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# Relative contributions of semantic and phonological associates to over-additive false recall in hybrid DRM lists

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ABSTRACT

Two experiments explored false recall of unstudied critical items (e.g., *chair*) following the presentation of 16 semantic associates to the critical word (e.g., *sit*, *desk*), 16 phonological associates to the critical word (e.g., *cheer*, *hair*), and every composition of hybrid list in between (e.g., 14 semantic and 2 phonological associates). Results replicated the over-additive pattern of critical false recall from hybrid lists relative to pure lists found by Watson, Balota, and Roediger (2003) and clarified the form of the false recall function across varying degrees of hybridization. Both experiments showed that including just one or two of the other type of associate in an otherwise pure list led to a considerable increase in false recall. A within-subjects design (Experiment 1) suggested that after this initial rapid increase, false recall continued to increase gradually to an apex at the balanced hybrid list composition, whereas a between-subjects design (Experiment 2) showed that false recall plateaued after the initial rapid increase and that the overall shape of the function is a ziggurat. Furthermore, the function is roughly symmetrical; semantic and phonological associates appear to make equivalent contributions to over-additive false recall from hybrid lists. The results provide constraints on theoretical accounts of DRM false memories, and can be accommodated by a modified activation/monitoring framework.

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## Introduction

When people study a list of related words, they are often susceptible to falsely recalling or recognizing a critical word that was strongly semantically associated to the whole list but was not itself studied (the DRM paradigm; Deese, 1959; Roediger & McDermott, 1995). Similar false remembering has been found using lists of words that are phonologically and/or orthographically associated to the critical unstudied word (e.g., Sommers & Lewis, 1999). These findings have informed theorizing about the nature of information storage in human memory, and the nature of retrieval processes (Gallo, 2010). A question of key interest is whether the two types of associates, semantic and phonological,[1] contribute to false memory in the same way.

Watson, Balota, and Roediger (2003) explored this issue by using hybrid lists composed of both semantic and phonological associates to a critical item (see also Watson, Balota, & Sergent-Marshall, 2001). In their Experiment 1, they found that adding 1–3 phonological associates to a list that already contained 10 semantic

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[1] We use the term phonological as a shorthand for representation in a lexical network, but mean to include visual/orthographic representation, too. In our experiments words were presented visually during study, so doubtless orthographic and phonological processes are involved during encoding.

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associates increased false recall more than adding 1–3 additional semantic associates to the same list. In Experiment 2 they found that combining a semantic and phonological list (length 36, 18 words of each type) yielded greater false recall than the sum of that yielded by either list alone (length 18): over-additivity (see Balota & Paul, 1996 for discussion of additivity). In Experiment 3 they found that a balanced hybrid list of length 16 (composed of 8 semantic and 8 phonological associates) led to greater false recall than either a pure semantic or pure phonological list of length 16. Thus, when examined three different ways, hybrid lists of semantic and phonological associates lead to greater false recall than pure lists of either type.

Watson et al. (2003) discussed several possible theoretical accounts of the over-additive false recall produced by hybrid lists. One account is a simple additive spreading activation model that posits distinct semantic and phonological (lexical) associative networks, that both could contribute to total activation of a critical item,[2] and that both have their own negatively accelerated activation functions that asymptote after a certain number of associates are activated. A hypothetical example is illustrated in Fig. 1. When there are already six semantic associates studied at encoding (step 1), adding three more semantic associates (step 2a) should not produce much of an increase in false recall of the critical item because the semantic network is probably already near asymptote and thus will not contribute much to the total activation of the critical item. That is, there are diminishing returns. However adding three phonological associates (step 2b) should provide a considerable increase in false recall, because of the large increase in phonological activation driven by going from zero to three phonological associates, which involves the rapidly rising portion of the activation function. Thus, a hybrid list with even just a few of the alternative type of associate should produce higher false recall than a pure list of the same length. Note that this theoretical account focuses on encoding processes: false recall of the critical item occurs because it was sufficiently activated by one or both of the associative networks at the time of study. But what of retrieval processes?

Another account discussed by Watson et al. (2003) is an activation/monitoring framework (Gallo, 2010; Roediger, Balota, & Watson, 2001; Roediger, Watson, McDermott, & Gallo, 2001). This account begins by positing that during study of a pure semantic DRM list, the critical item is activated (either consciously or unconsciously) via spreading activation. Then during retrieval, participants generate candidate items based on their semantic activation, but may reject those items due to a lack of corresponding phonological familiarity (cf. Jacoby, Kelley, & Dywan, 1989; Watkins & Gardiner, 1979). That is, participants may reject the critical item that is only semantically related to the list items if it is not also a familiar word form or sound. For example, if a participant studied words like *sit* and *desk* at encoding, later at retrieval she might generate the critical unstudied word *chair* based on semantic activation. But she may still be able to correctly reject that word and choose not to output it because it does not feel sufficiently familiar in sound and/or appearance, because there were no words that looked or sounded like *chair* in the list. Gallo (2004) refers to this strategy as diagnostic monitoring during retrieval. When phonological associates such as *cheer* and *hair* are included in the study list along with the semantic associates (*sit* and *desk*), not only does this boost activation of the critical unstudied item (as per the spreading activation account discussed earlier) but it also disrupts diagnostic monitoring during retrieval: the participant can no longer readily reject *chair* based on phonology because the words that sounded or looked like *chair* on the studied list have boosted its phonological familiarity. Thus this theory adds a strategic retrieval component to the basic idea that false memories arise during spreading activation through lexical or semantic networks (Balota & Paul, 1996). The activation/monitoring framework account also fits nicely with modality effects in the DRM paradigm: lists presented visually create less false recall than those presented auditorily, likely due to output monitoring of the word form driving down false recall in the visual case (see Gallo, McDermott, Percer, & Roediger, 2001; Kellogg, 2001).

We pause to mention one other theory of DRM false memories: fuzzy trace theory (e.g., Brainerd & Reyna, 2002; Reyna & Brainerd, 1995). Fuzzy trace theory posits that events are coded as verbatim traces (with specific details of the events) and/or gist traces (the semantic content). False memories arise from strong gist traces that lead to "phantom recollection" (Brainerd, Payne, Wright, & Reyna, 2003). Because false memories are entirely based on gist traces (semantic content) in this theory, there is no reason to expect phonological or orthographic associates to increase false recall or false recognition. Thus, in its current conceptualization, fuzzy trace theory is incapable of handling results from experiments showing false memories from phonological associates (Sommers & Lewis, 1999) or from hybrid lists of semantic and phonological associates (Watson et al., 2003). Of course, it is quite possible that a fuzzy trace could also involve phonological associates for gist based traces, but it would then be important to further stipulate what types of information are sufficient for gist based representations.

Watson et al. (2003) found increased false memory from hybrid relative to pure lists in both free recall and recognition (Experiment 3), with healthy young adult participants. Watson et al. (2001) additionally found the same false recall effect with healthy young adults, healthy older adults, and older adults with Alzheimer's disease. Curiously, Budson, Sullivan, Daffner, and Schacter (2003) found no difference in false recognition for hybrid versus pure lists with healthy young adults, healthy older adults, or older adults with Alzheimer's disease. Nevertheless, one issue that has not been resolved by prior research is the *relative contributions* of semantic versus phonological associates to false memory in the hybrid paradigm. That is, prior research has generally used equal numbers of the two types of associates (balanced hybrid lists) and not examined other list compositions. In the one study that has systematically varied the number of associates, Watson et al.

[2] Note that such an account is comparable to Dell's interactive model of speech production (Dell, 1986), which postulates that top-down semantic activation and bottom-up phonological activation combine to converge on a critical item, yielding a speech error.

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