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Does Memory Priming during Anesthesia Matter?

THE article in this issue of A NESTHESIOLOGY by Iselin-Chaves et al.4 consolidates recent evidence that memory “priming” persists during adequate anesthesia. We are now in a position to move on from wondering whether memory priming happens during anesthesia to asking how much happens, under what conditions does it happen, and what is its impact on patients’ well-being. Research in psychology shows that even this very basic form of learning can have profound effects on behavior. Early studies of learning during anesthesia produced equivocal results with interpretation hampered by inconsistent methodology.2 An important recent development is the combining of careful memory testing with monitoring of intraoperative awareness or anesthetic depth. Iselin-Chaves et al. presented the repetitions of each stimulus word consecutively while recording the Bispectral Index (BIS), allowing estimation of the anesthetic depth at which each word was presented. They found implicit memory for words presented with BIS between 41 and 60. Implicit memory refers to memories that we are unaware of, that we cannot consciously recall or recognize, but that reveal themselves through changes in behavior. Implicit memory is often preserved after brain damage or experimental manipulations that abolish conscious recall.

The type of learning demonstrated by Iselin-Chaves et al. is actually very limited. If human memory is conceptualized as a network of nodes representing different pieces of information, the simplest form of learning is temporary activation of a single node, known as perceptual priming because it facilitates subsequent perception of stimuli against background noise or, as here, from fragments such as word stems. Spread of activation to related nodes (e.g., tractor → farm) is known as conceptual priming because it facilitates perception of, or responding with, conceptually related information. Conceptual priming is prevented by adequate anesthesia.3

In contrast, perceptual priming seems to be preserved during anesthesia.5 Lubke et al.4 showed enhanced word stem completion performance for words presented during trauma surgery with isoflurane, with BIS between 40 and 60. The study by Iselin-Chaves et al. extends these findings to elective surgery with isoflurane. We found and then replicated word stem completion priming during elective surgery with relatively deep propofol anesthesia (median BIS = 42 and 405–6). Perceptual priming thus seems to be a general feature of anesthesia, not a peculiarity of a particular anesthetic technique.

The findings are still mixed, however. Kerssens et al.7 tested patients undergoing elective surgery and used a word stem completion task but found no evidence for priming during BIS-guided propofol anesthesia. They suggested that maintaining a constant anesthetic depth prevents priming. In the study of Iselin-Chaves et al., moments of light anesthesia just before or after presentation of a particular word may have facilitated priming, but this explanation does not apply to our own demonstration of priming.8 We found priming even in a retrospectively selected subgroup of patients for whom BIS happened to remain below 60 throughout word presentation. The evidence for priming during anesthesia is not simply an artifact of inadequate depth control.

It is generally true, though, that memory activation is more likely with lighter anesthesia. It is more likely to occur with opiate-based techniques than with volatile anesthetics that produce deeper hypnosis,5 and it does not occur when BIS is less than 40.1,4 The exact relation between priming and depth is not clear. Lubke et al.4 found a significant although not very strong linear relation between priming and anesthetic depth at which words were presented. However, the measure of memory used in this analysis included explicit as well as implicit components. Using a measure specifically of implicit memory, Iselin-Chaves et al. found as much memory for words presented during anesthetic depths of BIS 41–60 as for words presented to volunteers receiving no anesthesia (and no surgery). Their inclusion of a group of awake participants is interesting because it raises the question of whether priming during anesthesia is a mere shadow of priming activity in the conscious brain or whether perceptual priming is insensitive to all but the most extreme manipulations of brain function. Their finding suggests that a sudden decrease in perceptual priming occurs when anesthetic depth decreases below BIS of 40, but until then, it is unaffected by the transition from consciousness to unconsciousness.

Another factor affecting memory priming is the presence of surgical stimulation. The sudden increase in concentrations of circulating catecholamines caused by surgery may enhance any residual memory function via the amygdala.5,9 Fear conditioning occurs in the amygdala,10 as does enhancement of memory consolidation during emotional events or when experimental applica-
tions of norepinephrine mimic natural stress.\textsuperscript{11} We
found no evidence for priming when words were pre-
sented during anesthesia but before surgery, but signifi-
cant priming at equivalent anesthetic depth during
surgery.\textsuperscript{5} Most stimulus presentation in the study of
Iselin-Chaves \textit{et al.} was completed before surgery began,
making their priming effect more impressive than it
might seem at first glance.

Therefore, some memory function persists during clin-
cally adequate anesthesia. Patients do not learn new
information or even new associations between already
familiar information. All that happens is slight activation
of existing representations of words in memory detect-
able on a carefully designed memory test. Given that
patients are unlikely in everyday life to be asked to
complete memory tests, is this any cause for concern?
Research in psychology suggests it may be, showing
profound effects on behavior of even this very rudimen-
tary memory activity. In what has become a classic
experiment, Bargh \textit{et al.}\textsuperscript{12} asked participants to rear-
range word lists into sentences. When the lists included
words relating to the concept of old age (\textit{e.g.}, conserva-
tive, wrinkle), participants subsequently walked away
from the laboratory more slowly than participants ex-
posed to neutral words, even though they had not no-
ticed the repeated occurrence of references to old age.
Conversely, priming of the concept of professor im-
proved performance on a test of general knowledge.\textsuperscript{13}

Physiology is not immune to these priming effects: Hull
\textit{et al.}\textsuperscript{14} found that subliminal exposure to an “angry”
prime increased blood pressure relative to exposure to a
“relax” prime.

You can only prime behaviors that are likely to happen
anyway. Surreptitious exposure to words related to
speed led to better performance on a timed test of
intelligence than exposure to neutral words, but only
when participants already had the goal of working quick-
ly.\textsuperscript{15} People poured themselves a larger drink, and drank
more of it, after subliminal presentations of smiling faces
compared with angry faces, but only if they were already
thirsty.\textsuperscript{16} Subliminal priming of the concept “blacks” led
white participants to form a more negative impression of
someone described verbally, but only if they already had
high levels of prejudice.\textsuperscript{17}

These laboratory studies show that priming of con-
cepts in memory, occurring without participants’ aware-
ness, can affect behavior in many ways, making people
seem slower, thirstier, more prejudiced, or more intelli-
gent. Iselin-Chaves \textit{et al.} have shown that priming can
still happen when patients are anesthetized. Comments
made in the operating room about a patient’s prognosis,
appearance, or state of consciousness could exacerbate
their existing anxieties about the operation, about them-
sewels, or about the anesthetic and may contribute to
postoperative anxiety, depression, and insomnia even in
patients with no explicit recollection of surgery.

Jackie Andrade, Ph.D., Department of Psychology, University of
Sheffield, Sheffield, United Kingdom. j.andrade@sheffield.ac.uk

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