

Why and how the co-occurring familiar object matters in Fast Mapping (FM)? Insights from computational models

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Why and how the co-occurring familiar object matters in Fast Mapping (FM)? Insights from computational models

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Abstract: This commentary aims to enrich Cooper et al.'s (2018) discussion by using computational semantic networks (e.g., Steyvers & Tenenbaum, 2005) to explain why the co-occurring familiar objects are critical to the Fast Mapping (FM) procedure. I first propose that the co-occurring familiar objects provide the novel targets with a 'mimicry opportunity', which may facilitate the establishment of targets in long-term cortical memory networks. I then argue that the occurrence of *rapid* cortical learning may depend on how 'well-connected' the co-occurring familiar object is in long-term memory networks.

Keywords: fast mapping; familiar object; computational semantic network; semantic growth; consolidation

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Computational models that simulate how new words are added into the mental lexicon offer valuable insights into the FM procedure. Before discussing them, some rudimentary concepts are required.

Lexical items in the mental lexicon are often thought to be organized in network-like structures (e.g., Collins & Loftus, 1975). Some computational models (e.g., Siew, 2018) see each lexical item as a node, which is connected to other word nodes. One factor that determines whether two word nodes are connected is phonological/orthographic resemblance (e.g., *dog* and *dig* would be connected, while *dog* and *superstitious* are unlikely to be). Another factor is semantic relatedness (e.g., *dog* and *cat* are likely to be strongly connected, while *dog* and *printer* are unlikely to be connected).

One highly relevant characteristic of these networks is that frequently used words (e.g., *dog*) are often connected to a large number of other nodes, and they tend to cluster together in the network, forming dense neighbourhoods. In contrast, rarely used lexical items (e.g., *pomegranate*) usually have significantly fewer connections, forming sparse neighbourhoods.

Steyvers & Tenenbaum (2005) proposed that when a new word (for example, *limousine*) is introduced into the mental lexicon, it will first mimic the connection patterns of a pre-existing node. In this case, *limousine* may mimic the connection patterns of the *car* node, forming connections with nodes that are already connected to *car* (e.g., *wheel*, *vehicle*). As a function of experience, this *limousine* node will gradually differentiate itself from the *car* node by establishing unique connections to nodes that are not necessarily connected to *car* (e.g., *prom*, *luxury*).

So how does this semantic growth process relate to the FM procedure? I propose that the FM procedure provides the novel targets with the chance to mimic the connection patterns of the co-occurring familiar objects. This ‘mimicry opportunity’, I suggest, is what makes the FM procedure special: since lexical entries in long-term memory are stored in association with one another (i.e.,

connected), it is reasonable to assume that the formation of connections between a novel word and pre-existing nodes is a necessary precursor to that word being established in long-term cortical memory networks. As novel targets learnt under the FM procedure could theoretically mimic the connection patterns of the co-occurring familiar objects, these targets (vs. those learnt without a co-occurring familiar object) might more easily form connections with pre-existing nodes. Establishments of these novel targets in long-term cortical memory networks may therefore be facilitated.

Furthermore, the occurrence of *rapid* neocortical integration, as claimed by Sharon et al. (2011), may partially depend on how ‘well-connected’ the co-occurring familiar item is in one’s long-term memory networks.

Steyvers & Tenenbaum (2005) further postulated that the growth of semantic networks follows the principle of *preferential attachment* (Barabási & Albert, 1999): the more connections a word node possesses, the more adept it is at acquiring new connections (cf. Hills et al., 2011). In other words, well-connected nodes (e.g., *dog*) may be more likely to acquire new connections than poorly-connected nodes (e.g., *pomegranate*). In relation to FM, I suggest that in a FM trial, if a novel word target is paired with a familiar object that has numerous pre-existing connections (vs. one that has few connections), forming connections with pre-existing nodes in the neocortical system may become less challenging. This may allow the retention of the novel targets to be more reliant on these newly formed connections with the pre-existing nodes within the neocortical system, thereby reducing hippocampal involvement.

This proposal, however, does not appear to be line with Coutanche & Koch (2017), who reported that FM was more likely to yield evidence of rapid neocortical integration when the co-occurring familiar object was an ‘atypical’ entity (e.g., a *hedgehog* was considered atypical while a *dog* was typical). By inference, novel words may be able to integrate into long-term cortical networks more rapidly if they are associated with a poorly-connected node (i.e., *hedgehog*) rather than a well-connected node (i.e., *dog*). One explanation is that association with a poorly-connected

node means that the novel target node will be, at least initially, situated in a sparse neighbourhood, which entails less interference from neighbouring nodes (see Siew & Vitevitch, 2016). Reduced interference may help preserve the memory traces of the novel targets, thereby facilitating their integration into cortical memory networks. Note, however, that caution is warranted in interpreting Coutanche & Koch's (2017) study, which seems to lack statistical power (<120 observations per condition¹). In addition, the fact that the authors analysed various subgroups of the dependent variable (e.g., typical vs. atypical; high vs. low semantic traits) without stipulating whether subgrouping was planned *a priori* or done *post hoc* is concerning (Kerr, 1998; Motulsky, 2015).

This article highlighted the reasons why the co-occurring familiar objects may play a crucial role in FM. In light of these proposals, future neuropsychological studies interested in FM should ascertain if the amnesic subjects indeed have intact representations of objects that are presumed to be familiar. If such representations were compromised, this could render rapid cortical learning via FM impossible. This may partly explain why the effect of FM was observed in one study but not another (Smith et al., 2014).

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¹ In highly comparable studies (e.g., Wang et al., 2017), the number of observations/condition was at least 300. Also note that the dependent variable of these studies was Reaction Time, which is a naturally noisy measure. Therefore, in order to find reliable results, the number of observations/condition must be large (see for example Brysbaert & Stevens, 2018).

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