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# No evidence that 'fast-mapping' benefits novel learning in healthy Older adults

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ABSTRACT

Much evidence suggests that the Hippocampus is necessary for learning novel associations. Contrary to this, Sharon, Moscovitch, and Gilboa (2011) reported four amnesic patients with Hippocampal damage who maintained the capacity to learn novel object-name associations when trained with a 'fast-mapping' (FM) technique. This technique therefore potentially offers an alternative route for learning novel information in populations experiencing memory problems. We examined this potential in healthy ageing, by comparing 24 Older and 24 Young participants who completed a FM procedure very similar to Sharon et al. (2011). As expected, the Older group showed worse memory than the Young group under standard explicit encoding (EE) instructions. However, the Older group continued to show worse performance under the FM procedure, with no evidence that FM alleviated their memory deficit. Indeed, performance was worse for the FM than EE condition in both groups. Structural MRI scans confirmed reduced Hippocampal grey-matter volume in the Older group, which correlated with memory performance across both groups and both EE/FM conditions. We conclude FM does not help memory problems that occur with normal ageing, and discuss theoretical implications for memory theories.





## 1. Introduction

Lesions to the medial temporal lobe (MTL), particularly those that include the Hippocampus, are known to produce amnesia; particularly deficits in episodic memory (Scoville & Milner, 1957). It has been suggested that Hippocampal lesions specifically affect the ability to rapidly encode new associations between two items, such as the name of a novel object; a key feature of declarative, relational and recollective memory theories (Rempel-Clower, Zola, Squire, & Amaral, 1996; Spiers, Maguire, & Burgess, 2001; Zola-Morgan, Squire, & Amaral, 1986). Nonetheless, some amnesic patients show evidence of learning new associations when this information is linked to information established prior to the onset of amnesia (O'Kane, Kensinger, & Corkin, 2004; Skotko, Kensinger, Locascio, Einstein, & Rubin, 2004), albeit at a slower rate than controls (Bayley & Squire, 2005). Moreover, evidence from individuals with Hippocampal damage at birth (developmental amnesia) suggests that they can learn new associations, at least to the extent that they acquire relatively normal levels of semantic knowledge despite their impaired episodic memory (Martins, Guillery-Girard, Jambaqué, Dulac, & Eustache, 2006; Vargha-Khadem, Gadian, & Mishkin, 2001). This intact associative learning in developmental amnesia is consistent with claims that the brain has two, complementary learning systems, with rapid learning occurring in the Hippocampus (as necessary for episodic memory) and slower learning occurring in other cortical regions (to enable semantic memory). Some computational models justify the slower cortical learning in terms of minimising interference between competing associations, as they become integrated into semantic memory (McClelland, McNaughton, & O'Reilly, 1995; Norman & O'Reilly, 2003).

Evidence from healthy young children in the developmental literature suggests that new associations can be learned very quickly. Surprisingly, these associations seem to be incorporated directly into their developing semantic memory, without needing a period of time for slow cortical learning. For example, it has been claimed that children as young as 18 months can rapidly associate a novel word with a novel object, and then continue to demonstrate semantic knowledge and comprehension of that word in future behaviour; a phenomenon called 'fast-mapping' (Carey & Bartlett, 1978). Such fast-mapping may account for the massive increase in vocabulary during the first few years of life (Bion, Borovsky, & Fernald, 2013). It is not clear whether this rapid learning is specific to the developing brain, or reflects instead computational factors such as reduced interference from existing associations. Nonetheless, the finding that individuals with developmental amnesia following Hippocampal damage appear to have

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normal vocabulary acquisition raises the possibility of a rapid cortical learning mechanism that does not depend on the Hippocampus.

As mentioned previously, one possibility is that cortical learning can be rapid when new information is presented in conjunction with familiar information, and this provides a schema for assimilating the new information (Tse, Langston, Kakeyama, Bethus, & Spooner, 2007; van Kesteren, Ruiter, Fernández, & Henson, 2012). This is consistent with demonstrations that fast-mapping in children is more likely when the novel word and novel object are present together with other familiar objects (Halberda, 2006; Kucker & Samuelson, 2012). The familiar object may activate a schema, which in turn helps discriminate or individuate the novel item, facilitating its integration into semantic memory. If so, then FM may not be unique to children, and might occur in adults under the appropriate conditions.

This was part of the rationale for a recent study by Sharon, Moscovitch, and Gilboa (2011), which investigated FM in four adults with acquired amnesia following damage to the MTL that included the Hippocampus in every case. Amazingly, despite their amnesia on typical episodic memory tests, performance on a paired associate learning task was restored to the level of matched controls when a fast-mapping procedure was used. More specifically, Sharon et al. (2011) tested participant's ability to learn the association between a novel word and a novel picture of an object (e.g., an animal or fruit). They compared two conditions: a standard intentional learning condition they called explicit encoding (EE) and an incidental learning condition they called the fast-mapping (FM) condition. In each trial of the study phase of the EE condition, participants were presented with one word and one object, and told to remember the name of the object. In each study trial of the FM condition, on the other hand, participants were presented with two objects – one novel and one familiar – and answered a yes/no question that employed a novel word to refer to the novel object (such that participants had to infer that the word was the name of the novel object; see Fig. 1). Thus the FM condition differed from the EE condition in terms of (i) involving incidental rather than intentional encoding, (ii) presenting a concurrent familiar object, and (iii) requiring a response based on the disjunctive inference needed to infer the name of the novel object. Following each study phase, identical test phases were completed, where participants were shown a single word together with three objects, and asked to select the object that was paired with the word in the study phase (i.e., 3-alternative forced choice, 3AFC). Memory was tested at two delays: after 10 min and after 1 week. Regardless of delay, the 3AFC performance showed a striking interaction between FM vs. EE and patient vs. control group, such that controls performed better on the EE than FM condition, and patients performed better on the FM than EE condition (see Smith et al., 2014, and Section 4). Most importantly, Q2 the patients were no longer "amnesic" in the FM condition, i.e., performed at a similar level to controls. Furthermore, two additional patients who had damage that included the anterior temporal lobe (ATL) did not show the same improvement with FM as did the other patients, implicating the ATL in this form of rapid but non-Hippocampal associative learning. These findings clearly offer much hope for the rehabilitation of people with memory problems, in that the fast-mapping procedure may help individuals with significant Hippocampal atrophy to acquire new information.

Given that the Hippocampus has also been shown to decrease in volume during normal, healthy ageing (Du, Schuff, Chao, Kornak, & Jagust, 2006; Jernigan, Archibald, Fennema-Notestine, Gamst, & Stout, 2001; Raz, Rodrigue, Head, Kennedy, & Acker, 2004; Schuff et al., 1999), and that older people generally perform worse on tests of associative memory than do younger people (Naveh-Benjamin, Guez, Kilb, & Reedy, 2004; Naveh-Benjamin, Hussain, Guez, & Bar-On, 2003), we wondered whether FM could also be used to support memory in older individuals. Previous FM studies have almost exclusively focused on young children, with only a few studies investigating university students (Halberda, 2006, Markson & Bloom, 1997). While Sharon et al. (2011) were the first to extend FM studies into a middle-aged population, the present study is the first to investigate FM learning in Older adults, and directly compare results with Young adults. More specifically, we replicated Sharon et al.'s design (bar a few procedural changes,

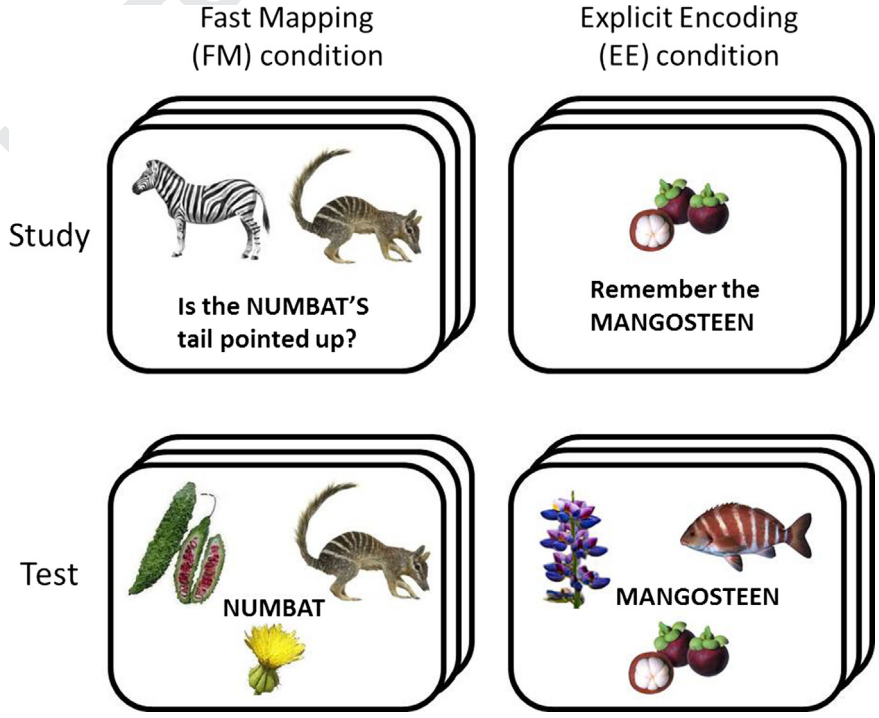


**Fig. 1.** Example trials for the study and test phases of the fast-mapping (FM) and explicit encoding (EE) conditions.