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Distinctive Sans Forgetica Font Does Not Benefit Memory Accuracy in the DRM Paradigm

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by

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ABSTRACT

A common method used by memory scholars to enhance retention is to make materials more challenging to learn—a benefit termed desirable difficulties. Recently, researchers have investigated the efficacy of Sans Forgetica, a perceptually disfluent or distinctive font, which may increase the processing effort required at study and, as a result, enhance memory. We examined the effects of Sans Forgetica relative to a standard control font (Arial) on both correct memory and associative memory errors using the Deese/Roediger-McDermott (DRM) false memory paradigm. Across four experiments which included nearly 300 participants, Sans Forgetica was found to have no impact on correct or false memory of DRM lists relative to a standard Arial control font when font type was manipulated in both within- and between-subject designs and when memory tests involved free recall and recognition. Our results indicate that Sans Forgetica is insufficient to induce a memory accuracy benefit even when accounting for associative memory errors.

Keywords: Sans Forgetica, Associative Memory Errors, Free Recall, Recognition, Distinctiveness

DEDICATION

I could never extend enough gratitude to my family, friends, and significant other for their unconditional love and eternal support, so I would like to dedicate this thesis to them. They are the entire plane of my existence, and I do not know what I would without any of them. Thank you.

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BAS	Backward Associative Strength
DRM	Deese-Roediger McDermott (associative false memory paradigm J
RMIT	Royal Melbourne Institute of Technology
SF	Sans Forgetica

CHAPTER I: INTRODUCTION

Memory researchers are highly invested in discovering techniques that can promote memory accuracy. While dozens of strategies have been identified, including those that affect processes occurring at study and test (see Neath, 1998, for review), tasks that improve encoding processes are often focal given they are simple to manipulate and produce reliable benefits. Effective encoding tasks often operate to enhance semantic processing of study materials. Based on the levels-of-processing framework (Craik & Lockhart, 1972), effective encoding tasks (often termed "deep" processing tasks) qualitatively affect the processing of study materials which improve later correct recall and recognition. For instance, deep tasks can facilitate semantic processing of study materials and/or may enhance the distinctiveness of individual study items, making them more memorable (see Gallo et al., 2008, for review; Fisher & Craik, 1977). Deep tasks are often contrasted to "shallow" or "neutral" (a read-only or intentional encoding) tasks which do not enhance semantic processing or distinctiveness. While over 50 years of memory research has affirmed the advantage for deep encoding tasks (though interactions can occur with retrieval context; see Blaxton, 1989; Morris et al., 1977), the present study evaluated whether a recently developed disfluent/distinctive font type termed Sans Forgetica can similarly produce correct memory benefits relative to a standard evaluated by evaluating font effects on both correct memory and associative memory errors.

Sans Forgetica font was recently developed by a team of researchers from the Royal Melbourne Institute of Technology (RMIT) with the goal of producing a font that would aid memory retention. This font is characterized by an italicized, back slanted, and hashed style that presumably requires additional processing effort to perceive and encode (see Illustration 1 for examples). While challenging at study, these additional efforts often produce memory benefits which is a pattern termed desirable difficulties. The memorial benefits of these difficulties have been well-supported by previous research (see Bjork, 1994; Bjork & Bjork, 2011, for reviews of desirable difficulties). For instance, generating words at study either through stem-completions or solving anagrams produces correct memory benefits relative to studying words intact (Bertsch et al., 2007; Huff & Bodner, 2013; Slamecka & Graf, 1978). Similar patterns have also been reported via production (saying words aloud vs. silently; Ozubko & MacLeod, 2010; Fawcett, 2013) and drawing images of a word's referent compared to studying the words intact (Namias et al., in press; Wammes et al., 2016). Similarly, Rosner et al. (2015) found that blurring words can improve memory relative to non-blurred words. Collectively, additional efforts that operate at encoding can facilitate memory, and these benefits manifest in many effortful study tasks.

Consistent with desirable difficulties, early evidence using Sans Forgetica font yielded similar memory benefits. Specifically, the RMIT team presented university undergraduates with a set of word pairs that were displayed in one of three different types of broken or disjointed formats that varied between slight, moderate, and extreme disfluency and one set of word pairs presented in a standard fluent Arial font. Pairs presented in the moderate disfluent font were better remembered than the slight and extreme disfluency formats (8% improvement) and only slightly better (1%) than the fluent font. In a second dataset collected online, the moderate disfluent font was directly compared to a standard Arial font and a 7% memory benefit was reported (see Earp,

2018) . Thus, Sans Forgetica appeared to be a method for improving memory consistent with desirable difficulties.

Although initial benefits of Sans Forgetica were encouraging for both basic and applied contexts given the relative ease in which textual font types can be adjusted for educational materials, the effects of disfluent font types on memory are mixed. Some disfluent fonts/word presentations have been shown to produce memory benefits (e.g., Deimand-Yauman et al., 2011; Sungkhassettee, et al., 2011). However, presenting study materials in disfluent or unique fonts has also been shown to produce no effects on memory (Arndt & Reder, 2003; Rhodes & Castel, 2008), and in some cases, can produce a memory cost (Eitel & Kühl, 2016; Kühl et al., 2014; Maxwell et al., in press; Yue, et al., 2013). However, a meta-analysis (Xie et al., 2018), indicated that perceptual disfluency, which included study materials that were perceptually distorted, were found to produce no effect on later recall relative to non-distorted controls.

More recently, researchers have directly compared the memory effects of Sans Forgetica words relative to words presented in a standard font type. Using a within-subject design, Taylor et al. (2020) reported that Sans Forgetica font yielded a memory cost for target memory following study of cue-target pairs and no effect of font type for cued-recall of prose passages and of educational materials relative to a standard Arial font type. The lack of Sans Forgetica benefits occurred despite participants rating Sans Forgetica items as being subjectively more challenging to read than materials in Arial font. Similar null effects on educational materials were echoed by Geller et al. (2020) who found that Sans Forgetica had no effect on recognition discriminability. Finally, Maxwell et al. (in press) found a Sans Forgetica cost on target recall of word pairs and that participants did not expect Sans Forgetica pairs to be better remembered at study based on judgments of learning provided at study. Collectively, presenting study materials via Sans Forgetica font does not appear to produce a memory benefit relative to a control font and may even produce a memory cost when participants study cue-target pairs.

Despite relatively consistent findings that disfluent fonts do not procure an advantage to correct memory, they may still benefit overall memory accuracy when errors are considered. A common method for examining the effects of errors on memory accuracy is by using study materials that are conducive to commission errors such as the Deese/Roediger-McDermott (DRM; Deese, 1959; Roediger & McDermott, 1995) paradigm. In this paradigm, participants study lists of associatively related word lists (cake, nice, sugar, etc.) that are directly related to a non-presented critical lure (e.g., sweet). At test, participants are highly susceptible to falsely remembering the critical lure, a pattern termed the DRM illusion. False recall can eclipse 50% (Roediger & McDermott, 1995) and false recognition can approach and even exceed hit rates of studied list items (see Gallo, 2006; Huff & Bodner, 2014, for reviews; Lampinen et al., 1999). Given that memory and intrusions and false alarms are far more common for associatively related items, an important question is whether a distinctive font such as Sans Forgetica might reduce false memory errors despite evidence indicating that Sans Forgetica is ineffective at facilitating correct memory.

There is reason to expect that distinctive fonts may benefit overall accuracy in the DRM paradigm through the reduction of memory errors. For instance, Israel and Schacter (1997; see too Schacter et al., 1999) found that the DRM illusion was reduced when

DRM list items were studied alongside a picture of the word's referent relative to studying words in isolation. Moreover, this pattern occurred despite picture presentations not consistently showing a concomitant increase in correct recognition of list words. Similar reductions in false recall and recognition have also been reported with other types of distinctive manipulations such as generation of DRM list words from anagrams (Gunter et al., 2007; McCabe & Smith, 2006), generating mental images of individual words (Oliver et al., 2016; Robin, 2010), drawing images of words (Namias et al., in press), and using study tasks such as pleasantness ratings which encourage the processing of item-specific characteristics (Huff & Bodner, 2013; Huff et al., 2015; McCabe et al., 2004). Aside from picture encoding studies, most distinctive manipulations also induce a mirror effect pattern in which correct memory increases while false memory decreases relative to a read-only/intentional encoding control group.

More germane to Sans Forgetica, distinctive fonts have also been manipulated when evaluating the DRM false memory illusion. Arndt and Reder (2003) presented participants with DRM lists in which all words were presented using the same font (i.e., a non-distinctive condition) or were presented such that each list word was presented in a unique font (i.e., a distinctive condition). Overall, presenting DRM lists in the same or unique font had no effect on correct recognition of list words, but unique fonts reduced false recognition of critical lures and this pattern was found in both between- and within-subject designs. When considered alongside studies using Sans Forgetica, Arndt and Reder's findings suggest that distinctive/unique fonts may be ineffective at improving correct recognition but may still benefit overall memory accuracy by reducing false recognition of critical lures.

The present study tested this possibility by comparing correct and false memory for DRM study lists that were presented in either Sans Forgetica or standard Arial font. First, in Experiments 1A and 1B, participants studied a series of DRM lists presented in either Sans Forgetica or Arial font and were then tested via free recall. Importantly, font effects were manipulated both within- and between-subjects (Experiment 1A and 1B, respectively). We assessed the effects of experimental design given that distinctive encoding effects such as pictorial encoding have been shown to be effective at reducing the DRM illusion in between-subject but not within-subject designs, suggesting the use of a global distinctiveness heuristic (Schacter et al., 2001; see Huff et al., 2015 for further discussion). Experiments 2A and 2B then tested whether Sans Forgetica could reduce false memory using old/new recognition rather than free recall. Like Experiment 1, Experiment 2 similarly tested for these effects using both within-subject (2A) and between-subject (2B) designs. Thus, any reductions in the DRM illusion occurring as a function of font type were expected regardless of whether participants completed free-recall or recognition testing, as distinctive encoding has been shown to be effective at reducing the DRM illusion for both test types (Huff & Bodner, 2013; 2019). Finally, any reductions in the DRM illusion that occurred as a function of font type were expected to occur regardless of whether participants completed free-recall or recognition testing, as distinctive encoding has been shown to be effective at reducing the DRM illusion for both test types (Huff & Bodner, 2013; 2019).

CHAPTER II: EXPERIMENTS 1A and 1B

Experiment 1A: Arial vs. Sans Forgetica Within-Subject Recall

The goal of Experiment 1A was to test whether Sans Forgetica font would benefit memory within the context of the DRM paradigm using a within-subject design. Because previous research has shown no benefit of Sans Forgetica on correct memory (e.g., Geller et al., 2020; Maxwell et al., in press), we similarly expected no benefit in correct recall for items presented in Sans Forgetica relative to Arial font. However, given that previous work by Arndt and Reder (2003) showed that presenting DRM lists using unique, distinctive fonts reduced the DRM illusion, we anticipated that Sans Forgetica would produce a similar reduction, such that false recall of critical items would be lower when study lists were presented using Sans Forgetica relative to Arial font.

Methods

Participants. Forty University of Southern Mississippi undergraduates were recruited to participate in the experiment for partial course credit. Participants were recruited online. Data from eight participants were eliminated for either failing to complete memory tests for all study lists ($n = 4$) or for prefect or near-perfect recall (suggestive of cheating; $n = 4$) leaving 32 participants available for analysis. A sensitivity analysis using G*POWER 3 (Faul et al., 2007) indicated that the sample had adequate statistical power (.80) to detect medium effect sizes of Cohen's $d = 0.44$ and larger. All participants reported normal or corrected-to-normal color vision.

Materials. Twenty DRM lists with the highest backward associative strength (BAS) from Roediger et al. (2001) served as study materials. Each list contained 12 total items and words were presented in descending order of BAS. Words were displayed for

2.5 s each. Lists were divided into two sets of 10 lists that were matched on BAS and were counterbalanced across participants. List order was once randomized and presented in the same order across participants. From these two sets of lists, half were presented in a standard 32 pt. Arial font, whereas the other half were presented in a 32 pt. Sans Forgetica font. Lists alternated between Arial and Sans Forgetica font types and two additional counterbalances were created in which one version started with Arial font type such that list fonts alternated Arial, Sans Forgetica, Arial, etc. and the other started with Sans Forgetica font type and alternated Sans Forgetica, Arial, Sans Forgetica, etc. During study, lists were separated by a filler task which consisted of a word-generation task in which participants were given a letter and asked to generate as many words that begin with that letter as possible. The letter that was used for the filler tasks were also once randomized and presented in the same order across participants.

Procedure. Participants were tested online via *Collector*, an open-source program designed to proctor web-based experiments in Psychology (Garcia & Kornell, 2015). Following informed consent, participants were instructed that they would view a series of word lists and that after each list they would complete a memory test that was not specified. No explicit encoding strategy was requested, and participants were not informed that the word lists would be presented in different fonts. Following the presentation of the first list, participants completed a 60 s filler task in which they were to list as many words as they could that begin with a specified letter (e.g., “K”). Immediately following the filler task, participants then completed a free-recall test in which they were instructed to recall as many words from the most recent study list as they could without penalty for error. They were further informed that they would have 60 s to complete the test. Following the test phase, the computer program immediately advanced to an instruction screen informing the participant that they would study another list which would be followed by another memory test. Participants repeated this cycle until all 10 DRM lists were studied and tested. Following the final test phase, participants completed a brief demographics questionnaire and were fully debriefed regarding the study. The experimental duration was less than 30 minutes.

Experiment 1B: Arial vs. Sans Forgetica Between-Subject Recall

Next, Experiment 1B tested whether Sans Forgetica would affect recall in the DRM paradigm using a between-subject design. We again expected that correct recall would not differ between items presented in Sans Forgetica and Arial fonts, and, further, that participants in the Sans Forgetica group would show a reduction in the DRM illusion compared to participants in the Arial group. Thus, we anticipated that any effects of Sans Forgetica on false recall would not be restricted to a within-subject design.

Methods

Participants. One-hundred-four University of Southern Mississippi undergraduates were recruited to participate in the study for partial course-credit. Participants were recruited online and were randomly assigned to either the standard-font group or the Sans Forgetica font group. Data from 10 participants was eliminated for either failing to complete memory tests for all study list (n = 3), or perfect or near-perfect recall suggesting cheating (n = 7). After these participants were eliminated, 44 were available in the standard-font group, and 50 in the Sans Forgetica group. A sensitivity analysis again indicated that the sample had adequate statistical power (.80) to detect medium effect sizes of Cohen's *d* = 0.52 or larger. All participants reported normal or corrected-to-normal vision.

Materials and Procedure. The materials and experimental procedures used in Experiment 1B were identical to that of Experiment 1A with one exception. Specifically, depending upon group assignment, participants only saw lists presented in a standard Arial font or in the Sans Forgetica font. As a result, only the list set was counterbalanced across participants.

Results: Experiments 1A and 1B

Proportions of correct recall of list items, false recall of critical lures, and mean number of extra-list intrusions recall per list as a function of standard and Sans Forgetica fonts are reported in Table 1 for Experiment 1A and 1B. A $p < .05$ significance criterion was adopted for all analyses. For brevity, *p*-values are not reported for statistically reliable comparisons. For non-reliable comparisons, a further test using a Bayesian estimate of the strength supporting the null hypothesis was conducted (Masson, 2011; Wagenmakers, 2007). In this analysis, a model which assumes a null effect is compared to a model which assumes an effect. A *p*-value is then computed (termed p_{BIC}; Bayesian Information Criterion), which provides an estimate of the probability that the null hypothesis is retained. Null effects are therefore supplemented with this Bayesian analysis to increase the confidence in the reliability of null results.

Correct recall was found to be equivalent for lists presented in both a standard Arial font and in the Sans Forgetica font both when font type was manipulated within-subjects in Experiment 1A (.53 vs. .54, for standard and Sans Forgetica fonts, respectively), $t < 1$, $p_{BIC} = .86$, and when font type was manipulated between-subjects in

Experiment 1B (.59 vs. .56), $t(42) = 1.13$, $SEM = .03$, $p = .26$, $p_{BIC} = .83$. This equivalence extended to false recall of critical lures where standard and Sans Forgetica fonts produced similar rates both in Experiment 1A (.27 vs. .32), $t(42) = 1.13$, $SEM = .04$, $p = .26$, $p_{BIC} = .77$, and in Experiment 1B (.27 vs. .31), $t < 1$, $p_{BIC} = .86$. Finally, mean numbers of extra-list intrusions did not differ between standard and Sans Forgetica fonts in either Experiment 1A (.27 vs. .26), $t < 1$, $p_{BIC} = .86$, or Experiment 1B (.26 vs. .22), $t < 1$, $p_{BIC} = .88$. Thus, Sans Forgetica font type had no effect on correct or false recall in either within- or between-subject contexts.

Discussion

Experiments 1A and 1B tested the effects of Sans Forgetica font on correct recall within the DRM paradigm. In doing so, we tested whether the distinctive nature of Sans Forgetica would 1) improve correct recall for studied items relative to Arial font and 2) whether Sans Forgetica would reduce the DRM illusion by lowering false recall of non-presented critical items. Consistent with our predictions, correct recall did not differ between items presented in Sans Forgetica or Arial fonts, regardless of whether font type was manipulated within- or between-subjects. Similarly, false recall of non-presented critical items did not differ between font types. Thus, Sans Forgetica font was ineffective at reducing the DRM illusion.

Our finding that correct recall did not differ as a function of font type is in line with previous research showing no memorial benefit of Sans Forgetica when compared to a more perceptually fluent font (e.g., Geller et al. 2020; Maxwell et al., in press; Taylor et al., 2020). Additionally, our extension of this null pattern to false recall provides further evidence that Sans Forgetica is not effective at improving memory accuracy. However, given that encoding manipulations have also been shown to be effective at reducing the DRM illusion when recognition testing is used (e.g., Huff & Bodner, 2013; 2019), it may be the case that Sans Forgetica would be effective at reducing the illusion for this test type. Experiments 2A and 2B were designed to test this possibility using within- and between-subject designs.

CHAPTER III: EXPERIMENTS 2A AND 2B

Experiment 2A: Arial vs. Sans Forgetica Within-Subject Recognition

The primary goal of Experiment 2A was to test whether Sans Forgetica font would reduce the DRM illusion on recognition. Like Experiments 1A and 1B, we expected that Sans Forgetica would produce no benefit on correct recognition, given previous research by Geller et al. (2020) showed that null effects of Sans Forgetica versus Arial fonts extend to recognition tests. Recognition testing, however, may be more sensitive towards detecting Sans Forgetica effects, provided Sans Forgetica is promoting distinctive/item-specific processing. Indeed, free recall tests benefit from improved organization which is promoted via relational encoding and not item-specific encoding. In contrast, items in recognition tests are often presented randomly and therefore may benefit from item-specific encoding (Huff & Bodner, 2014; McDaniel et al., 1988). Therefore, we expected that recognition testing would be more sensitive at detecting Sans Forgetica effects on memory, particularly on false recognition which is highly sensitive to item-specific processing (Huff & Bodner, 2013).

Our adoption of recognition tests also allowed for the application of a signal-detection analysis to provide estimates of both encoding and monitoring processes (see Huff & Bodner, 2015 for an in-depth discussion of applying signal detection to the DRM paradigm). Signal detection attempts to separate memory experiences for studied and non-studied items from bias, or the relative tendency to report that a test item was studied. Using this analysis, we will generate two parameter estimates. The first parameter is discriminability (or d') which refers to the standardized mean distance between the hit rate and false alarm distributions. We interpret d' as an index of the amount of memory information encoded for a particular item type. This parameter can also be extended to DRM critical lures in which false alarms to critical lures are treated as hits and are compared to false alarms to critical lure controls (i.e., DRM critical lures from lists that were not studied). This analysis can therefore provide an estimate of the amount of memory information encoded for studied list items and DRM critical lures. The second parameter is a bias measure termed lambda (or λ), which is computed as the *z*-score of 1 minus the false alarm rate to control items. Higher lambda estimates suggest a more conservative response bias, which we interpret as evidence for more (vs. less) test-based monitoring. Therefore, to provide a more comprehensive assessment of Sans Forgetica effects on recognition, we provide signal-detection estimates to accompany standard hit and false alarm recognition analyses.

Methods

Participants. Fifty-three University of Southern Mississippi undergraduates completed the study online for partial course credit. Data from eight participants were eliminated due to excessive false alarm rates to non-studied control items (> 90%), indicating that participants were repeatedly pressing the "old" key and were not following directions. Forty-five participants were available for analysis. A sensitivity analysis again indicated that the sample had adequate statistical power (.80) to detect small-to-medium effect sizes of Cohen's $d = 0.38$ or larger. All participants reported normal or corrected-to-normal color vision.

Materials and Procedure. All study materials and procedures were the same as those used in Experiment 1A with the following exceptions. First, the recall test was replaced with an 80-item old/new recognition test in which all items were presented in the standard 32-pt. Arial font. The test was composed of 30 list items (15 from standard and Sans Forgetica list types) taken from presented study lists (positions 2, 8, and 10), 10 critical lures from studied lists (5 from standard and Sans Forgetica list types), 30 list item controls taken from the counterbalanced set that was not studied (from the same positions as the list items), and 10 critical lure controls taken from the non-studied counterbalance. Participants studied all 10 lists back-to-back with an instruction screen in between indicating that a new list would be presented. Participants did not complete a filler task in between lists. After the final list was presented, participants were informed that they would complete an old/new recognition test in which a test item would be presented on the center of the screen and they were to use their mouse to click on the "old" button if the word was studied, and the "new" button if the word was not studied. Participants were encouraged to respond as quickly as possible but not to compromise accuracy. Following the recognition test, participants completed the same brief demographics questionnaire and debriefing as Experiment 1A.

Experiment 2B: Arial vs. Sans Forgetica Between-Subject Recognition

Experiment 2B tested whether Sans Forgetica font would reduce the DRM illusion for recognition testing when font-type was manipulated between subjects. Like Experiment 2, we again expected that correct recognition of list items would not differ between items presented in Sans Forgetica and Arial fonts. Furthermore, false recognition of critical items was not expected to differ as a function of font. Thus, we expected that Sans Forgetica would not be an effective means of reducing false recognition in the DRM paradigm, regardless of whether font-type was manipulated within or between subjects.

Methods

Participants. An additional 124 University of Southern Mississippi undergraduates completed the study for partial course credit. Participants were randomly assigned to either the standard-font group, or the Sans Forgetica font group. Data from eight participants were eliminated due to either excessive false alarms to non-studied control items (> 90%; $n = 5$), or due to excessive misses on studied list items (hit rates < 10%), the latter of which indicates that participants were repetitively pressing the "new" button. In both cases, participants likely did not follow study instructions. Of the remaining participants, 58 were in the standard-font group, and 58 were in the Sans Forgetica font group. A sensitivity analysis again indicated that the sample had adequate statistical power (.80) to detect medium effect sizes of Cohen's $d = 0.46$ or larger. Again, all participants had normal or corrected-to-normal vision.

Materials and Procedure. The same materials and procedure from Experiment 2A, including the recognition test, were used. The only difference was that, like Experiment 1B, participants only studied items from one list type (either standard Arial font or Sans Forgetica font).

Results: Experiments 2A and 2B.

Like in Experiment 1, a $p < .05$ level of significance was adopted for all reported analyses. For the signal-detection analyses, false alarm rates of 0 and hit rates of 1 were adjusted using Macmillan and Creelman's (1991) 1/2*n* correction. Mean proportions of correct recognition of list items, false recognition of critical lures, and their corresponding signal-detection indices are reported in Table 1.

For correct recognition, an index of discriminability (*d′*) was computed by taking the *z*-score of the hit rate for studied items minus the *z*-score of the false alarm rate for list item controls. For false recognition, *d′* was similarly computed, but false alarms to critical lures were treated as hits and false alarms to critical lure controls were subtracted. Memory monitoring was also computed (λ), which was calculated by taking the *z*-score1 minus the false alarm rate to list item controls to estimate correct recognition monitoring, and the *z*-score of 1 minus the false alarm rate to critical lure controls to estimate false recognition monitoring (cf. Huff & Bodner, 2013).

Starting with correct recognition of studied list items in Experiment 2A (within-subjects), standard and Sans Forgetica fonts were found to be similar in both in raw hit rates (.70 vs. .70), $t < 1$, $p_{BIC} = .87$, and in estimates of *d′* (1.58 vs. 1.58), $t < 1$, $p_{BIC} = .87$. A similar pattern was found in between-subject groups in Experiment 2B where again, hit rates were again equivalent between standard and Sans Forgetica font types (.70 vs. .66), $t(114) = 1.28$, $SEM = .03$, $p = .20$, $p_{BIC} = .83$, and in *d′* (1.57 vs. 1.42), $t(114) = 1.03$, $SEM = .14$, $p = .31$, $p_{BIC} = .86$. Given the between-subject design in Experiment 2B, estimates of memory monitoring (λ) were computed for correct recognition in both font types. Monitoring however was also t equivalent between standard and Sans Forgetica fonts (0.97 vs. 0.96), $t < 1$, $p_{BIC} = .91$.

Turning to false recognition of critical lures, in Experiment 2A, standard and Sans Forgetica fonts again produced equivalent false recognition (.66 vs. .65), $t < 1$, $p_{BIC} = .87$, and equivalent *d′* rates (1.19 vs. 1.16), $t < 1$, $p_{BIC} = .86$. In Experiment 2B, false recognition of critical lures was similar between standard and Sans Forgetica fonts (.70 vs. .66), $t(114) = 1.09$, $SEM = .04$, $p =.28$, $p_{BIC} = .86$, as was *d′* (1.27 vs. 0.99), $t(114) =$

1.84, *SEM* = .15, $p = .07$, $p_{BIC} = .66$, though this latter comparison was marginally significant. Finally, standard and Sans Forgetica fonts also yielded equivalent memory monitoring for critical lures (0.65 vs. 0.54), $t < 1$, $p_{BIC} = .88$.

Discussion

The results of Experiments 2A and 2B are quite clear. First, consistent with our findings in Experiment 1 as well as other studies showing Sans Forgetica to be ineffective at promoting correct memory (e.g., Geller et al., 2020; Maxwell & Huff, in press), Sans Forgetica produced no benefit on correct recognition relative to list items presented in Arial font. Second, Sans Forgetica was ineffective at reducing the DRM illusion for recognition testing, as false recognition of critical lures did not differ between Sans Forgetica and Arial lists. Finally, like the previous experiment, null effects of Sans Forgetica held regardless of whether font-type was manipulated within- or between-subjects. Thus, it is evident that Sans Forgetica is not effective at reducing the DRM illusion

CHAPTER IV: GENERAL DISCUSSION

Sans Forgetica is a perceptually disfluent font designed to improve retention via desirable difficulties. Recently, however, the benefits of this font on learning have been disputed. Although previous research suggests that Sans Forgetica is not effective at promoting retention (e.g., Geller et al., 2020; Maxwell et al., in press, Taylor et al., 2020), the present study tested whether the distinctive nature of this font would be beneficial at improving memory accuracy within the DRM paradigm. Specifically, we assessed whether Sans Forgetica could reduce the DRM illusion by reducing false recall/recognition of critical items. The present study therefore provided an additional method for testing the efficacy of Sans Forgetica, as previous research has only assessed this font within the context of correct memory for studied items. Each experiment provided a further test of whether Sans Forgetica would be beneficial to retention of studied items within the context of recall and recognition testing (Experiments 1 and 2, respectively). Thus, in addition to testing the effects of Sans Forgetica on the DRM illusion, our experiments also provided additional opportunities to replicate previous work showing Sans Forgetica does not promote memory for studied items.

Overall, Sans Forgetica consistently failed to improve correct memory for studied items, as proportions of correctly remembered list items did not differ between Sans Forgetica and Arial lists, regardless of whether participants were tested via free-recall (Experiments 1A and 1B) or recognition testing (Experiments 2A and 2B). The present study therefore replicated previous work showing Sans Forgetica does not produce a memorial benefit compared to an Arial control font while extending these findings to include associative word lists as opposed to cue-target pairs (e.g., Geller et al., 2020, Experiment 1; Maxwell et al., in press). Importantly, the present study also showed that Sans Forgetica was ineffective at reducing the DRM false memory illusion. Across experiments, proportions of falsely recalled/recognized critical items did not differ between lists encoded via Sans Forgetica or Arial font. Furthermore, these null effects of font-type were observed regardless of whether fonts were manipulated within subjects (Experiments 1A and 2A) or between subjects (Experiments 1B and 2B). Comparisons of signal detection parameters for encoded memory information (d') and test-based memory monitoring (λ) were similarly equivalent between the two fonts, indicating that underlying memory processes in recognition are also not sensitive to font differences. Thus, the present study replicated previous research showing no benefit of Sans Forgetica on correct memory while subsequently extending this finding to include false memories within the DRM paradigm.

Our repeated finding that Sans Forgetica was ineffective at benefitting correct recall/recognition of list items is consistent with previous research showing this font is ineffective at promoting later retention. Previous research has commonly reported no memorial benefits (and even memorial costs) for material encoded using Sans Forgetica relative to standard fonts such as Arial. For example, Taylor et al. (2020) recently showed that Sans Forgetica produced no memory benefits when this font was applied to text passages, and additionally, showed that this font produced a memory cost on recall of cue-target word pairs. Similarly, Geller et al. (2020) found Sans Forgetica to be ineffective at improving both cued-recall and recognition memory. Finally, Maxwell et al. (in press) similarly showed that Sans Forgetica did not benefit recall of cue-target pairs and, instead, produced a memory cost. Furthermore, participants ’JOL ratings did not differ between cue-target pairs presented in Sans Forgetica or Arial. Taken together, it is evident that Sans Forgetica is not beneficial to memory, and furthermore, participants do not expect this font to improve later remembering.

While our findings are consistent with previous research showing no benefit of Sans Forgetica on retention of studied items, a novel finding from the present study is that this font is similarly ineffective at reducing false memories in the DRM paradigm. Due to previous research has shown that a variety of distinctive encoding measures including generation (Gunter et al., 2007; McCabe & Smith, 2006), drawing (Namias et al., in press; Wammes et al., 2016), and, importantly, font manipulations (Arndt and Reder, 2003) are effective at reducing false memories within the DRM paradigm, we reasoned that the distinctive nature of Sans Forgetica would similarly reduce false memories relative to a control font. At first glance, our results appear discrepant with Arndt and Reder who reported that presenting DRM list words in different fonts (vs. the same font) reduced the DRM illusion. However, it is important to clarify that Arndt and Reder's unique font conditions presented each DRM list word in a different font that was not shared with any other words within the list. In contrast, while we reasoned that Sans Forgetica would be a distinctive type of font, all words within a given list were presented using the same typeface (i.e., Sans Forgetica or Arial), with fonts only differing between DRM lists (Experiments 1A and 2A) or between participants (Experiments 1B and 2B). Therefore, font manipulations may still be effective at reducing the DRM illusion, but lists cannot simply use a "distinctive" type font for all words, as each word may need to be presented using a unique font.

Collectively, our findings that Sans Forgetica yields no benefits on correct or false memories within the DRM paradigm provide further evidence that this font is not beneficial for learning. Thus, while Sans Forgetica is purported by its developers to improve retention via desirable difficulties, it appears that either the disfluent nature of this font does not produce sufficient difficulties necessary to trigger a memory improvement or any encoding difficulties of this font are simply not desirable for learning. Furthermore, although desirable difficulties have been shown to occur in a variety of contexts (see Bjork & Bjork, 2020, for review), it is not always clear what level of task difficulty is necessary to facilitate retention (e.g., McDaniel & Butler, 2010), and further, studies investigating font disfluency on memory have produced mixed results (e.g., Eitel et al., 2014; Rhodes & Castel, 2008). Additionally, the effects of desirable difficulties on learning have been shown to be moderated by individual differences in intelligence (Wenzel & Reinhard, 2019). Likewise, Eskenazi and Nix (2021) recently showed that within the context of learning spellings and definitions of low-frequency words, any benefits of Sans Forgetica on learning were moderated by individual differences in spelling/reading ability. Specifically, high-skill individuals showed improved learning for both definitions and spellings when words were presented using Sans Forgetica relative to a control font. Low-skill spellers, however, showed no difference between Sans Forgetica and control font items. Thus, future research assessing the efficacy of Sans Forgetica on retention may wish to control for these factors along with other individual differences measures related to memory (e.g., measures of attentional control, working memory capacity, etc.). Ultimately, however, our findings support the notion that disfluent fonts do not encourage the type of processing that is beneficial for retention (Xie et al., 2018).

Conclusion

In sum, the present study tested the effects of Sans Forgetica on correct memory while also assessing whether this font would be used to improve memory accuracy in the DRM paradigm by reducing false recall and recognition. Across four experiments, we replicated existing research showing that Sans Forgetica produced no benefit on correct recall/recognition of list items compared to Arial font, regardless of whether font-type was manipulated between- or within-subjects (e.g., Geller et al., 2020; Maxwell et al., in press; Taylor et al., 2020). Additionally, we showed that Sans Forgetica produced no benefits on overall DRM accuracy, as false memory occurrences similarly did not differ between fonts. Thus, the present study adds to the existing literature showing Sans Forgetica is not an effective tool for promoting retention.

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Table 1. Mean (± 95% CI) Proportions of Correct and False Recall and "Old" Recognition Responses and Signal-Detection Indices for Experiments 1 and 2.

	Experiment 1A Within Recall		Experiment 1B Between Recall	
List Type	Standard Lists	SF Lists	Standard Lists	SF Lists
N	43		44	50
Correct Recall	.53 (.04)	.54 (.04)	.59 (.04)	.56 (.03)
False Recall	.27 (.07)	.32 (.07)	.27 (.06)	.31 (.05)
# Intrusions per List	0.27 (.10)	0.26 (.12)	0.26 (.08)	0.22 (.07)
	Experiment 2A Within Recognition		Experiment 2B Between Recognition	
List Type	Standard Lists	SF Lists	Standard Lists	SF Lists
N	45		58	58
List Items	.70 (.05)	.70 (.05)	.70 (.04)	.66 (.04)
List Item Controls	.21 (.04)		.21 (.04)	.21 (.04)
List Item *d′*	1.58 (.26)	1.58 (.24)	1.57 (.21)	1.42 (.18)
List Item λ	0.97 (.18)		0.97 (.17)	0.96 (.17)
Critical Items	.66 (.08)	.65 (.08)	.70 (.06)	.66 (.06)
Critical Item Controls	.24 (.06)		.29 (.06)	.33 (.06)
Critical Item *d′*	1.19 (.24)	1.16 (.24)	1.27 (.22)	0.99 (.21)
Critical Item λ	0.75 (.17)		0.66 (.19)	0.54 (.19)

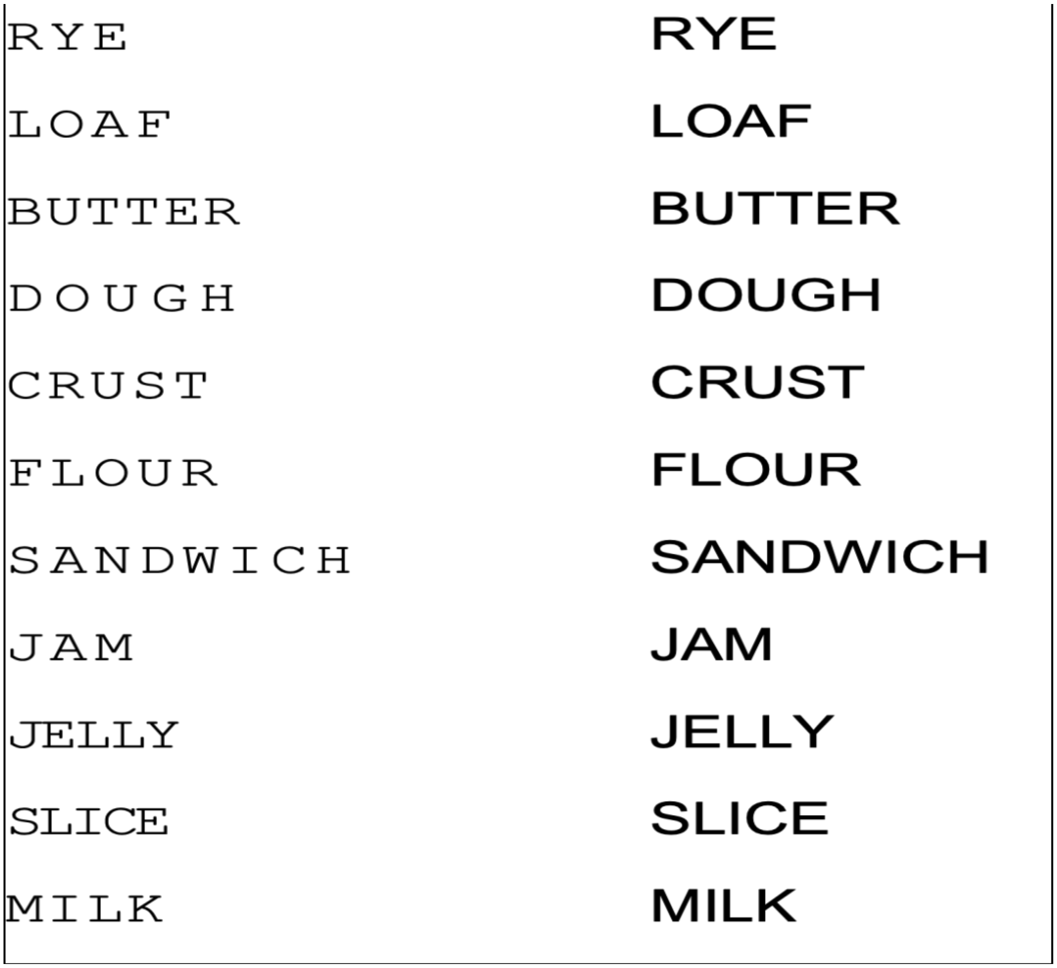

Figure 1. Examples of DRM lists presented using Sans Forgetica font (left) and Arial font (right).

APPENDIX A: IRB APPROVAL LETTER

NOTICE OF INSTITUTIONAL REVIEW BOARD ACTION

The project below has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services regulations (45 CFR Part 46), and University Policy to ensure:

- The risks to subjects are minimized and reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered involving risks to subjects must be reported immediately. Problems should be reported to ORI via the Incident template on Cayuse IRB.
- The period of approval is twelve months. An application for renewal must be submitted for projects exceeding twelve months.
- Face-to-Face data collection may not commence without prior approval from the Vice President for Research's Office.

PROTOCOL NUMBER: IRB-21-59
PROJECT TITLE: The Effects of Sans Forgetica Distinctive Fonts on Associative Memory
SCHOOL/PROGRAM: Psychology
RESEARCHER(S): Anie Mitchell, Mark Huff

IRB COMMITTEE ACTION: Approved
CATEGORY: Expedited

7. Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

PERIOD OF APPROVAL: April 5, 2021

Donald Sacco, Ph.D.
Institutional Review Board Chairperson

APPENDIX B: DRM LISTS STUDIED IN EXPERIMENT 1 (COUNTERBALANCES 1 AND 2) AND EXPERIMENT 2 (COUNTERBALANCE 1)

"Window" List

Pane Sill Shutter Curtain Door Ledge Glass View Screen
Shade Open Frame

"Rough" List

Sandpaper Smooth Coarse Tough Rugged Bumpy Jagged
Riders Uneven Road Ready

"Anger" List

Rage Mad Enrage Fury Temper Ire Wrath Mean Hatred Fight
Hate Fear

"Trash" List

Garbage Rubbish Debris Dump Litter Landfill Junk Waste
Sewage Pile Scraps Refuse

"Doctor" List

Physician Nurse Stethoscope Surgeon Patient Clinic Dentist
Medicine Lawyer Health Sick Cure

"Slow" List

Fast Snail Turtle Sluggish Quick Molasses Lethargic Speed
Delay Hesitant Cautious Traffic

"River" List

Mississippi Creek Stream Flow Bridge Brook Lake Barge Water

Boat Tide Swim

"Bread" List

Rye Loaf Butter Toast Dough Crust Flour Sandwich Jam

Jelly Slice Milk

"Flag" List

Banner Checkered American Stripes Pole Anthem Emblem National

Freedom Symbol Wave Stars

"Shirt" List

Blouse Sleeves Collar Shorts Button Pants Polo Jersey Vest

Cuffs Tie Pocket

APPENDIX C: DRM LISTS STUDIED IN EXPERIMENT 1 (COUNTERBALANCES 3 AND 4) AND EXPERIMENT 2 (COUNTERBALANCE 2)

"Smell" List

Aroma Scent Whiff Stench Reek Sniff Perfume Fragrance Nose Rose Salts Breathe

"Soft" List

Hard Loud Tender Fluffy Pillow Downy Plush Cotton Skin Fur Touch Furry

"Sweet" List

Honey Bitter Sugar Sour Candy Tart Chocolate Nice Taste Cake Good Tooth

"Chair" List

Table Swivel Rocking Recliner Seat Stool Desk Couch Sit Sofa Bench Sitting

"Mountain" List

Climber Hill Climb Molehill Peak Valley Summit Steep Ski Bike Goat Glacier

"Music" List

Band Concert Jazz Symphony Orchestra Rhythm Radio Melody Piano Sound Instrument Note

"Rubber" List

Foam Latex Galoshes Tire Flexible Elastic Gloves Eraser

Bounce Ball Soles Springy

"Foot" List

Toe Inch Ankle Shoe Sandals Sock Hand Boot Yard Kick

Knee Walk

"Girl" List

Boy Dolls Pretty Female Dress Date Beautiful Daughter Sister

Cute Niece Young

"Black" List

White Gray Brown Coal Dark Color Funeral Blue Charred Ink

Death Cat