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A grand memory for forgetting: Directed forgetting across contextual changes

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ABSTRACT

Using an item-method directed forgetting task, we presented homographic homophonic nouns embedded in sentences. At study, each sentence was followed by an instruction to remember or forget the embedded word. On a subsequent yes-no recognition test, each word was again embedded within a sentence. In Experiments 1, 2, and 4 we varied the embedding sentence at test so that it was identical to that at study, changed but retained the meaning of the studied word, or changed to alter the meaning of the studied word. Repeated context – whether the sentence and/or the word meaning – proved to be as useful a retrieval cue for TBF items as for TBR items. In Experiment 3, we demonstrated that physical repetition was insufficient to produce context effects for either TBR or TBF items. And, in Experiment 4, we determined that participants were equally accurate in reporting context repetition/change following the correct recognition of TBR and TBF items. When considered in light of the existing literature, our results suggest that when context can be dissociated from the study item, it is encoded in "one shot" and not vulnerable to subsequent efforts to limit unwanted encoding.

Intentional forgetting is an adaptive function motivated by the desire to retain a subset of items in long-term memory while discarding others that are deemed irrelevant or outdated (Anderson, 2003; Anderson & Huddleston, 2012; Bjork, 1989). In the laboratory, intentional forgetting can be studied using a directed forgetting paradigm (see MacLeod, 1998 for a review). The list-method version of this paradigm presents participants with a mid-list instruction to remember or forget all the items that they have already rehearsed and (presumably) encoded into long-term memory. Where a *directed forgetting effect* is operationalized as better memory performance for to-be-remembered (TBR) items than to-be-forgotten (TBF) items, a directed forgetting effect obtained using the list-method paradigm is attributed to inhibition (e.g., Geiselman, Bjork, & Fishman, 1983) and/or a mental context change (e.g., Sahakyan & Kelley, 2002) that reduces the likelihood that previously encoded TBF items will be retrieved. In contrast, the item-method version of the directed forgetting paradigm presents participants with study items one at a time, each followed with equal probability by an instruction to remember or forget. A directed forgetting effect in the item-method paradigm is attributed to selective rehearsal of TBR items to the relative exclusion of TBF items. This selective rehearsal operates at encoding to limit the commitment of unwanted TBF items to long-term memory. Thus, both the method and the underlying mechanism of directed forgetting differ depending on whether the intention to forget is formed *after* the TBF items have already been committed to memory (list method) or *before* the TBF items have been encoded (item method). The current study is concerned exclusively with intentional forgetting that operates to limit unwanted encoding – *before* the TBF items have been committed to memory. We are therefore interested exclusively in the item-method paradigm and its underpinnings.

Efficient control over encoding processes ensures that limited-capacity resources are not wasted rehearsing unwanted TBF items and are, instead, focused on rehearsing TBR items. To this end, an instruction to forget in the item-method paradigm engages frontal control mechanisms (e.g., Bastin et al., 2012; Rizio & Dennis, 2013; van Hooff & Ford, 2011; Wylie, Foxe, & Taylor, 2008; Yang et al., 2012) in common with – albeit, not identical to (Fawcett & Taylor, 2010) – those used to prevent countermanded motor responses (e.g., Aron, Fletcher, Bullmore, Sahakian, & Robbins, 2003; Aron & Poldrack, 2006; Aron, Robbins, & Poldrack, 2004). Although this top-down control cannot prevent TBF item encoding entirely (Bancroft, Hockley, & Farquhar, 2013; Lee, Lee, & Tsai, 2007), it does limit further rehearsal (cf. Hourihan & Taylor, 2006) by initiating a withdrawal of attentional resources from the TBF item representation in working memory (Fawcett & Taylor, 2010; Taylor & Fawcett, 2011; Thompson, Hamm, & Taylor, 2014; Thompson & Taylor, 2015). Reflecting its episodic nature,

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this representation includes information about the location of the TBF item (Hourihan, Goldberg, & Taylor, 2007) as well as information about its perceptual attributes (Lee, Lee, & Fawcett, 2013). It also includes information about other items presented during the same encoding epoch. Accordingly, the withdrawal of attentional resources limits unwanted TBF item encoding as well as processing of non-study items that occur subsequently in close spatial/temporal proximity (Fawcett & Taylor, 2008, 2012; Lee & Hsu, 2012). Yet, in a test of context effects within an item-method directed forgetting task, Burgess, Hockley, and Hourihan (2017) argued that a forget instruction does not impact encoding of the context in which the TBF item is presented.

Context effects refer to improved episodic retrieval when study context is reinstated at test (e.g., Tulving & Thomson, 1973) – likely due to reactivation of the neural processing that had been associated with the studied item (e.g., Wing, Ritchey, & Cabeza, 2015). Burgess et al. (2017)) presented an item-method directed forgetting task in which study words were superimposed on an otherwise irrelevant background picture. Words were later tested on a background that had been presented at study or else on a novel background that contained no picture. The results revealed a directed forgetting effect, with better recognition of TBR than TBF words. There was also evidence of context effects, with better recognition of words presented on a test background that was also presented at study compared to a novel background. There was, however, no significant interaction of memory instruction and context, with TBR and TBF recognition benefiting equally from the re-presentation of a background that had been presented at study. Burgess et al. (2017) interpreted this *null* interaction as support for Malmberg and Shiffrin's (2005) "one-shot" hypothesis that context is encoded in the first 1–2 s of stimulus presentation. When the memory instruction is delayed longer than this, context is already encoded – and, by implication, unaffected by processes initiated by the memory instruction. Consequently, repetition of the context at test is as effective at cueing recognition of TBF words as TBR words.

When describing context effects, a distinction is made between *context alpha* and *context beta* (Wickens, 1987). The classic example of context alpha comes from Godden and Baddeley (1975) who showed better memory for word lists that were studied and tested in the same environmental context – both on land or both under water – rather than in a different environmental context. Context alpha is independent of the stimulus but establishes a seemingly irrelevant background that nevertheless influences performance (cf. Baddeley, 1982). In contrast, context beta interacts with the item by providing meaning to an otherwise ambiguous stimulus. The Burgess et al. (2017) manipulation of the background image on which a study word was superimposed constituted a manipulation of context alpha. It is not clear whether their conclusions also hold for context beta. Indeed, where the embedding context interacts with the TBF item to disambiguate its meaning, it seems possible that the purported withdrawal of processing resources could render the embedding information as unavailable as the item itself.

To determine whether memory instructions interact with context beta, the current study presented participants with sentences one at a time. Each sentence served as the context for an embedded noun that was designated as the study item. Each noun was a homographic homophone whose meaning was disambiguated by the embedding sentence. Critically, these same nouns were also presented in a sentence context during a subsequent yes-no recognition test. The key manipulation was the relationship between the study and test sentence contexts. Nouns at test were a) embedded in the same sentence and thus shared the same meaning as at study (Same sentence, Same meaning: SsSm); b) embedded in a different sentence but nevertheless had the same meaning as at study (Different sentence, Same meaning: DsSm); or c) embedded in a different sentence that established a different meaning for the noun relative to study (Different sentence, Different meaning: DsDm). For example, if the designated study word was *coach* embedded in the sentence "Drinks and snacks were available in the third coach of the train", then at test participants might be presented with this same sentence again, in which case the sentence and the designated noun meaning remained unchanged (SsSm); an altered sentence in which the designated noun retained the same meaning, e.g., "The horse-drawn coach rattled noisily over the cobblestone drive" (DsSm); or, an altered sentence in which the designated noun assumed a different meaning, "Peter sometimes felt like he could use a life coach" or "The football coach was tough but the players liked her" (DsDm). Because each designated noun in our study had more than one possible interpretation, the embedding sentence served to constrain the interpretation and establish the intended meaning.

The critical question was whether the repetition of context – viz. repeated sentence (e.g., SsSm vs DsSm) and/or word meaning (e.g., DsSm vs DsDm) – was equally effective in cueing TBR and TBF item recognition. Certainly, there should be context effects for TBR items, with improved recognition due to contextual overlap between study and test. The prediction for the TBF items is less clear. On the one hand, if the attempt to limit unwanted encoding of an ambiguous TBF item also limits the encoding of its disambiguating context, overlap in study-test context should provide relatively little cueing of TBF item recognition. With benefits to TBR item recognition but not TBF item recognition, directed forgetting effects (defined as the difference in TBR and TBF item recognition) should therefore be larger when context repeats between study and test. On the other hand, if context beta – like context alpha – is encoded in "one-shot" within the first seconds of stimulus presentation, TBF items should benefit from contextual cueing as much as TBR items (e.g., Burgess et al., 2017). As a result, the magnitude of the directed forgetting effect should not vary as a function of context repetition across study and test.

1. Experiment 1

In Experiment 1, embedding sentences disambiguated the meanings of homographic homophones that served as study words in an item-method directed forgetting task. At test, these words were presented in one of three conditions: Same sentence-Same meaning (SsSm); Different sentence-Same meaning (DsSm); and, Different sentence-Different meaning (DsDm).

Note that there was no Same sentence-Different meaning (SsDm) condition as might be expected if our experimental manipulation of context reflected a factorial crossing of sentence identity and noun meaning. To understand this, it is critical to keep in mind that in all three of our context conditions – SsSm, DsSm, DsDm – the embedded noun repeated at study and test, even when the noun meaning changed. It is logically impossible for the same noun (e.g., *coach*) to appear in the same sentence at *both* study and test ("Drinks and snacks were available in the third ___ of the train") and yet have a different meaning in each instance. Thus, there was no possibility of including SsDm as one of the experimental context conditions in which the studied nouns repeated at test.[1]

1.1. Method

1.1.1. Participants

A total of 48 Dalhousie undergraduate students participated in

[1] One might argue that even if it could not serve as an experimental context condition, the "missing" SsDm condition could nevertheless serve as a type of foil trial at recognition by replacing the studied noun with an unstudied noun. There are two problems with this. First, for the sentence to remain sensible generally requires inserting a synonym in place of the studied word – for example, the word *carriage* when *coach* refers to a conveyance and the word *instructor* when it does not. In this way, the sentence could remain the same at study and test (Ss); however, using a synonym for the studied word would not constitute a different meaning (Dm) for the embedded noun (as would be required to create a SsDm condition). Second, these synonyms would not necessarily be homographic homophones in each case. Participants could therefore reject these unstudied words on this basis alone, making them poor foils for testing recognition memory of studied words.