British Journal of Anaesthesia **102 (3):** 379–84 (2009)
doi:10.1093/bja/aen404 Advance Access publication February 3, 2009

BJA

PAEDIATRICS

Does implicit memory during anaesthesia persist in children?

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Background. Recent studies suggest that implicit memory (especially perceptual implicit memory) persists during adequate general anaesthesia in adults. Studies in children, however, have failed to demonstrate implicit memory during general anaesthesia, possibly because of differences in methodological design. We therefore designed a prospective study with the aim of evaluating implicit memory in children undergoing general anaesthesia, using a perceptual memory test based on the mere exposure effect, previously tested in a control group.

Methods. Twelve infrequent neutral words were played 12 times in a random sequence via headphones to 36 children aged 8–12 yr during elective or emergency surgery. The children were not premedicated, and general anaesthesia was maintained with isoflurane. The word presentation started immediately after the surgical incision. Within 36 h after the stimulus presentation, the memory was assessed by using a forced-choice preference judgement task. Time constraint and word deterioration with a low-pass filter were used to prevent the subjects from utilizing intentional retrieval. The implicit memory score was obtained by calculating the proportion of target words preferred, which was compared with the chance level (0.5).

Results. The percentage of correct responses given by the children was comparable with the chance level. The memory score was mean (SD) 0.48 (0.16) (95% CI 0.43–0.53).

Conclusions. The use of a perceptual implicit memory test based on the mere exposure procedure in children failed to reveal any evidence of implicit memory under general anaesthesia.

Br J Anaesth 2009; **102**: 379–84

Keywords: anaesthesia, paediatric; memory

Accepted for publication: November 22, 2008

Implicit memory implies the influence of past experience on a person's performance or behaviour that does not require intentional or conscious recollection of a prior learning episode.[1] Procedures for the study of implicit memory are classified into two groups: perceptual and conceptual implicit memory tasks. This distinction is made on the basis of the task's processing demands: in the first group, the performance involves the analysis of stimulus form (e.g. the identification of a word masked in background noise, or the generation of a word from a fragment), whereas in the second group, the performance involves the analysis of stimulus meaning (e.g. the production of a category exemplar).

Early studies of implicit learning during anaesthesia in adults produced conflicting results because of the lack of standardization of the methodology.[2 3] However, recent studies with control of the depth of anaesthesia have furnished evidence that implicit memory persists in adults, even at an adequate level of anaesthesia.[4] Moreover, it has been suggested that only one form of implicit memory, perceptual implicit memory, persists during adequate general anaesthesia and can exist in the absence of

conscious awareness.[5] Nonetheless, the psychological consequences of implicit memory during anaesthesia on the subsequent state of the patients have still not been characterized.

Intriguingly, implicit memory during anaesthesia has not been systematically investigated in children. Few early studies demonstrated no evidence of learning during general anaesthesia in children.[6–8] Many reasons may explain these negative results, such as the lack of a control group, which is essential for the verification of the adequacy of the test to detect implicit memory, and the use of conceptual implicit memory tests that are known to be less persisting than perceptual processing during anaesthesia. Moreover, the use of benzodiazepines for premedication may have contributed to the absence of implicit memory.[9] A very recent study conducted in a large group of children that used an adequate perceptual implicit memory test pretested on a control group failed to demonstrate any evidence of implicit memory in the anaesthetized group.[10] Given these sparse findings, further studies with the application of different perceptual implicit memory tests are still needed before categorical conclusions can be drawn concerning the absence of implicit memory under general anaesthesia in children.

In an attempt to investigate the role of the type of test in the detection of implicit memory in children undergoing general anaesthesia, we designed a prospective study that involved a perceptual implicit memory task different from that applied by Andrade and colleagues.[10] Accordingly, we explored implicit memory during general anaesthesia in unpremedicated children admitted for elective or emergency surgery, through the use of a perceptual memory test based on the mere exposure effect, previously tested in a control group.

Methods

After approval by our University Hospital Ethics Committee and written informed consent from the parents and the children, we enrolled into the study 38 children, aged between 8 and 12 yr, ASA I or II, who had been admitted for elective or emergency surgery under general anaesthesia. Children who had a diagnosis of hearing defect, who did not speak French fluently, or who had a pathology that could affect cognitive functions were excluded from the study. In addition, we did not include any child undergoing adenotonsillectomy to preclude any hearing problem that may occur in these patients.

All the patients received acetaminophen 20 mg kg^{-1} 30 min before the operation. At the time of arrival in the operating room, the patients were monitored using ECG, pulse oximeter, non-invasive blood pressure monitor, and a precordial stethoscope. The induction of anaesthesia was left at the discretion of the anaesthesiologist with either mask induction with sevoflurane or i.v. induction with propofol depending on the child's preference and our routine practice. The airways were maintained by a laryngeal mask or a tracheal intubation (after the administration of atracurium 0.5 mg kg^{-1}). Analgesia and maintenance of anaesthesia were standardized in all children with the administration of fentanyl (up to 3 $\mu g\ kg^{-1}$) and isoflurane (1 MAC) in a mixture of 50% O_2 in air or N_2O. In some cases, regional anaesthesia was performed for the postoperative analgesia.

The task consisted of the presentation of spoken words immediately after the surgical incision, followed by a preference task testing the implicit memory of these words during a postoperative evaluation within 36 h after the presentation of the stimuli.

The stimuli comprised 36 neutral French words, which were nouns, verbs, or adjectives. They had similar lexical characteristics, the same length (three syllables), and a low but equal distribution of frequency of occurrence in the French language.[11] These 36 words were divided into three lists of 12 words. Each list was read out by a different woman. The sound level was normalized by using Sonic Foundry Sound Forge 4.5 (Sonic Foundry Inc.).

In the exposure phase, one list of 12 words was played to the children via headphones placed on their ears (the volume was identical for each child as it was adjusted during the pilot study), connected to a Compaq nx7010 personal portable computer, interfaced with E-Prime software version 1.0 (Psychology Software Tools Inc., Pittsburgh, PA, USA).[12]

The children were told that music would be played via their headphones during the operation and that an attentional test would be performed after their operation. The test was presented as an attentional task and not as a memory task. In this way it is possible to reduce the probability that the children consciously make a link between the two phases of the test, and thus reduce the use of conscious or intentional retrieval of the words. In the operating room, after the children had lost consciousness, headphones were placed on their ears. The presentation started immediately after the surgical incision. The words were pronounced slowly and were played 12 times in a random sequence that was different for each child, with a 2 s delay between each word. The duration of the task was 5 min. A psychologist, who was not involved in the anaesthesia management, was always present during the presentation of the words to ensure that it was performed without any interruptions. Three subject groups were formed in different versions of the test during this first phase, according to the three lists of words, each one pronounced exclusively by one voice (list I, voice 1; list II, voice 2; list III, voice 3).

In the test phase, a forced-choice preference judgement task was performed within 36 h after the presentation of the stimuli, when the children were comfortable enough to answer adequately. The children were first asked whether they explicitly remembered any intraoperative event. They were then presented with 12 pairs of words containing a target word (a word heard previously and pronounced by the same voice as during the exposure phase) and a