Memory Development: Halfway There?

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Abstract

Jabes and Nelson's reappraisal and revision of Nelson's (1995) model of memory development is a welcome swing of the developmental pendulum away from a strong early-competence position. The authors review the fast-breaking news about the neural substrates of memory, and use these facts to propose a new model of memory development. They distinguish (1) between nonspatial-relational memory and spatial relational memory, and (2) between the two kinds of relational memory and episodic memory. However, there are problems with their tripartite typology. Many investigators would regard these three categories as close to synonymous. Relational memory, or binding, is often seen to be at the heart of episodic or autobiographical memory, and spatial and episodic memory are often conceptualized as deeply intertwined. Edgin, Spano, Kawa and Nadel (2014) present a different typology for the development of relational and episodic memory, along with a different timeline.

The study of development vacillates between a focus on change (i.e., studying how and why infants are so different from adults) and excitement about early competence and continuity (i.e., studying how capable infants are, and marveling at how similar they turn out to be to adults). The study of memory development has been no exception. Initially, researchers examined school-age children and developmental change in conscious memory strategies, such as rehearsal (e.g., Kail & Hagen, 1977; Ornstein, 1978). But soon, attention turned to the amazing memory capabilities of infants, documented using non-traditional memory paradigms, such as visual paired comparison, conjugate reinforcement and delayed imitation. Thus, 20 years ago, Nelson (1995) was on apparently firm ground in expressing the view that explicit memory was well established within the first year of life, naturally enough since it was supported by the maturity of the relevant neural substrates.

This conclusion always sat somewhat uneasily with the fact that adults are rarely able to remember events occurring in infancy and early childhood. However, the problem of infantile amnesia was often attributed to non-mnemonic factors; the prevailing view was that early memories are encoded and stored, but become inaccessible because they were not linguistically encoded, or because they were encoded using very different event schemata, or because they can be difficult to express without narrative skills (for a review, see K. Nelson & Fivush, 2004).

Another problem, however, with the view that basic explicit memory capabilities are pretty firmly in place by the end of the first year was the fact that this conclusion did not address the question of exactly what kind of explicit memory was posited. Explicit memory is widely considered to consist of two separable subtypes, namely semantic and episodic memory. One way to reconcile early explicit memory with the phenomenon of infantile amnesia is to suggest that early explicit memory is primarily semantic, and that episodic memory develops more slowly than semantic memory, perhaps only after the first 2 years (Newcombe, Lloyd & Ratliff, 2007). In fact, such a sequence would make adaptive sense; it is far more important for infants to learn how the world works in general, and how to talk about what happens in the world in general, than to remember highly specific episodes and events.

Against this background, Jabes and Nelson's reappraisal and revision of Nelson's (1995) model of memory development is a welcome swing of the developmental pendulum away from the strong early-competence position. The authors review the fast-breaking news about the neural substrates of memory, about which we know much more than we did even a few years ago, and use these facts to propose a new model of memory development, summarized in their Figure 3. Jabes and Nelson distinguish (1) between nonspatial-relational memory and spatial relational memory, and (2) between the two kinds of relational memory and episodic memory. Figure 3 suggests that nonspatial-relational memory appears first, followed by spatial relational memory and finally by episodic memory. The new sequence extends over the first 4 years of human life, and is thus more consistent with the phenomena of infant and childhood amnesia than the old model was. Furthermore, although not shown in the figure, Jabes and Nelson discuss changes in memory that occur after 4 years and that may be linked to cortical development. Such an extended timeframe for development is consistent with what we now know about memory on both the behavioral and the neural levels.

However, are the distinctions made in the Jabes and Nelson model the right ones? There are problems with their tripartite typology. First, many investigators would regard these three categories as close to synonymous. Relational memory, or binding, is often seen to be at the heart of episodic or autobiographical memory, and spatial and episodic memory are often conceptualized as deeply intertwined, as in discussions of episodic memory as mental time travel or what-where-when memory (e.g., Nadel & Peterson, 2013; Tulving, 2002). Both spatial and episodic memory depend on hippocampal circuitry (Burgess, Maguire & O'Keefe, 2002). Second, developmentally, as Jabes and Nelson note, transitions are seen in hippocampally-dependent spatial learning at the end of the second year (for a recent demonstration involving an adaptation of the Morris water maze, see Balcomb, Newcombe & Ferrara, 2011). It seems odd to ignore the fact that this transition occurs in the same age range as the offset of dense infantile amnesia, and the first appearance of what-where-when episodic memory (Newcombe, Balcomb, Ferrara, Hansen & Koski, 2014).

Edgin, Spano, Kawa and Nadel (2014) present a different typology for the development of relational and episodic memory, along with a different timeline. They distinguish among three kinds of binding arrayed in developmental sequence: unitary representations (extending up through 18 months to 4 years depending on task parameters), separated representations but with bound elements (extending up to 10 to 14 years), and separated representations but with bound elements that are represented in more sophisticated forms. Their proposal helps to make sense of the fact that Richmond and Nelson (2009) found evidence that infants remember the background against which a face was shown, as evidenced by their looking behavior, while Koski, Olson and Newcombe (2013) found no such evidence in 4-year-olds, except in cases where the children could also verbally recognize the pairing. Jabes and Nelson suggest that the 4-year-olds may have approached the task quite differently than the babies did. But this explanation ignores findings that adults reliably behave in the same way as infants do (Hannula, Ryan, Tranel, & Cohen, 2007). We need some way to explain this apparently U-shaped developmental function. Edgin et al. provide such a way: infants show us evidence of their unitary representations of face-and-scene, 4-year-olds separate the face from the scene but are only inconsistently able to bind the two elements together, and adults bind the two elements with flexibility and confidence.

Emerging new models of memory development will also need to consider important recent discussions of the role of age-related changes in sleep patterns in creating age-related changes in hippocampally-dependent memory functions (for review, see Huber & Born, 2014). Research on this topic is particularly relevant to the issue of why we see age-related changes in forgetting. Sleep cannot be the whole explanation, given the fact that Lloyd, Doydum and Newcombe (2009) found that 4-year-olds were able to show evidence of relational binding in a working memory task, but not in a longer-term task still taking place within a single laboratory session. But sleep is central to remarkable findings on generalization (or abstraction) in memory. While sleep is generally found to support generalization in both infants and adults, toddlers appear to form general memories when they do not sleep (Werchan & Gomez, 2014). This finding is broadly consistent with the Edgin et al. typology.

Lastly, we should keep an eye on whether changes in memory after the age of 4 years are entirely linked to change at the cortical level. Recent evidence suggests that changes in hippocampus, at both the functional and even the structural levels of analysis, may be linked to changes in memory during middle and late childhood (Lee, Ekstrom & Ghetti, 2014).

We are tantalizingly on the brink of exciting breakthroughs in our understanding of the development of memory and the relation of behavioral and neural change. But there is much we still do not understand. The overview we can expect in another 20 years will be fascinating to read.

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