sense of self does not emerge until 24 months (Howe *et al.*, 1994), and that true mental time travel (specifically the ability to remember the past using episodic memory) does not emerge until 3–4 years of age (Suddendorf & Busby, 2005; Tulving, 2005).

One possibility is that a concept of self, as well as episodic memory, is present much earlier in life than previously thought. However, it could be argued that the first interview did not actually reveal all of the components of true episodic memory. Michael did not spontaneously verbalize his experiences or tell the story of what had happened. Instead, his verbalizations were brief and entirely dependant on questions, even though he was capable of speaking in complete sentences. Apparent inconsistencies did not appear to bother him, such as stating that he could not see and then describing the colour of a nurse's clothing. Furthermore, when pressed for further explanations about his eyes being closed, he said, 'I closed my eyes because they hurt', indicating that he thought he had voluntarily closed them. There was no memory of the fact that his eyes had been forced shut (by tissue swelling). Thus, he appeared to remember that he could not see, but not how it happened. His explanation reflected his *interpretation* of the event based on his knowledge as a 2-year-old. This distinction corresponds to the differences between semantic memory and episodic memory as measured in other studies, in which young children's memory for facts is better than their memory for the context in which they were learned (Perner & Ruffman, 1995; Tulving, 2005). This finding also fits in with the theory that memory, even for traumatic events, is a reconstructive process (Howe, 2000). Perhaps he was able

to use his newly developed sense of self as a 2-year-old to give an interpretation and meaning to the salient sensory impressions in his memory.

Any theory of early memory must explain not only how preverbal memories are encoded, stored, and retrieved, but also the process by which these memories are eventually lost. In the present case study, the memories appeared to be recalled at 29 months old but not at 40 months old. A key theoretical question is whether memory loss is caused by storage failure or retrieval failure (Bauer, 2006). To use a computer analogy, a text document could become unavailable either because of a hard drive failure (storage failure) or software failure (retrieval failure). In the case of software failure, the information is still intact on the computer hard drive, but simply inaccessible.

Most adults' earliest memories are around 3 years of age, although there are large individual differences (Bauer, 2007). The cognitive development theory of infantile amnesia suggests storage failure as the root cause, due to immaturity of neural structures. There is considerable evidence from laboratory studies of neutral events to support this theory (Bauer, 2005, 2007). However, this theory does not account for the finding from the present case study, in which memory loss occurred *after* a period of long-term recall lasting for 2 years.

It is possible that storage failure occurred during the 11 months between the two interviews, perhaps through the process of neurological pruning, whereby unused neural connections in the brain simply disappear. The memory was not maintained either by verbal reinstatement with his parents or by being placed in the supine position for diaper changes at age 3 (because Michael was toilet trained by the date of the second interview).

Support for a retrieval failure theory for traumatic events comes from studies that have found behavioural recall and post-traumatic symptoms resulting from early traumas even though the children are unable to verbalize their experiences (Gaensbauer, 2002; Terr, 1988). It is possible that traumatic memories are permanently stored in the brain, even though they might not be available for verbal recall. An example of long-term memory storage of a traumatic early memory is the case of a woman who recalled an anxiety-producing image of her mother's miscarriage, but without understanding what it was. She had been 18 months old and the memory had lasted for 30 years (Sugar, 1992).

Two major retrieval failure theories have been proposed. Freud explained the phenomenon of infantile amnesia by his theory of repression, a process whereby people push painful memories into the unconscious in order to be able to function well in daily life (Freud, 1905/1953). According to this theory, the traumatic memory in the present study would have endured until the child's developing ego was strong enough to repress it.

Another retrieval failure theory suggests that the development of new cognitive structures, specifically language, produces a new 'lens' through which children process their experiences, making it increasingly difficult for them to access memories that were encoded before those structures had developed (Bauer, 2007). Although Michael already had good language skills at the first interview, it could be argued that his developing language skills between 2 and 3 years of age made it increasingly difficult for him to access the memory.

Whatever the reason for the apparent memory loss, the results from this study suggest the possibility of a sensitive period between 2 and 3 years of age for the conscious retrieval of early traumatic memories (occurring before 6 months of age). This would correspond to the development of brain regions involved in the retrieval of memories from long-term stores, notably the prefrontal and temporal

cortices. Interestingly, the prefrontal cortex reaches peak synaptic density by about 2 years of age, after which it declines (Huttenlocher, 1990).

If this is a universal stage, then only those children with sufficient language skills during this sensitive period would be able to verbally recall early traumas. Perhaps this is why there are so few reports of verbal recall by children of traumatic memories from early infancy. By the time most children become verbally proficient enough to talk about their past, the memories are no longer available. Michael was a verbally precocious child with sufficient language skills at 29 months of age to talk about the past. It is of interest to note that the 28-month-old girl who remembered a painful hospital procedure from 3 months of age was also verbally precocious (Bernstein and Blacher, 1967).

There are several limitations to the present case study. Some of Michael's correct answers in the first interview could have been 'lucky' answers (especially to the yes–no questions), or based on general knowledge rather than actual memory (for example, who was usually with him, how he was fed as a baby, what his grandfather usually sang to him, or what happens in hospitals). An additional control measure would have been to ask him about an event that did *not* happen.

While the first interview might have overestimated the child's memory, the second interview might have underestimated it. It is possible that he simply was not interested in talking about his hospital experience during the second interview. Asking him to draw about his experience might have elicited more verbal reports, as has been found in other studies (Gross & Hayne, 1998).

Another limitation is the difficulty inherent in all case studies, making any generalizations extremely tentative. The child in the present study might have been unusual in his ability to recall early events or to map verbal labels onto non-verbal experiences.

If the findings from this case study are an indication of accurate memory, this study supports other findings suggesting that some form of long-term memory system appears to be in place early in life, at least for highly salient, traumatic events. It also supports other studies showing that, under certain conditions, preverbal memories can 'cross the language barrier' and be available for later verbal recall. Further research is needed to confirm these findings, to determine whether the storage system for traumatic memories is mediated by different neural structures than those involved in memory for neutral events, and to clarify the factors that enhance verbal recall of preverbal memories.

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