



Memory by association: Integrating memories prolongs retention by two-year-olds



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ABSTRACT

Recalling one memory often leads to the recollection of other memories that share overlapping features. This phenomenon, spreading activation, was originally documented in studies conducted with verbal adults, and more recently, it has been demonstrated with pre-verbal infants. Here, we examine the effect of spreading activation on long-term retention by 2-year-olds. Participants were tested in the Visual Recognition Memory (VRM) paradigm and the deferred imitation paradigm. Typically, infants of this age exhibit retention in the VRM paradigm for 24 h, while they exhibit retention in the deferred imitation paradigm for at least 8 weeks. In the present experiment, we paired these tasks together during original encoding and tested infants after an 8-week delay. Two-year-olds exhibited retention in both tasks. That is, when these two tasks initially occurred together – one task that is extremely memorable and one that is not – retrieving the memory of the more memorable task cued retrieval of the less memorable task, extending its longevity.

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1. Introduction

If someone asked you to describe the first time that you gave a lecture, you initially might recall the nervous feeling that you experienced when you walked into the classroom for the very first time. Recalling that anxiety might also remind you of other times that you were nervous, like the day that you took your driving exam or the day that you were married. This hypothetical example illustrates a phenomenon that we have all experienced – retrieving one memory often leads to the recollection of a host of other memories that share overlapping features. In the example provided here, recalling one nerve-racking experience cued the retrieval of other nerve-racking experiences that occurred years before, and after, the event that you were initially trying to remember. In the present experiment, we explore another potentially powerful outcome of spreading activation – prolonged retention. Here, we show that when two events occur together – one event that is extremely memorable and one event that is not – retrieving the memory for the memorable event cues retrieval of the less memorable event, extending the retention of it.

Research with human infants has shown that some memory tasks are remembered longer than others. For example, studies conducted with 6-month-olds have shown that infants exhibit retention in the operant train task for approximately 2 weeks (Hartshorn & Rovee-Collier, 1997), but infants of the same age exhibit retention in the deferred imitation (DI) task for only 1 day (Barr, Dowden, & Hayne, 1996; Collie & Hayne, 1999). In their landmark experiment, Barr et al. used the differences in retention between the operant train and DI tasks to examine the effect of pairing the two together on retention in the

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deferred imitation task (Barr, Vieira, & Rovee-Collier, 2001). In the Barr et al. (2001) study, 6-month-old infants learned to operate a miniature train by pressing a lever. At the end of the second acquisition session with the train, these same infants were shown three target actions using a hand-held puppet. In the puppet task, the experimenter removed the mitten, shook it ringing a bell inside, and then replaced the mitten on the puppet's hand.

Two weeks after the conclusion of this second session, infants were initially tested for retention of the train task and then they were tested for retention of the DI task. Consistent with past research using the operant train task, 6-month-olds exhibited excellent retention when they were tested after a 2-week delay (Barr et al., 2001). Infants also exhibited excellent retention when they were tested in the DI task after the same delay. That is, associating the DI task with the train task, which is typically remembered longer, prolonged retention in the DI task. Subsequent research has shown that, if retention in the train task is extended further through the presentation of a retrieval cue during the retention interval, memory in the DI task is extended further as well (Barr, Rovee-Collier & Learmonth, 2011). In short, retrieving the memory for the more memorable task cued retrieval of the less memorable task, extending retention of it.

Barr and her colleagues have also shown that spreading activation continues to develop over the infancy period. For example, Barr, Walker, Gross, and Hayne (2014) used a different combination of memory tasks, the same DI task used by Barr and colleagues and a visual recognition memory (VRM) task, to examine the effect of pairing the two together on 6-, 12-, and 18-month olds' retention in the VRM task. When tested in the VRM task, 6- and 12-month-olds exhibit retention immediately after familiarization, but not after a 24-h delay, and 18-month-olds exhibit retention after a 24-h delay, but not after 1-week delay (Morgan & Hayne, 2006; Rose, 1983). Retention in the DI task, on the other hand, is substantially longer: 6-month-olds exhibit retention after 1 day, but not after 3 days, 12-month-olds exhibit retention after 7 days, but not after 14 days, and 18-month-olds exhibit retention after 28 days, but not after 42 days (Barr & Hayne, 2000; Barr et al., 2001).

In Barr et al.'s (2014) study, the experimenter initially modelled the target actions in the DI task and then participants were familiarized with the target stimulus in the VRM task. The 6- and 12-month-olds were tested 24 h later, first in the DI task then in the VRM task. The 18-month-olds were tested one week later, first with the DI task and then in the VRM task. Barr et al. found that while infants in all three age groups exhibited retention of the DI task when tested after their respective delay, only the 18-month olds exhibited retention of the VRM task after the same delay. Thus, under these encoding conditions, only the 18-month-olds showed evidence of spreading activation. When the DI memory was made stronger through the opportunity to practice or additional exposure to the target actions, 6- and 12-month-olds also exhibited retention of the VRM task. Taken together, these results provide evidence for spreading activation in 6- to 18-month-olds, but they also show that the conditions under which it is likely to occur change as a function of age during the infancy period.

The ability of one memory to prolong retention of another provides a potentially powerful mechanism by which infants might retain the effects of their prior experiences, allowing them to use those experiences as a basis of responding over increasingly longer delays. In the present experiment, we assessed the generality of this potentially important memory phenomenon by examining the retention of 2-year-olds who could be tested over a substantially longer delay. Prior research with infants of this age has shown that they exhibit excellent retention in the deferred imitation task after delays as long as 8 weeks (Herbert & Hayne, 2000), but they exhibit a null preference in the VRM task when tested after delays longer than 24 h (Morgan & Hayne, 2006). In the present experiment, we asked, would pairing these tasks together during original encoding prolong retention in the VRM task?

2. Method

2.1. Participants

The sample consisted of 24 2-year-olds (12 female) who were recruited from public birth records and by word of mouth. All infants were tested 2 weeks either side of their 2nd birthday. Children received a small, age-appropriate, gift for their participation in the study and parents received \$5 to offset the travel costs of bringing their child to the University. Infants were predominantly of European descent and came from a range of socio-economic backgrounds. The research was reviewed and approved by the University's Human Ethics Committee, which is approved by the New Zealand Health Research Council and whose guidelines are consistent with those of the American Psychological Association.

2.2. Apparatus

2.2.1. Deferred imitation stimuli

For the deferred imitation paradigm, we used two sets of stimuli that were modelled after those previously developed by Bauer and her colleagues (Bauer, Hertsgaard, & Wewerka, 1995). The stimuli for the *rattle* consisted of a green stick (12.5 cm long) attached to a white plastic lid (9.5 cm in diameter) with velcro attached to the underside of the lid, a round green block (3 cm in diameter × 2.5 cm in height), and a clear plastic square cup with velcro around the top (5.5 cm in diameter × 8 cm in height). The opening of the plastic cup (3.5 cm in diameter) was covered with a 1 mm black rubber diaphragm, with 16 cuts radiating from the centre (see Fig. 1, top).

The stimuli for the *rabbit* consisted of two plastic eyes (3 × 2 cm) attached to a 9 × 6 cm piece of plywood with velcro on the back, a 12 cm orange wooden carrot with green string attached to the top, a white circle of wood (the head, 15 cm in diameter) mounted horizontally on a white rectangular wooden base (30 × 20 cm). A 3 cm (in diameter) hole was drilled at

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