Adapted Fast-Mapping Memory Research Is Based on a Misinterpretation of Developmental-Word-Learning Data

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Abstract
Fast mapping is often used to refer to children's remarkable ability to learn the meanings of new words with minimal exposure and in ambiguous contexts. It is one thing to claim that children are capable of learning words this way; it is another to claim that this ability relies on a specific fast-mapping neurocognitive mechanism that is critical for early word learning. Yet that claim has recently been made in adult memory research and used as a theoretical justification for research into an adult fast-mapping mechanism. In this review, we explain why the existence of such a mechanism in children is not supported by developmental research and explore the implications for adult fast-mapping data and research.

Keywords
word learning, fast mapping, hippocampus

In everyday conversation, it is not uncommon for adults to be ambiguously exposed to new words that they have to work out and remember the meanings of for themselves. Imagine you hear for the first time a friend say “My Huawei is great” while holding both a cup of coffee and a new piece of technology. We can easily infer that the friend is talking about his or her new phone, and we are able to remember this new word after hearing it only once or twice. Indeed, in a seminal study, Carey and Bartlett (1978) found that 3-year-old children are capable of doing this, too. They exposed children to an unknown color word on a single occasion and tested their retention of this novel word 7 to 10 days later. Just under half the children could identify the novel color a week later. The authors called this capability fast mapping.

In such scenarios, children must first make an inference as to the meaning (or referent) of the novel word. That initial process of referent selection has itself been called fast mapping (e.g., Horst, McMurray, & Samuelson, 2006; Horst & Samuelson, 2008) and has been contrasted with children’s capability to retain and consolidate word-referent mappings across an extended period (i.e., word learning). As noted by Horst and colleagues, those two processes are logically independent. That said, a number of developmental researchers have used fast mapping to describe both initial disambiguation of the meaning of a novel word and long-term retention of that novel word (often days or weeks) despite having been exposed to it only a minimal number of times (e.g., Carey & Bartlett, 1978; Markson & Bloom, 1997; see also Carey, 2010; Swingley, 2010).

The idea that children learn new words following such minimal learning conditions has recently prompted memory researchers to investigate word learning in adults under similar conditions. In fast-mapping learning conditions, adults are introduced to novel words a minimal number of times in contexts that require disambiguation of the words’ meaning (e.g., Sharon, Moscovitch, & Gilboa, 2011; for a recent review, see Cooper, Greve, & Henson, 2019b). Moreover, several adult-memory researchers have interpreted the developmental data to show that these specific learning conditions engage a fast-mapping neurocognitive mechanism that critically supports word learning in children at an age when their hippocampus, a structure typically critical for human memory, is functionally
immature (e.g., Atir-Sharon, Gilboa, Hazan, Koilis, & Manevitz, 2015; Himmer, Müller, Gais, & Schönauer, 2017; Merhav, Karni, & Gilboa, 2015; Sharon et al., 2011). By using fast-mapping conditions to tap into a purported developmental fast-mapping mechanism, some researchers have argued that adult word-learning studies reveal evidence for a special form of learning that is rapid and independent of the hippocampus (e.g., Coutanche & Thompson-Schill, 2014; Himmer et al., 2017; Merhav et al., 2015; Sharon et al., 2011). For example, Sharon et al. (2011) reported that patients with hippocampal damage are able to remember new words seen under fast-mapping learning conditions but not new words seen under explicit-encoding learning conditions, in which objects were explicitly labeled and participants were instructed to remember them. Such data are interesting because models of declarative memory propose that learning such information involves a slow process of consolidation, in which memories are first dependent on the hippocampus and then over an extended period of time become hippocampus independent (e.g., McClelland, McNaughton, & O’Reilly, 1995). These models explain the difficulties that hippocampal patients have with learning new information in explicit-encoding learning conditions. The claim that a special form of hippocampus-independent learning exists, supporting both developmental and adult word learning following fast-mapping learning conditions, has therefore attracted considerable attention (Cooper et al., 2019b).

We would argue, however, that such a claim misinterprets developmental word learning and memory research. It is one thing to suggest that children of a certain age are capable of learning new words from ambiguous contexts with minimal exposure. It is another thing entirely to claim that word learning is dependent on a specific neurocognitive mechanism triggered by specific fast-mapping learning conditions. According to this latter view, one ought to predict that children learn words under fast-mapping learning conditions prior to the functional development of the hippocampus. Furthermore, if fast-mapping learning conditions give rise to a specific form of hippocampus-independent learning, then one ought to predict that children, in whom the hippocampus is still developing, would show better retention under these conditions compared with conditions that are purportedly hippocampus dependent, such as explicit instruction. After all, it was this logic that prompted researchers to compare retention after fast-mapping and explicit-encoding conditions in adult populations with known hippocampal abnormalities (e.g., Korenic et al., 2016; Sharon et al., 2011).

As we explain below, though, there is no developmental evidence supporting either of these predictions. The existence of a critical fast-mapping mechanism in children—hippocampus independent, giving rise to long-term retention with minimal exposure—is not supported by developmental research. Recognizing this misinterpretation is important for adult-memory researchers. If one erroneously believes in the existence of a developmental fast-mapping neurocognitive mechanism to predict and explain adult data, then important research questions, such as establishing which specific features of fast-mapping learning conditions actually affect word learning, are at risk of not being addressed.

**Fast-Mapping Learning Conditions Do Not Promote Learning in Children Prior to Functional Development of the Hippocampus**

Understanding the age at which children show evidence of word learning after exposure to novel words in fast-mapping learning conditions is critical for understanding how some adult-memory researchers have misinterpreted the developmental data. There is evidence that from 17 months, toddlers can disambiguate the referent of a novel word, for example, by looking more at a novel object than to a familiar object after hearing a novel word (e.g., Halberda, 2003; cf. Markman, 1990). However, such “fast-mapping” studies do not test retention of the novel word. The few researchers reporting memory after a delay for new object–word pairings in infants and toddlers do not use fast-mapping learning conditions: They make use of multiple repetitions of the word–object mappings or provide unambiguous word–object pairings (e.g., Houston-Price, Plunkett, & Harris, 2005; Woodward, Markman, & Fitzsimmons, 1994). Such learning conditions are very different from the fast-mapping learning conditions used by adult-memory researchers, with the latter critically involving minimal exposure and disambiguation of word meaning.

As first noted by Horst and colleagues, there is very little evidence that young children do learn new words under fast-mapping learning conditions (Horst et al., 2006; Horst & Samuelson, 2008). In fact, several studies show that 18- to 24-month-old children fail to learn word meanings from fast-mapping conditions even after only a 5-min delay (e.g., Bion, Borovsky, & Fernald, 2013; Horst & Samuelson, 2008; Kucker, McMurray, & Samuelson, 2018). In cases in which memory has been shown in 2-year-old children following fast-mapping conditions, memory has been tested almost immediately after the learning trials (e.g., Bion et al., 2013;
Spiegel & Halberda, 2011). As noted by Horst and Samuelson (2008), it is not clear whether such immediate memory performance measures word learning or simply repetition of a recent previous selection.

The fast-mapping studies that have used more significant delays (e.g., 24 hr or more) typically show retention only in children above 3 years old (e.g., Carey & Bartlett, 1978; Holland, Hyde, Riggs, & Simpson, 2018; Holland, Simpson, & Riggs, 2015; Markson & Bloom, 1997; Vlach & Sandhofer, 2012). Furthermore, such studies introduce children to only a single novel word. Some researchers have questioned whether this is a robust test of word learning—at test, children could merely be remembering which object had been previously singled out with a label (e.g., Schafer & Plunkett, 1998). Indeed, Axelsson and Horst (2013) found that 2-year-olds failed to show even immediate retention of novel words following fast mapping of more than one novel word. Recent data, however, suggest that 2.5-year-olds can show some retention 24 hr after fast mapping four novel words, but only if they nap immediately after learning (Axelsson, Swinton, Winiger, & Horst, 2018).

It is important to note that outside of word learning, children begin to show long-term memory on tasks believed to be dependent on hippocampal function by the end of their second year. For example, 20-month-olds show delayed recall of a temporal sequence following a single exposure (Bauer & Leventon, 2013), a task typically failed by patients with hippocampal damage (McDonough, Mandler, McKee, & Squire, 1995). The hippocampus may not have reached full functional maturity at 2 years old, but there is evidence that it can support declarative memory by this age (for reviews, see Bauer, 2013; Gómez & Edgin, 2016). Thus, in cases in which 2.5- and 3-year-old children have shown memory after a significant delay following fast-mapping conditions, this is not evidence for a nonhippocampal learning mechanism, as suggested by some adult-memory researchers. Indeed, it is conceivable that functional development of the hippocampus supports the emergence of long-term retention. That would be consistent with the sensitivity of such retention to whether children nap immediately following learning (Axelsson et al., 2018), given the role that sleep has been proposed to play in hippocampus-mediated memory consolidation (e.g., Davis & Gaskell, 2009; Gais & Born, 2004; cf. Himmer et al., 2017).

**Fast-Mapping Learning Conditions Are Not Beneficial for Word Learning**

As we have seen, children begin to consistently show evidence of word learning following fast-mapping learning conditions only from 3 years of age. Furthermore, even when retention is seen, fast-mapping conditions do not provide any special word-learning benefit over other learning conditions. In research in which children’s retention in fast-mapping conditions has been directly compared with conditions explicitly giving the word–object mappings, there is no evidence that fast-mapping conditions specifically help children to learn those words (Jaswal & Markman, 2003; Zosh, Brinster, & Halberda, 2013). Indeed, even in studies with developmental populations associated with compromised hippocampus functions (e.g., Down’s Syndrome), fast-mapping conditions do not give rise to better learning than explicit-instruction conditions (Sakhon, Edwards, Luongo, Murphy, & Edgin, 2018).

In fact, in studies that make the association between word and object more explicit by introducing additional cues during fast mapping, long-term retention has been found to improve in children (e.g., Vlach & Sandhofer, 2012). Furthermore, long-term retention in fast-mapping studies is typically found only when children learn specific types of words, such as count nouns. Fast-mapping conditions do not readily support the long-term learning of color, shape, and texture words (Holland et al., 2015), thus limiting the conceived usefulness of any purported fast-mapping mechanism for children’s word learning. It may be the case that in certain circumstances and after reaching a certain age, children are able to learn from fast-mapping conditions. However, this does not imply that these conditions therefore engage a specific neurocognitive mechanism that is both conducive and critical for word learning, contrary to the claims of some researchers (e.g., Atir-Sharon et al., 2015; Merhav et al., 2015).

**What Does This Mean for Adult-Memory Researchers?**

Addressing misinterpretations of developmental data is important for researchers investigating adult memory because it was exactly those misinterpretations that informed the original theoretical justification for using fast-mapping learning conditions in their research (Sharon et al., 2011). Once it is recognized that a key justification for expecting fast-mapping conditions to produce hippocampus-independent learning in adults was based on a misinterpretation, it is perhaps not surprising that there is conflicting evidence and considerable debate in this regard (see Cooper et al., 2019b). For example, although two early studies found that patients with damage to the hippocampus learn new words under fast-mapping but not explicit-encoding conditions (Merhav, Karni, & Gilboa, 2014; Sharon et al., 2011), this finding has not been readily replicated with similar patient groups (Smith, Urgolites, Hopkins,
& Squire, 2014; Warren & Duff, 2014; Warren, Tranel, & Duff, 2016). Furthermore, a number of studies with participant populations associated with compromised hippocampal function have failed to find any difference in word learning between explicit-encoding and fast-mapping conditions relative to control conditions (Greve, Cooper, & Henson, 2014; Korenic et al., 2016; Sakhon et al., 2018). Finally, brain-imaging studies with healthy adults have found the hippocampus to be active during both fast-mapping encoding and retrieval (Atir-Sharon et al., 2015; Merhav et al., 2015). The developmental data discussed in this review add to this body of evidence speaking against the claim that fast-mapping conditions support any special form of hippocampus-independent learning.

Furthermore, by rejecting the idea that the learning conditions in fast-mapping studies engage a specific neurocognitive mechanism, we hope to encourage a more systematic focus on how different encoding contexts affect word learning. Clearly, children and adults do encounter situations in which they incidentally hear a new word and have to work out its meaning. Within laboratory-based tasks that attempt to reproduce such situations, fast-mapping conditions differ from explicit-encoding conditions in several respects (e.g., the presence or absence of familiar objects, different task instructions), each of which might affect word learning. Although in the developmental literature a number of researchers have attempted to manipulate factors within fast-mapping conditions to assess their effects on memory (e.g., Axelsson & Horst, 2014; Vlach & Sandhofer, 2012), relatively few studies with adults have done so (for recent exceptions, see Cooper, Greve, & Henson, 2019a; Coutanche & Koch, 2017; Coutanche & Thompson-Schill, 2014). Beyond a consistent finding that healthy adults remember more from explicit-encoding conditions, there do appear to be some additional differences in memory performance between fast-mapping and explicit-encoding conditions, such as in susceptibility to catastrophic interference or the extent to which novel words are integrated into the lexicon (e.g., Coutanche & Koch, 2017; Coutanche & Thompson-Schill, 2014; Merhav et al., 2014; see Cooper et al., 2019b). Convincing explanations for these latter differences in learning between fast-mapping and explicit-encoding conditions will result only from (a) robust replication of these effects and (b) systematic investigation of those specific features of fast-mapping that cause such effects (for similar arguments, see Cooper et al., 2019a, 2019b).

To conclude, we have argued that developmental research does not support the claim that fast-mapping conditions trigger in children a neurocognitive mechanism critical for word learning. Specifically, there is no evidence of hippocampus-independent retention following fast-mapping conditions, given the age at which children show evidence of long-term retention, and there is no evidence that children learn differently under those conditions than under explicit instruction. By highlighting this misconception, we hope this review will inform the thinking of future researchers interested in memory and word learning across the life span.

### Recommended Reading

Cooper, E., Greve, A., & Henson, R. N. (2019b). (See References). A recent critical review and discussion of adult fast-mapping research.

Coutanche, M. N., & Thompson-Schill, S. L. (2015). Rapid consolidation of new knowledge in adulthood via fast mapping. Trends in Cognitive Sciences, 19, 486–488. A review and discussion of adult fast-mapping research from researchers interested in adult memory and word learning.

Gómez, R. L., & Edgin, J. O. (2016). (See References). A review of the development of children’s performance on hippocampus-dependent memory tasks.

Holland, A., Simpson, A., & Riggs, K. J. (2015). (See References). A representative study illustrating recent developmental fast-mapping research, including a review of developmental research on long-term retention of words following fast mapping.

Sharon, T., Moscovitch, M., & Gilboa, A. (2011). (See References). The original article, from researchers interested in adult memory, that made claims about fast mapping in children as a “neurocognitive mechanism” and applied a fast-mapping paradigm to adult amnesic patients.

### Action Editor

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### Declaration of Conflicting Interests

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### Note

1. Although Zosh et al. (2013) suggest in their article that there is a difference between their fast-mapping and explicit-encoding conditions (respectively called inference and instruction in their article), they do not report a direct statistical test of the significance of that difference. When directly comparing the number of children showing memory following each condition (Experiment 1: fast mapping = 13/24, explicit encoding = 7/24; Experiment 2: fast mapping = 8/12, explicit encoding = 5/12), one finds no significant statistical difference between the two conditions in either experiment.

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