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INDIVIDUAL DIFFERENCES IN FALSE MEMORIES IN THE DEESE-ROEDIGER-MCDERMOTT PARADIGM: AN ATTENTION CONTROL ACCOUNT (35pp.)

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This study examined the underlying mechanisms of false memories observed in the classic Deese–Roediger–McDermott (DRM) paradigm. Previous work indicates that greater working memory capacity and inhibition are associated with lower susceptibility to such false memories. We hypothesized that this may be, due to the closely related construct of attention control. We examined if individual differences in attention control accounted for variance in susceptibility to false memories, above and beyond inhibition and WMC alone. We used a standard DRM procedure in an individual differences approach to examine how working memory, inhibition, and attention control contribute to false memories as indicated by false word recall on the DRM task. Our results indicate that not only does attention control account for unique variance in susceptibility to the false memories, but it also may mediate the relationship between working memory capacity and DRM performance to a degree to which working memory becomes non-significant.

INDIVIDUAL DIFFERENCES IN FALSE MEMORIES IN THE DEESE-ROEDIGER-MCDERMOTT PARADIGM: AN ATTENTION CONTROL ACCOUNT

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Introduction

False memories, as defined by the APA dictionary of psychology, are “a distorted recollection of an event or, most severely, recollection of an event that never actually happened (American Psychological Association, n.d.).” For example, imagine you are at the grocery store and are trying to recall what you needed to buy because you didn't bring your list. Trying to recall your list, you pick up cherries, apples, pears, bananas, and oranges. You get home only to find that you did not write oranges on your original list, even though you were sure you did when you tried to recall it at the store. In this example you had the false memory of writing oranges on your shopping list despite never doing so. You accurately recalled other fruits you needed to purchase, but you falsely recalled oranges because they were semantically and thematically related to the other fruits. There are many theoretical explanations for why this occurs and the impetus for this investigation is to examine the underlying cognitive mechanisms and processes that can make one more or less susceptible to this phenomenon. There have been many investigations of individual differences that may be associated with susceptibility to false memories such as working memory capacity (Parker, et al, 2008; Peters, et al, 2006; Peters, et al, 2007) and inhibition (Lövdén et al, 2003), but few, including have examined attention control as an underlying individual difference of which we are aware. As such, the primary aim of this investigation is to examine if attention control accounts for unique variance in susceptibility to false memories, above and beyond inhibition and working memory capacity (WMC).

Study of false memories formally started in the 1880s (Oliveira et al, 2018). Much of the early literature was focused on “errors of omission” also known as forgetting, including

Ebbinghaus' development of his "curve of forgetting" (Ebbinghaus, 1885). These studies lead to what is often considered the first laboratory study of false memories by Kirkpatrik in 1894 in which he demonstrated that participants falsely recalled words that were associated with previously presented items (Oliveira et al, 2018). You can see this in action in the previous example, as you falsely recalled the word oranges was on your list since it was related to the other fruit you were picking up. The literature evolved in the 1910s with Stern (1910) demonstrating children creating a false memory of an event when asked a series of suggestive questions. In the 1970s Loftus & Palmer (1974) demonstrated that one could create false memories of events by introducing false information. In more recent literature, a great deal of the research of false memories has coalesced around the use of a particular paradigm, that being the Deese-Roediger-McDermott or DRM paradigm (Roediger et al., 1996). This paradigm has been shown to be able to induce false memories in participants by presenting them with a list of associated words. Participants are asked to try and remember all of the presented words and then asked if a series of words appeared on the list, including a "critical lure" which is highly related to the words presented in the list but not actually present. An example of a trial in the DRM would be to present the following list of words: bed, tired, …. Then participants are asked if a series of words were presented or not. The word sleep is presented in the recognition list, but was not in the presented list. Sleep becomes the critical lure. Participants who say that the critical lure was present in the word list are thus said to have formed a false memory of its inclusion. This is similar to oranges in the previous example, as it was related to the other words on your list, which induced the false memory of writing oranges on your shopping list. To understand the enduring interest in this paradigm, one need only change the context. Consider the previous example. Imagine if instead of trying to remember what you wrote on your grocery list, you were trying to remember what a group of robbers took when you saw them run off. In this case, falsely recalling that the robbers took items that were left alone could confuse an investigation, and potentially cast doubt on your credibility as a witness when a trial eventually comes. While this example is unique to a specific context, these kinds of false memory errors can occur in serious situations and contexts, which warrants a particular focus of investigation.

This DRM paradigm has grown in ubiquity since its codification in the 1990s with ~971 papers published before 2001 according to google scholar. Today, a simple search of "DRM Paradigm" in Google Scholar returns ~27,600 results as of June 2023 according to google scholar. Part of this growth in popularity can be attributed to two unique factors of the DRM paradigm compared to other similar paradigms. First, the paradigm is easy to administer and allows for collecting multiple observations quickly which can be necessary in larger scale individual differences research. In addition, the false memories seen in the DRM paradigm are produced internally by association instead of retrieval enhanced suggestibility as in the misinformation paradigm. The DRM paradigm itself is also rather simple to implement. Subjects are first presented with a series of semantically related words which are all related to a certain target word (critical lure). In the previous example oranges would be the target word, since it is related to the rest of the words on the list but never actually present. The subject is then asked to either write down all the words they can remember from the task, also known as a free recall task, or the subject is asked to indicate whether each of a series of presented words was in the original list, also known as a recognition task (Pardilla-Delgado & Payne, 2017). Both of these variations examine the same behavior, those instances in which the participant indicates that the critical lure that was not actually present on the original list was present. These errors are the false memories that the paradigm seeks to measure. When analyzing data from the

DRM task one examines the hit rate (number of presented words correctly identified as being presented) and false alarm rate (number of items not presented identified as presented previously). This can be done across conditions or, as used in the current study, as a measure of individual differences. In this latter case,hit rates and false alarm rates are analyzed within multiple regression in relation to the other variables of interest.

There are many potential variables of interest one could examine when studying individual differences using the DRM paradigm. Research in this area has coalesced around two main processes for explaining the false memories found in the DRM paradigm. These are spreading activations and source monitoring (Gallo, 2010). Spreading activation models explain the false memories of the DRM paradigm arising from failing to inhibit responding with semantically or thematically related words which are activated while the participant is studying the word list (Meade, Watson, Balota, & Roediger, 2007). Meanwhile source monitoring accounts explain these false memories as a failure of source monitoring processes to reject items activated via spreading activations by not recognizing that such words were not presented in the list (Gallo, 2010). In both of these accounts we see a need to remember the list of words, and inhibit false responses. Thus, for this study I have collected measures that relate to three constructs that I hypothesize are related to the formation or resistance to the formation of false memories. These constructs are inhibition, working memory, and attention control.

Inhibition

Inhibition is the ability to ignore or inhibit non-task-relevant stimuli, including inhibiting prepotent responses. This definition is based primarily on the work of Miyake et al., (2000) who described executive functions as three separable but related processes, shifting, updating, and Inhibition. This framework is often used in studies of inhibition in relation to false memories and the DRM paradigm which makes it ideal for this investigation. In aging research in particular, inhibition has been given significant attention, thanks in part to Norman and Schacter (1997) demonstrating that older adults are more prone to false memories in the DRM paradigm compared to younger adults. In subsequent research, the decline in inhibitory ability has been proposed alongside declines in episodic memory performance as an explanation (Lövdén, 2003). According to the poor inhibition explanation, the rise in false memories is due to older adults having difficulty inhibiting the associations between the presented words in the DRM lists and the lure word (Balota et al., 1999). This idea has subsequently been incorporated into associative activation theory (AAT) proposed by Howe, Wimmer, Gagnon, & Plumpton, (2009). AAT describes false memories as the result of failing to inhibit prepotent responses based on spreading activations that become more and more automatic as our knowledge bases grow in use and depth (Knott et al., 2011). For example, as a child you might not have much experience with car parts, and as such you would not have many associative connections in that area. Thus, if you were given a DRM word list with car parts, the word car might not be immediately activated, reducing the chance of a false memory of hearing the word car. Contrast this with an adult who works as a mechanic. They would have significantly more associative connections between car parts and the word car, and those associations would be used much more frequently. If this adult was given a DRM word list of car parts they would have a higher likelihood of a false memory of hearing the word car due to the strength of this associative connection. Indeed, the hypothesis that strength of association underlies false memories is supported by research that shows that associative strength between the words in a DRM word list and the critical lure "significantly contribute to the formation of false memories" (Otgaar et al 2019, pg 192). Greater inhibition would allow our mechanic to inhibit the prepotent response of “car” caused by the activations of concepts surrounding the word car.

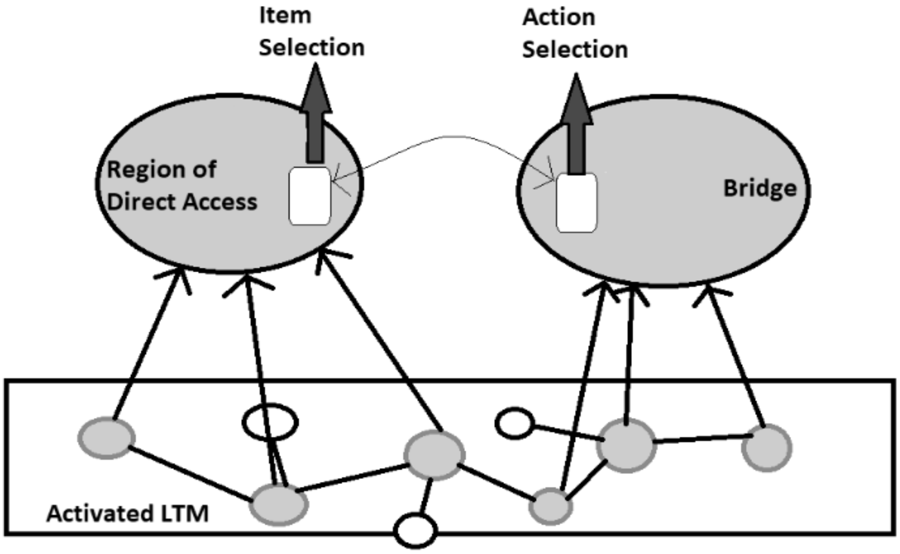
Similarly, gist theory proposes that subjects mentally construct a “gist” during the study phase that is made up of common semantic features or themes of the presented words and thus activates the critical lure because it has similar features (Gallo, 2010). So in the previous car part example, gist theory would say that the mechanic constructs a “gist” of the word list while studying it, and because car parts are features of a car and thus are semantically and thematically related, the concept of a car also gets activated. This theory is endorsed by findings that indicate including unrelated items on a recognition test enhances false recognition as these unrelated items increase the reach of the “gist” constructed while studying the list (Gallo, 2010).In all of these accounts we see that a failure to inhibit semantically and thematically related constructs is what gives rise to the false memories seen in the DRM paradigm.

Working Memory Capacity

The construct working memory has been defined in many ways in the cognitive literature (Cowan, 2016). One definition proposed by Kane and Engle (2002) describes working memory as a system consisting of short term memory (STM) and executive-attention components” (pg 639). In this framework, false memories in the DRM paradigm are caused by the limited capacity of STM being unable to maintain all of the words in the list, and thus requires retrieval later which can allow for retrieving falsely activated items in activated long term memory or secondary memory (Engle et al 1999). Alternatively Oberauer (2021) defined working memory as “... a medium for building, holding, and manipulating temporary representations that control our current thoughts and actions” (Oberauer, 2021, p.120). Similar to the framework proposed by Kane and Engle, Oberauer’s model is limited in capacity. This model is depicted in figure 1.

Figure 1

Oberauer's Model of Working Memory



In this model we can see declarative working memory capacity as the region of direct access. Similar to Kane and Engle's (2002) model, this is limited in capacity, and as such can not directly store all the words in a DRM word list. This means that when attempting to discern if an item was in the list, a participant must search activated long term memory which can include related but not presented words that have been activated by spread of activations. This is what leads to the false memories seen in the DRM paradigm, and why those with better working memory have been shown to be more resistant to false memories in the DRM paradigm (see Lövdén, 2003; Calvillo, 2014; Peters et al., 2006; Peters et al., 2007).

To measure individual differences in working memory capacity , I used the operation span task (OSpan). The OSpan task requires participants to solve a series of math problems which are presented as true or false questions. After each problem participants are presented with a and a word remember. For example, a subject might be presented with the equation "3*3 = 9? Frog" in which case the participant should respond "true," and try to remember the word frog. This is repeated for a given number of problem-word pairs, before asking the participants to recall the words they were asked to remember in order (Unsworth et al., 2005). This task assesses the participant's ability to hold and build a list of words, while simultaneously working out the math problem to correctly determine if the statement is true or false. Thus individuals with a larger working memory capacity would be able to hold more words before having to resort to searching activated long term memory thus leaving them vulnerable to false memory errors.

Attention Control

Attention Control is defined as the ability to hold, recall, and manipulate task relevant information, while simultaneously filtering and suppressing task irrelevant information and behaviors. This definition is based in part on the definition of "controlled attention" described by Kane and Engle (2002) who argued that attention control or executive attention is the capability to maintain memory representations in a highly active state despite the presence of interference. In the DRM paradigm, we could describe the automatic spreading of activations activating the "lure" word as the interference that Kane and Engle describe along with task-irrelevant stimuli such as hunger or thoughts about other topics. This has been largely explored in relation to working memory capacity (WMC), such as by Watson et al., (2005) who demonstrated that individuals with higher WMC had lower rates of false memories and were better able to use warnings about potential false memories to further reduce their rate of false memories. The literature has largely used WMC measures as a measurement of attention control, however I argue that this risks simplifying the underlying mechanisms to a singular mechanism and not separable executive processes such as attention control (Kane and Engle, 2002) and working memory capacity. While initially similar to working memory, attention control includes an element that is missing from working memory. Namely the presence of the suppressing or filtering of information and behaviors. This filtering component aligns with the source monitoring accounts of false memories, as lacking filtering of false items would lead to more false memories of words that were not present but still cued or semantically activated.

To measure this construct I used a task called the "sustained attention to cue task (SATC task) developed by Draheim et al. (2021). In this task participants are instructed to focus on a specific point on a computer screen indicated by a shrinking circle which then disappears once it reaches its smallest diameter. Then, after a brief delay, a set of letters at and around the focal point are displayed briefly before the central letter is obscured by …. The participant is then asked to select from a set of letters which one was the one in the center of the focal point before it was obscured. This task requires the participant to both hold the information about the location of the focal point, and what letter was presented in the center of focus. All while simultaneously ignoring the stimuli of the surrounding letters, all of which are options in the subsequently presented set of letters. Thus the surrounding letters act as the task-irrelevant information or interference indicated in our definition. Individual differences in the ability to maintain attention on the task relevant stimuli as seen in the Sustained Attention to Cue task (SACT) should be indicative of their ability to maintain attention on presented words (task relevant stimuli) in the DRM task.

To illustrate these three individual differences we can look back to our grocery store list example. In that scenario, holding and updating your list of items to buy would be part of your working memory, while inhibition would be involved in suppressing the spread of activations to the similar but unneeded oranges. Finally, attention control would involve continually maintaining that original list and not getting distracted by the various sales and advertisements in the grocery store, or your stomach telling you how hungry you are.

The purpose of this investigation is to examine if attention control accounts for unique variance in susceptibility to false memories, above and beyond inhibition and working memory capacity (WMC).. I hypothesize that attention control will account for unique variance above and beyond inhibition and working memory on their own or together. The accounts of the mechanisms underlying false memories suggest a failure to inhibit semantically and thematically related constructs as the storage needed to hold the entire list of words exceeds WMC. Thus requiring control of attention to continue actively updating the list of words as it grows, and suppressing both internal and external stimuli caused by the spread of activations and non-task related sources. In order to test this hypothesis participants in the current study completed the DRM, OSpan, Flanker, and SACT tasks in a randomized order. Given this protocol there are four potential outcomes from this investigation. The first is that none of the tasks account for significant variance in false memory resistance as measured by the DRM task. In which case further work will be needed in order to replicate the findings as they are counter to much of the existing literature. The second possible outcome is that the investigation shows that attention control as measured by the SATC task does not predict or account for unique variance in DRM performance, while the OSpan and flanker tasks do. In this case, we could conclude that attention control is not a significant factor in the formation of false memories as measured by the DRM task, disagreeing with my hypothesis. If instead, the investigation shows that attention control as measured by the SATC task does predict DRM performance but it does not account for unique variance above and beyond working memory and attention. In this case we can say that attention control is not contributing to the formation of false memories above its component constructs of working memory and attention control, disagreeing with my hypothesis. Finally, if the investigation shows that attention control as measured by the SATC task does account for unique variance in DRM performance above and beyond the inhibition and working memory. In this case we can say that attention control as a unique construct is involved in the formation of false memories as measured by the DRM task, confirming my hypothesis.

Method

Participants were administered all four tasks (DRM, OSpan, Flanker, SACT) in a counterbalanced order to alleviate the potential fatigue or training effects. Each task lasted ~15 minutes for a total of ~1 hour of total participation time for each subject. All tasks were coded and administered using E-Prime 3.0 (Psychology Software Tools, Pittsburgh, PA).

Participants

240 participants were recruited through the Kent state university subject pool receiving partial fulfillment of a course requirement or extra credit in exchange for their participation. Due to computer errors 80 participants were excluded from the analysis for missing two or more task scores. 17 participants who were only missing one score were included after using the "MICE" algorithm for multiple means imputation to estimate their missing score. This was done using the mice package in R version 3.16.

DRM

There were two components to the DRM task. For each trial in the first component, participants were presented with a set of 14 words which display for 1500 ms each. After each word list, a dialogue box appeared and participants were asked to recall as many words as possible, pressing enter after typing each individual word. To continue to the next trial participants were asked to leave the dialogue box blank and press enter. There were a total of 16 trials in this first section. In the second component which followed the 16 word lists and recall trials, subjects were presented with a list of words and asked to press 1 if the word had appeared in the first section or 2 if it did not appear. 96 words including the critical lures for each word list were presented this way in this section. The implementation of this task was provided by the E-Prime 3.0 experiment library and only minimally altered to function on lab computers (Psychology Software Tools, Pittsburgh, PA, 2024). It is not possible to calculate internal consistencies for the DRM paradigm, but test-retest reliability has been previously shown to range from r = .49 to r = .63 (Ost et al., 2013).

To analyze the data produced from the DRM task, we examined both the percentage of words correctly recalled in the first section, and the number of words correctly and falsely recalled as being present in the second section. These instances where participants indicate that a word was present when it was not are the false memories central to this paradigm.

O-Span

During this task, subjects were asked to memorize a series of letters presented while mentally computing math problems. A series of 3 practice trials occurred before the real trials began. The first set of practice trials tested a participant's ability to recall a series of letters. Two or three randomly selected letters were shown to the participant one at a time. Following the presentation of the last letter participants responded using the keyboard to enter the letters they were instructed to remember. The second practice trial tested a participant's ability to mentally compute math problems. Participants were shown problems with random multiplication and either addition or subtraction (e.g., (3*2) + 1) to compute. Once the participant computed the answer, a True or False option was presented on the screen with either the correct or incorrect answer. The participant must decide whether the answer presented is True or False. After deciding true or false the participant is presented with a letter to memorize before continuing to the next trial. After the final practice trial, the participant was asked to recall the series of letters and feedback is presented. The real trials worked similarly to the last practice trials except that feedback was not provided to participants. Participants completed a total of 20 blocks of trials with each block containing between two to four letters to memorize. There were five blocks of each number of letters (2,3,4, and 5) presented in a random order. Internal consistency was calculated using split-half reliability on odd and even trials r = .93. The implementation of this task was provided by the E-Prime 3.0 experiment library and only minimally altered to function on lab computers (Psychology Software Tools, Pittsburgh, PA, 2024).

To analyze the data produced from the OSpan task, we examine the number of words recalled in the correct order (True Span). The percentage of true or false math questions the subjects answered correctly was also recorded and used as a measure of compliance. With those who had less than 80% accuracy being excluded from analysis.

Flanker

In this task participants were shown a focal point centered on the center of the screen for a random duration between 50 and 500 ms before a series of arrows appeared directly above the focal point. Participants were instructed to press the arrow key corresponding to the arrow directly above the focal point as quickly and accurately as possible. The presented arrows surrounding the target arrow could be either “congruent” if they pointed in the same direction, or “incongruent” if they pointed in the opposite direction. Each block of trials consisted of 16 trials of an even number of congruent left, congruent right, incongruent left, or incongruent right arrows in a random order. Additionally, within each block participants were required to answer within a quickening timer beginning at 2500ms and decreasing to 700ms by trial 18. Participants first completed 3 practice blocks which gave feedback regarding their accuracy. Once complete, participants then completed 18 blocks of real trials with a self paced rest break in between each block.

In analyzing the data from this task we regressed the accuracy for congruent trials, onto incongruent trials and used the residuals as our predictor. Internal consistency estimates were calculated using split-half reliability on odd and even trials r_{SB} = .58.

SACT

In this task participants were shown a visual circle cue at a random location on screen and asked to focus on it, before a target letter was briefly presented at the center of the cue. This SACT task was adapted from Draheim et al (2021). Each trial started with a central fixation point. On half of the trials, the fixation was presented for 2s and for the other half the fixation was presented for 3 s. After the fixation, following a 300-ms tone, a large white circle cue was presented in a randomly determined location on either the left or right side of the screen. To orient the participant to the circle cue, the large circle began to immediately shrink in size until it reached a fixed size. Once the cue reached the fixed size, after a variable wait time (equally distributed among 2 s, 4 s, 8 s, and 12 s), a white distracting asterisk appeared at the center of the screen. The asterisk blinked on and off in 100-ms intervals for a total duration of 300 ms (on for 100 ms, off for 100 ms, on for 100 ms). Then, a 3 x 3 array of letters was displayed at the center of the cue. The letters in the array consisted of B, D, P, and R. The central letter was the target letter and was presented in a dark gray font. The nontarget letters were presented in black font with each letter occurring twice in the array and the target letter occurring three times. After 125 ms the central letter was masked with a # for 1,000 ms. Only the central target letter was masked. After the mask, the response options were displayed in boxes horizontally across the upper half of the screen. The participant used the mouse to select whether the target was a B, D, P, or R. Feedback was given during the practice trials but not the experimental trials. Sixty-four trials were administered. To analyze the data we simply analyzed the percentage of correct responses across all sixty four trials. Internal consistency was calculated using a split-half reliability using the Spearman-Brown prophecy formula. r_{SB} = .63.

Results

To explore if attention control, above and beyond inhibition and WMC alone, accounted for unique variance in susceptibility to false memories we examined our false memory data using three dependent variables. Table 1 presents the zero-order correlations among the four variables. False alarm rates, or the number of critical lure words that each participant indicated as being part of the original word list, Gamma, which is a general measure of signal detection ability, and 'd' a measure of how readily a signal can be detected similar to Gamma, but is resilient to potential response biases by taking into account the theoretical decision criterion developed by the participant (Wickens 2002). Each of these three dependent variables was regressed onto the following predictors: SACT score, OSpan letter accuracy, and Flanker Task and submitted to dominance analysis. See Table 2 for regression results All statistics were calculated in R version 4.3.1.

Working memory was measured by OSpan letter accuracy, Mean = .60 (SD = .24). Inhibition was measured by the flanker residuals from regressing the incongruent trial response time onto the congruent trial response time, Mean = 2.16 (SD = 36.66). Attention control was measured by the SACT score, Mean = 55.54 (SD = 8.89). Each of these three scores were used as predictors for False alarm rate, Mean = 7.59 (SD = 3.23), Gamma, Mean = 0.52 (SD = 0.21), and 'd', Mean = 0.01 (SD = 1.69).

False Alarm Rates

False Alarm rates were indicated by the number of critical lure words that each participant indicated as being part of the original word list even though they were not previously presented. We ran a multiple regression, with SACT score, OSpan letter accuracy, and Flanker residual as predictors. The model overall had an adjusted R2 of .05, F(3,151) = 3.827, p = .011. With all three predictors in the model, Working Memory was not a significant predictor (β = -.84, SE = 1.1, p = .447). Inhibition was significant (β = -.02, SE = .01, p = .037) as was Attention Control (β = -.08, SE = .03, p = .017). The significant negative associations indicate that as inhibition and attention control increase false alarm rates decrease. A dominance analysis was conducted on the model which indicated that attention control (.56) completely dominated inhibition (.34) in the model, indicating that attention control was in fact the dominant factor in predicting false alarm rates.

Gamma

Gamma is a general measure of signal detection ability defined by the equation $\boldsymbol{\gamma}$ = (AD-BC) / (AD+BC). Where A is the number of "hits," or how often the participant correctly remembered that a word had been on the word list. B is a "miss" or how often the participant failed to remember that a word had been on the word list. C corresponds to the number of "false alarms" or how often the participant incorrectly identified a word as being on their word list that had not been present. D is the number of "correct rejections" or the number of times the participant correctly indicated that a newly generated word was not on the originally presented word list. All three of our predictors had a positive correlation indicating that if one had better working memory, inhibition, and attention control abilities you were more likely to both correctly recognize words that were present in the original word list, and correctly reject newly generated words as not on the original word list. We ran a multiple regression, with SACT score, OSpan letter accuracy, and Flanker residual as predictors. The model overall had an adjusted R2 of .06, F(3,151) = 4.39, p = .005. With all three predictors in the model, Working Memory was not a significant predictor (β = .09, SE = .07, p = .282). Inhibition was significant (β = .001, SE < .01, p = .034) as was Attention Control (β = .005, SE < .01, p = 0.01). The significant positive associations indicate that as inhibition and attention control increase, the gamma score increases. A dominance analysis was conducted on the model which indicated that attention control (.57) completely dominated inhibition (.29) in the model, indicating that attention control was in fact the dominant factor in predicting gamma values.

Figure 2

Gamma Calculations

Word List / Response	Presented	Generated
Old	*Hit* (a)	*False Alarm* (c)
New	*Miss* (b)	*Correct Rejection* (d)

D Prime (d')

D Prime (d') is a measure of how readily a signal can be detected similar to Gamma and is calculated using the z score of a participant's hit rate minus the z score of a participant's false alarm rate. We ran a multiple regression, with SACT score, OSpan letter accuracy, and Flanker residual as predictors. The model overall had an adjusted R2 of .10, F(3,151) = 5.815, p < .001. With all three predictors in the model, Working Memory was not a significant predictor (β = .74, SE = .57, p = .196). Inhibition was marginally significant (β = .01, SE < .01, p = .069) however, Attention Control was significant (β = .05, SE = .02, p < .001). The significant positive associations indicate that as inhibition and attention control increase, d' scores increase. A dominance analysis was conducted on the model which indicated that attention control (.67) completely dominated inhibition (.14) in the model, indicating that attention control was in fact the dominant factor in predicting d’ values.

Table 1

Correlations

	False Alarms	Gamma	D Prime	SACT	OSpan	Flanker
False Alarms	—					
Gamma	-.98**	—				
D Prime	-.89**	.92**	—			
SACT	-.21**	.21**	.26**	—		
OSpan	-.09	.11	.15	.31**	—	
Flanker	-.17*	.16*	.14	-.08	-.15	—

Note: * $p < .05$ ** $p < 0.01$, for correlations between predictors and criterion variables.

Table 2

Results

	B(SE)	t(df)	p	Dominance
	False Alarms $R^2_{adjusted} = .05$			
Working Memory	-.84(1.1)	-.76(151)	.447	(3) .09
Inhibition	-.02(.01)	-2.1(151)	.037*	(2) .35
Attention Control	-.08(.03)	–2.41(151)	.017*	(1) .56
	Gamma $R^2_{adjusted} = .06$			
Working Memory	.09(.07)	1.27(151)	.206	(3) .16
Inhibition	.001(.0004)	2.06(151)	.042*	(2) .27
Attention Control	.005(.002)	2.58(151)	.011*	(1) .56
	d' $R^2_{adjusted} = .10$			
Working Memory	.74(.57)	1.30(151)	.196	(3) .17
Inhibition	.01(.004)	2.22(151)	.028*	(2) .24
Attention Control	.05(.02)	3.00(151)	.003**	(1) .59

Discussion

These results indicate that for all three measures of DRM performance (false alarms, gamma, and *d'*) as an independent variable, attention control and inhibition were significant predictors, while working memory capacity was not. In addition, we conducted dominance analysis in all three variations that indicated attention control was the dominant factor and completely dominated inhibition. These results support our hypothesis, as attention control accounted for unique variance when inhibition and working memory capacity were accounted for. This indicates that the ability to maintain memory representations in a highly active state despite the presence of interference is more important in preventing false memories than inhibition, or working memory capacity. Furthermore, because working memory became non-significant with inhibition and attention control in the model(s), these results suggest that previous research demonstrating a negative relationship between working memory capacity and false memory rates (e.g., Peters, et al, 2007) may have been mediated by attention control and inhibition. This is particularly likely given that attention control, inhibition, and working memory capacity are all highly interrelated (Kane et al., 2001, Kane & Engle, 2002, Logie et al., 2021, Miyake et al., 2000, Nieznański & Obidziński, 2019).

To put these results in context, recall our previous supermarket list example. In that example, you are at the grocery store and are trying to recall what you needed to buy because you didn't bring your list. Despite being sure that oranges were on your list along with several other fruits when you recalled it in the supermarket, you had never had oranges on your list and had instead falsely recalled oranges. These results suggest that the reason you falsely recalled the oranges was not because of a failure of your ability to hold and update your list of items to buy, which would be indicative of your working memory capacity. Instead it is because of a failure to suppress the spread of activations to the similar but unneeded oranges, indicative of a failure of inhibition, and a failure to continually maintain that original list and not getting distracted by irrelevant stimuli such as the various sales and advertisements in the grocery store, or your stomach telling you how hungry you are, which is indicative of a failure of attention control. Additionally, the dominance analysis results indicate that the dominant factor of these two is the failure to continually maintain that original list and not get distracted.

We can interpret these results from both spreading activations and source monitoring accounts of false memories around which much of the research in this area has coalesced (Gallo, 2010). The spreading activations account of false memories would suggest inhibition of the semantically or thematically related words which are activated while the participant is studying the word list should be the primary factor. The fact that working memory was completely dominated by inhibition in the dominance analysis of each of our measures of DRM performance clearly supports this. However, the fact that attention control accounts for unique variance and still completely dominates inhibition may indicate that there is more that this account does not explain. Notably the source monitoring account may provide this explanation, as such accounts would indicate that these false memories result from a failure to recall the true sources of each word during recall. Recalling our definition of attention control as the ability to hold, recall, and manipulate task relevant information, while simultaneously filtering and suppressing task irrelevant information and behaviors, we can see that this aligns with the source monitoring explanation quite well. As one recalls the word list, they must suppress irrelevant information while maintaining and adding to the list as they search through their memory. Thus, given that both inhibition and attention control accounted for unique variance and are best explained by different accounts, it would seem that our results indicate that a combination of both accounts is necessary to fully explain the susceptibility to false memories in the DRM paradigm.

Limitations

For pragmatic reasons, this study was conducted with an undergraduate psychology student population at a Midwestern American university. This may have caused a reduction in variability due to a limited age range of participants which may not capture age related effects on inhibition and working memory capacity (see Ackil & Zaragoza, 1998, and Rey-Mermet et al., 2018). Additionally, while we have no theoretical basis to expect a cross-cultural difference in these constructs, it is possible that such effects do exist, particularly given the vocabulary based nature of the DRM task. Additionally, for similar pragmatic reasons, this study used only a single measure for each construct. While the tasks chosen are representative of their constructs, a more thorough investigation could use additional tasks for each construct in order to avoid potential task effects. Finally, the DRM paradigm, while often used as a false memory, is limited in its ability to capture a more broad range of false memories and has potential issues of ecological validity.

Future Directions

Future work in this area should focus on replication with other false memory paradigms in order to accrue additional evidence that attention control and inhibition are really tapping the underlying mechanism behind false memories and overcome potential issues of ecological validity inherent to the DRM task. The current results also warrant a mediation analysis as mentioned above, investigating the possible mediation of the relationship between working memory and false memories by attention control. Additionally work using multiple measures of each individual difference described here should be conducted to preclude the potential confound of task effects.

Conclusions

These results indicate that resistance to false memories as examined in the DRM paradigm can be attributed to attention control and inhibition above and beyond working memory capacity. This, along with the fact that all three of these predictors are highly correlated with one another, may indicate that Attention Control and Inhibition may be the true predictors that other studies in this literature have been tapping into by measuring Working Memory capacity. While further research must be conducted in order to confirm these findings, these results indicate that working memory capacity may in fact not play a significant role in protecting against false memories. Furthermore, the results of the dominance analysis indicate that Attention Control is the dominant factor above inhibition and working memory capacity. This indicates that Attention Control may be more directly related to the true underlying mechanisms behind false memories, but more research is needed to confirm these findings in different experimental and procedural contexts.

Data Availability

The data that support the findings of this study are openly available in Open Science Framework at https://osf.io/gk2dj/files/osfstorage

Ethics Statement

The study involving human participants was reviewed and approved by the Kent State University, institutional review board (IRB #752). The participants provided their written informed consent to participate in this study. All American Psychological Association ethical standards were followed.

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