Running Head: DISTINCTIVENESS EFFECTS IN FALSE MEMORY & DYNAMIC VISUAL NOISE

# Reduced Effects of Pictorial Distinctiveness on False Memory Following Dynamic Visual Noise.

Andrew Parker* Timothy Kember and Neil Dagnall

Manchester Metropolitan University

Department of Psychology

Brooks Building

53 Bonsall Street

Manchester

M15 6GX

United Kingdom

* To whom correspondence should be addressed

e-mail: a.parker@mmu.ac.uk

Word count (approx) = 7363

NOTE
This is the final author copy. Minor differences may exist between this and the final published version in "Memory".

# Abstract

High levels of false recognition for non-presented items typically occur following exposure to lists of associated words. These false recognition effects can be reduced by making the studied items more distinctive by the presentation of pictures during encoding. One explanation of this is that during recognition, participants expect or attempt to retrieve distinctive pictorial information in an attempt to evaluate the study status of the test item. If this involves the retrieval and use of visual imagery, then interfering with imagery processing should reduce the effectiveness of pictorial information in false memory reduction. In the current experiment, visual-imagery processing was disrupted at retrieval by the use of dynamic visual noise (DVN). It was found that effects of DVN dissociated true from false memory. Memory for studied words was not influenced by the presence of an interfering noise field. However, false memory was *increased* and the effects of picture-induced distinctiveness was eliminated. DVN also increased false recollection and remember responses to unstudied items.

Keywords

False memory

Dynamic visual noise

Visual-imagery

Distinctiveness

Episodic memory

# Reduced Effects of Pictorial Distinctiveness on False Memory Following Dynamic Visual Noise.

False memory refers to memory for events or experiences that have not occurred. Although this phenomenon has been studied in the laboratory by the use of a number of procedures, the one of concern in the research presented here is based upon the Deese-Roediger-McDermott (DRM) paradigm (Roediger & McDermott, 1995). Use of this method involves the presentation of a list of words, all of which are associated to an unstudied critical lure. For example, in a list comprising of the words thread, pin, eye, sew and sharp, the critical lure is needle. The typical finding is that subjects falsely recall or recognize the critical lure at rates approaching or sometimes even surpassing true memory for studied words (e.g., Gallo, Roediger & McDermott, 2001; Roediger & McDermott, 1995; Thapar & McDermott, 2001).

Use of this technique has found false memory effects to be particularly robust even when participants are warned about the nature of the false memory effect (e.g., McCabe & Smith, 2002; McDermott & Roediger, 1998). In addition, it has also been found that the memory illusion is often accompanied by the subjective recollection of actually studying the critical lure when using the remember/know paradigm (Norman & Schacter, 1997; Roediger & McDermott, 1995; Seamon et al., 2002).

Explanations for DRM false memory effects have taken a number of forms; the most successful being the activation-monitoring and gist processing accounts (e.g., Gallo, 2010). From these perspectives, false memories arise as a function of particular processes occurring during encoding and retrieval. In relation to encoding, the reason false memories arise in the DRM paradigm is because of the strength of association between the critical lure and the list words (Roediger, Watson, McDermott, & Gallo, 2001), and the overlap of semantic features amongst the list words (Brainerd & Renya, 2005). As a result, the activation of the critical lure takes place and processing of the semantic gist of the words is emphasised beyond that of more distinctive item-specific information. During testing, the retrieval of associative or gist-based information, typically leads to false memory of the critical lures.

The accounts presented above suggest that if the processing of item-specific information were to be enhanced in some manner, then a reduction in false memory should be observed. One way to achieve this is through the presentation of pictorial information during encoding. By using pictures to accompany each word on the list, additional item-specific information would then be available for processing and, presumably, a reduction in false memory would result. Israel and Schacter (1997) assessed this idea by providing one group of subjects with a list of semantically associated words with corresponding line drawings. Another group were exposed to the same words, but in the absence of the drawings. A subsequent recognition test revealed that false memory for auditorily presented critical lures was reduced in the picture encoding condition[1].

Further research has extended these findings. For example, Schacter, Israel, and Racine, (1999), found that older adults, like younger participants, were able to make use of pictorial encoding to reduce false recognition. It has also been found that pictorial encoding reduces false recognition to a greater extent when manipulated as a between (vs. within) subject manipulation (Schacter, Cendan, Dodson, & Clifford, 2001). In addition, Schacter, et al., (2001) found that altering the test conditions, so as to reduce the importance of retrieving item-specific information, attenuated the effects of pictorial distinctiveness. Similar effects to those observed with DRM lists have also been found in other paradigms such as the repetition-lag paradigm (Budson et al., 2005; Dodson & Schacter, 2002).

From a cognitive perspective, it is important to consider how pictorial distinctiveness effects arise in order to reduce false recognition. One explanation is based upon metacognitive monitoring processes that come into operation during retrieval following the encoding of picture information. Generally, false memories can be reduced by the effective application of *retrieval monitoring* processes (Gallo, 2010; Johnson, Hashtroudi, & Lindsay, 1993). More recently, Gallo and Lampinen, (2015) identified three types of such monitoring referred to as orientation, evaluation and corroboration. Orientation denotes the use of different retrieval strategies in order to query memory about a possible event. Evaluation refers to the use of expectations about the characteristics of what would constitute a likely memory. In some previous research, this has been called diagnostic monitoring (Gallo, 2010). Corroboration specifies the use of additional secondary information in order to decide on the validity of a memory. Previously this has also been called disqualifying monitoring (Gallo, 2010). In relation to the use of pictorial information, the role of retrieval evaluation or diagnostic monitoring is important (Gallo, 2010; Gallo & Lampinen, 2015).

A specific example of the use of retrieval evaluation is the distinctiveness heuristic (Israel & Schacter, 1997; Schacter et al., 1999). The reasoning supporting the role of this in false memory reduction is as follows. Firstly, following the encoding of distinctive information (such as pictures), participants develop the expectation that they should recall distinctive representations during the memory test. Those exposed to pictures during encoding, are hypothesised to demand access to distinctive pictorial information during retrieval in order to support decisions to the test items. Secondly, when distinctive information is *not* retrieved, participants are more likely to claim that the item was unstudied. Use of this heuristic is able to reduce false memory for critical lures because the critical lures, being unstudied, have not been associated with pictorial information during encoding. Participants exposed to words only, are not as likely to demand access to distinctive information and thus false alarms to critical lures arise as a result.

Although this explanation claims that participants are *expected* to recall distinctive representations during retrieval, it is not clear what type or types of information are *actually* recalled. Presumably, following the study of pictures, then the recall of visual-imagistic representations is both expected and used by participants to reduce false memory. However, whether actual visual-imagistic representations are actually retrieved or used is not certain.

One way to assess the extent to which visual or imagistic information is used is through the use of a task that interferes selectively with visual-imagery processing; an example is the dynamic visual noise task (DVN) (Quinn and McConnell, 1996). This involves the presentation of a visual noise field that comprises a display of an array of small black and white squares on a computer monitor. The squares change between black and white on a random basis over the presentation period and in many respects is similar to observing an out of tune TV monitor. Quinn and McConnell (1996) demonstrate DVN disrupts *selectively* the processing of imagistic representations without disrupting other components of memory. For example they show that DVN produces memory impairments under conditions of visual mnemonic processing, but no effect under non-visual rote rehearsal instructions (Quinn & McConnell, 1996).

Later research has indicated that the magnitude of interference was directly related to the complexity of the DVN display (McConnell & Quinn, 2000; 2004) and that DVN impaired memory during encoding or retrieval, but not when used during the retention interval (Quinn & McConnell, 2006. Importantly, these effects were found only when participants were asked to use a visual mnemonic technique to memorise the information. More recently, DVN has been shown to interfere with storage processes in memory when the information to be retained is not easily recoded into non-visual elements (Dean, Dewhurst, & Whittaker, 2008). Also, it has been demonstrated that DVN interferes with the recall and recognition of visual color information but not spatial location (Dent, 2009), recognition confidence (Kemps & Andrade, 2012) and the recall and recognition of high (vs. low) imagery words (Parker & Dagnall, 2009). Finally, interference effects have been found in other image generation tasks. In particular, Dean, Dewhurst, Morris, and Whittaker (2005) found that a DVN display interfered with the formation of mental images when participants were asked to make size comparisons between the names of animals presented verbally (e.g., is a whale larger than a lion?). However, DVN did not influence performance on non-imagery based tasks.

These interference effects can be explained by assuming that DVN influences activity in a form of visual short-term memory that has been variously labelled as a passive visual store (Quinn & McConnell, 1996) or visual buffer (Kosslyn, Thompson &

Ganis, 2006; Quinn & McConnell, 2006). In particular, DVN gains access to this store and disrupts the generation, or manipulation of visual representations currently undergoing on-line processing (Quinn & McConnell, 2006). This notion of a visual buffer can be differentiated from other components of a visuospatial working memory system. For example, Logie (1995; 2011) describes a model of visuospatial working memory that comprises a number of processing components. One of these is the visual cache that functions as a visual short-term store that is able to maintain the outputs of visual perception or information retrieved from a long-term knowledge base. Information within the cache can be refreshed through a rehearsal mechanism called the inner scribe. Both of these components are separate from other components such as the visual buffer, and from other functions like visual mental imagery and visual perception. Rather, they function to hold and maintain visual and imagery based information in short-term storage. The nature of the representations held by the visual cache are of a more abstract nature compared to those of the visual buffer and are not considered visual mental images as such. In this model, visual mental images can be generated from the long-term store, and executive functions are then able to operate upon this as dictated by relevant task demands or processing goals (Logie & Van der Meulen, 2009).

The results reviewed above appear to indicate the DVN task to be a good method for producing *selective* interference in the processing of visual-imagistic information. More specifically, when imagistic representations are generated during a memory task, then the presence of DVN should be able to disrupt the formation or use of these representations and impair responding. Consequently, the DVN task may provide an ideal method for examining the contribution of imagery-based processes in false memory reduction.

In the current experiment, participants were exposed to a set of semantically associated words in the presence or absence of pictures. Later, they undertook an auditory recognition task in the presence of either dynamic visual noise or a static visual noise control. The items on the recognition task comprised of studied words, unstudied semantically related critical lures or unstudied unrelated lures. Participants were asked to indicate if they recognised the word and also to provide remember/know responses in order to assess recollective experience (Tulving, 1985). If imagery based processes play a role in false memory reduction during the retrieval of words following picture encoding, then it is predicted that with the presence of DVN, imagistic processing will be disrupted and participants will not be able to generate or use visual information in order to reduce false memory. Demonstration of this will provide evidence for the use of visual-imagistic processing during retrieval and its importance in false memory reduction.

## Method

### *Design*

The experiment had two between-subject independent variables. The first was the encoding condition and had two levels: word only condition and word plus picture condition. The second was the presence of visual noise during retrieval and had two levels: dynamic visual noise and static visual noise.

The dependent variables were the hit rate to studied words, the false alarm rate to critical lures of the studied lists, the false alarm rate to words from nonstudied lists, and the false alarm rate to critical lures from nonstudied lists. In experiments using DRM stimuli, it is typical to differentiate between list items and critical lures. Furthermore, this differentiation is done for both presented and non-presented lists. For the most part, responses to list words and critical lures from non-presented lists do not differ (as neither were presented). However, incorporation of both types of item on a recognition test, creates a more “balanced” design and it enables items of equivalent status to be used in analyses that involve composite discrimination scores like *d*’. In the latter, it provides a basis for computing a score in which the hit and false alarm rates are calculated from similar items (e.g., critical lures or list words). This is outlined further in the results.

Each of the responses to the item types outlined above were further analyzed in terms of remember, know and guess responses. In addition, the “raw” remember and know responses were converted into process-based estimates of recollection and familiarity (Yonelinas & Jacoby, 1995; Yonelinas et al., 1998). Finally, the signal detection measures of *d*’ and response bias (β) were calculated for both true and false memory.

### *Participants*

A total of 80 individuals took part in the experiment. These were recruited from the student population of Manchester Metropolitan University and took part on a voluntary basis.

### *Materials & Apparatus.*

Twenty lists of words and pictures were taken from Israel and Schacter (1997) who adapted stimuli derived from Russell and Jenkins (1954) and Roediger and McDermott (1995). These lists were constructed by selecting the 12 word stimuli from each list that could be most readily depicted in pictorial form. The pictures themselves consisted of black and white line drawings of objects (e.g., a picture of a coin for the word “coin”) or concepts related to the word (e.g., a stack of logs for the word “wood”). For the present experiment each of the lists comprised of the 12 words together with a picture depicting that word. In addition, each list had an associated critical lure that itself comprised of both a word and a picture. The 20 lists were divided into two sets of 10 lists for the purpose of counterbalancing. Participants were exposed only to one of the sets, whilst the other set served to create unrelated distracters on the recognition test.

The recognition test was created by taking the first and seventh words from the presented set to serve as studied items (20 words). These were randomly intermixed with the word comprising the critical lure for each of the presented lists (10 words), the first and seventh words from the unstudied lists (20 words), and the critical lures from the unstudied lists (10 words). This created a recognition test of 60 words in total. Within the test booklet itself, the words were presented on the left together with the response options of ‘yes’ and ‘no’ to the right. Aligned with these response options were the words ‘remember’, ‘know’ and ‘guess’. As the test was auditory, only the experimenter viewed the test booklet.

The DVN task was adapted from Quinn & McConnell (1996) and consisted of a display of 120 X 120 black and white dots (squares) each measuring 3 mm by 3 mm. In the static noise condition, the ratio of white to black dots was 50:50 and the distribution was random across the display. In the dynamic noise condition, the dots changed from black to white and vice versa in a random manner every 0.25 s. As in the static condition, a ratio of white to black dots of 50:50 was maintained. Also, following the procedure of Dean et al., (2005) the percentage of dots changing was set to 50%. This represented a change rate of 7200 dots every 0.25 s. The overall appearance of the DVN field was of a gentle random flickering pattern.

A computer was used to present the stimuli during the encoding phase and the noise fields during the retrieval phase.

### *Procedure.*

All participants were tested individually. During the encoding phase, participants were informed that they were to be presented with 10 lists of stimuli and they should concentrate upon these in preparation for a subsequent test of memory. In both encoding conditions, all the words from each list were presented before the next list. In the word only encoding condition, the items were presented one at a time in decreasing order of associative strength to the critical lure. Each word appeared in the centre of the screen for 2 s with a 1 s interstimulus interval. In the words plus pictures encoding condition, each word together with its corresponding picture appeared side by side on the screen for 2 s with a 1 s interstimulus interval. Pilot research has shown that these timing parameters were sufficient to encode both words and pictures. The words appeared in 48-point Arial font and the pictures were all black and white line drawings whose size varied from approximately 3.5 by 3.5 cm to 8 cm by 8 cm.

Following the presentation of the final list of words, participants were given a distractor task and asked to write down the names of as many U.K. towns and cities that they could generate in 3 minutes.

In the retrieval phase, participants were informed that the experimenter was going to read aloud a list of sixty words. For each word the participant was asked to say either ‘yes’ or ‘no’ to indicate recognition of the word. If the participant responded ‘no’ the experimenter moved onto the next word. If a ‘yes’ response was made, the experimenter asked the participant for a ‘remember’, ‘know’ or ‘guess’ response before moving onto the next word.

The remember-know instructions were adapted from Gardiner and Richardson-Klavehn (2000). A remember response was defined as one which leads to conscious recollection of the study episode. A know response was defined as one in which the item is recognised because it seems familiar in the context of the experiment but which lacks associated recollective details. A guess response was defined as a yes response to a word that is neither associated with recollection or familiarity.

Participants were also informed that during the auditory recognition test, they would be asked to look at a screen displaying the static (vs. dynamic) visual noise pattern. They were told that they should look at the noise pattern throughout the whole of the test. Compliance with these instructions was monitored by the experimenter. Once participants indicated that they had understood the instructions, they were asked to look at either the static or dynamic noise field and the test began.

## Results

All results were analysed by 2 (encoding condition: word only vs. word + picture) between-subjects by 2 (noise condition: static vs. dynamic) between-subjects ANOVAs. Effect sizes for ANOVA's are reported as partial eta squared $\eta_p^2$. Effect sizes for simple main effects are reported as Cohen's d. Where the follow-up tests (simple main effects) resulted in *p* values greater than .05, subsequent analyses were conducted in order to estimate the Bayes factor (BF). The BF provides an index of the extent to which the empirical data provide support for one hypothesis (e.g., the experimental hypothesis) compared to another hypothesis (e.g., the null hypothesis). In the calculations presented here, the posterior odds in favor of the experimental hypothesis were used as the numerator with the posterior odds for the null hypothesis as the denominator. Consequently, a BF of less than 0.3 provides substantial evidence for the null hypothesis, one over 3.0 provides substantial evidence in favor of the experimental hypothesis. Bayes factors in between these values is relative evidence of an inconclusive result, the weighting in either direction depends upon the closeness of the value to either 0.3 or 3.0 (Dienes , 2011, 2014).

*Overall recognition.* Yes responses to the proportion hit rate (together with false alarm rate and signal detection measures) can be seen in Table 1.

INSERT TABLE 1 ABOUT HERE

This revealed no effect of encoding condition, $F(1, 76) = 1.76$, $p = .19$, $\eta_p^2 = .02$, noise condition, $F(1, 76) = 2.34$, $p = .14$, $\eta_p^2 = .03$, or interaction, $F(1, 76) = 0.17$, $p =$

.68, $\eta_p^2$ = .002. The same was true of *d*’, *F*(1, 76) = 0.63, *p* = .43, $\eta_p^2$ = .008, for encoding condition, *F*(1, 76) = 0.007, *p* = .93, $\eta_p^2$ = < . 001, for noise condition and *F*(1, 76) = 0.04, *p* = .84, $\eta_p^2$ = .001, for the interaction. Analyses of response bias (β)[3] revealed a significant effect of noise condition *F*(1, 76) = 4.16, *p* = .04, $\eta_p^2$ = .05, indicating a more liberal response bias in the presence of DVN. The effects of encoding condition and the interaction were not significant; *F*(1, 76) = 1.50, *p* = .22, $\eta_p^2$ = .02, and *F*(1, 76) = 0.005, *p* = .94, $\eta_p^2$ = < .001 respectively.

Analyses of the yes response to critical lures produced a significant effect of encoding condition *F*(1, 76) = 14.10, $p \leq$ .001, $\eta_p^2$ = .16, indicating greater false memory in the absence of pictures. The main effect of noise was also significant *F*(1, 76) = 8.44, *p* = .005, $\eta_p^2$ = .10, showing more false memories in the presence of DVN. Importantly, the interaction was also significant, *F*(1, 76) = 5.99, *p* = .01, $\eta_p^2$ = .07. Observation of the means suggested DVN reduced the typical distinctiveness effect in the picture encoding condition. This was confirmed by analysis of simple main effects at each level of noise condition. In the SVN condition, the presence of picture reduced the proportion of false memories (*t*(38) = -3.92, $p \leq$ .001, Cohen’s *d* = 1.23), replicating previous research on this effect. In the DVN condition, the effect of pictures was eliminated, *t*(38) = -1.06, *p* = .29, Cohen’s *d* = 0.34. BF = 0.23. Thus the presence of a DVN field eliminated distinctiveness-induced false memory reduction. Further analyses of simple main effects at each level of encoding condition showed that when pictures were present, the presence of DVN increased false memories to critical lures, *t*(38) = 4.67, $p \leq$ .001, Cohen’s *d* =1.48. When pictures were absent, DVN had no effect, *t*(38) = -0.28, *p* = .78, Cohen’s *d* = 0.05, BF = 0.2.

In addition, the signal detection measure *d*' was used to measure false memory. Using this measure, it is typical to treat yes responses to critical lures words from studied lists as "hits" and yes responses to critical lures from unstudied lists as false alarms and calculating d' accordingly (e.g., Koutstaal & Schacter, 1997; Seamon, Lee, Toner, Wheeler, Goodkind, & Birch, 2002; Seamon, Luo, et al., 2002). Higher scores indicate greater false memory effects. These analyses indicated a marginal effect of noise condition, $F(1, 76) = 3.04$, $p = .08$, $\eta_p^2 = .03$, a significant effect of encoding condition $F(1, 76) = 6.26$, $p = .001$, $\eta_p^2 = .08$, and a significant interaction, $F(1, 76) = 4.30$, $p = .04$, $\eta_p^2 = .06$. These findings indicated a significant reduction in false memory when pictures were presented but only under SVN. This was confirmed by follow-up tests showing no difference under DVN conditions, $t(38) = - 0.32$, $p = .75$, Cohen's $d = 0.09$ BF = 0.3, but a significant difference under SVN, $t(38) = - 3.08$, $p = .004$, Cohen's $d = 0.97$, showing a higher *d'* value (greater false memory to critical lures) in the *absence* of pictures. Consequently, the *d*' value for false memory differed under SVN showing a *lower* false memory effect in the presence of pictures. In other words, DVN eliminated this difference. Further analyses of simple main effects at each level of encoding condition showed that when pictures were present, the presence of DVN increased false memories to critical lures, $t(38) = 2.89$, $p = .006$, Cohen's $d = 0.91$. When pictures were absent, DVN had no effect, $t(38) = -0.22$, $p = .83$, Cohen's $d = 0.07$, BF = 0.42. Although the Bayes factor was above 0.3, it is clearly closer to evidence in support of the null hypothesis.

Analysis of response bias showed no significant effects; *F*(1, 76) = 0.002, $p$ = .96, $\eta_p^2 < .001$, for noise condition, *F*(1, 76) = 1.88, $p$ = .17, $\eta_p^2 = .02$, for encoding condition and *F*(1, 76) = 1.74, $p$ = .19, $\eta_p^2 = .02$, for the interaction.

The effects of encoding and noise condition on yes responses to critical lures and words from non-studied lists produced no effects, all *p*'s > .05.

*Remember/Know Responses*. Remember, know and guess responses were analysed for each item type. The means (SDs) can be found in Table 2.

INSERT TABLE 2 ABOUT HERE

For studied list words, no significant effects arose for remember, know or guess responses, all *p*'s > .05. For remember responses to critical lures, there was a significant effect of encoding condition, *F*(1, 76) = 8.60, $p$ = .004, $\eta_p^2 = .10$, with a greater proportion of remember responses when pictures were absent. There was no main effect of noise condition, *F*(1, 76) = 1.38, $p$= .25, $\eta_p^2 = .01$. However, the interaction was significant, *F*(1, 76) = 3.98, $p$ = .05, $\eta_p^2 = .05$. Subsequent analyses revealed a significant difference between the proportion of remember responses under SVN (*t*(38) = -3.34, $p$ = .002, Cohen's *d* = 1.07) but no difference under DVN (*t*(38) = -0.69, $p$ = .49, Cohen's *d* = 0.22, BF = 0.21). This effect was brought about by DVN increasing the proportion of remember responses in the picture condition (*t*(38) = 2.36, $p$ = .02, Cohen's *d* = 0.77) but not in the picture absent condition (*t*(38) = -0.55, $p$ = .58, Cohen's *d* = 0.20).

No significant effects were found on know responses; *F*(1, 76) = 0.56, $p$ = .45, $\eta_p^2 = .007$, for encoding condition, *F*(1, 76) = 2.70, $p$ = .10, $\eta_p^2 = .03$, for noise condition and $F(1, 76) = 0.02$, $p = .88$, $\eta_p^2 < .001$, for the interaction. For guess responses, only the main effect of encoding condition was significant, $F(1, 76) = 6.67$, $p = .01$, $\eta_p^2 = .08$. For noise condition and the interaction the results were $F(1, 76) = 0.06$, $p = .81$, $\eta_p^2 = .001$ and $F(1, 76) = 0.22$, $p = .64$, $\eta_p^2 = .003$ respectively.

The effects of encoding and noise condition on the remember and know responses to critical lures and words from non-studied lists produced no effects, all *p*'s > .05.

*Independence Process Based Estimates of Recollection & Familiarity*. The results presented above made use of "raw" remember and know responses to estimate recollection and familiarity. Use of responses in this manner is based on the assumption of exclusivity (Richardson-Klavehn, Gardiner, & Java, 1996; Yonelinas, 2002; Yonelinas & Jacoby, 1995). This assumption postulates that there is no overlap between recollection and familiarity processes. That is, a particular response to a test item reflects either recollection or familiarity but *not* both. Because of this, "raw" remember and know responses can be used to index recollection and familiarity respectively. However, the direct mapping of responses onto underlying processing is problematic if both processes act conjointly (in parallel) to facilitate performance. This idea is represented in certain dual-process theories of memory in which recollection and familiarity are independent of one another (Jacoby, 1991, 1998; Jacoby, Begg & Toth, 1997; Yonelinas, 2002; Yonelinas & Jacoby, 1995; Yonelinas et al., 1998). Under the assumption of independence, both recollection and familiarity can work in parallel to influence overt behavioural performance. Consequently, remember and know responses cannot be taken as "process-pure" measurements of underlying cognitive processes. This is particularly the case with process estimates of familiarity. With regard to familiarity, know responses may underestimate the real contribution of familiarity-based processes to recognition because participants only respond “know” when recollection fails. Algebraically, this can be represented as $K = F(1 - R)$, where K equals the probability of a know response, F represents familiarity and R represents recollection. To correct this, Yonelinas & Jacoby (1995) recommend calculating familiarity by rearranging the preceding formula. Thus a corrected measurement of familiarity is given by $F = K/(1-R)$. The independence process estimate of recollection is less problematic and can be calculated by subtracting remember responses to non-studied items from remember responses to studied items (Yonelinas et al., 1998). Typically, across the literature, fewer differences are observed between the “raw” remember responses linked to process estimates of recollection compared to differences between “raw” know responses and process estimates of familiarity. In other words, the process estimates of familiarity are more dependent upon the statistical assumptions of independence (vs. exclusivity) compared to recollection. This is especially the case when the relevant false alarm rate is low. Consequently, process estimates of recollection are often very similar to those based on the actual proportion of remember responses. However, process estimates of familiarity can often diverge from the proportion of know responses. For the sake of completeness, process estimates of *both* recollection and familiarity are presented even though the former do not typically differ as function of the assumptions made. The means and SDs can be seen in Table 3.

INSERT TABLE 3 ABOUT HERE

Process based analyses of recollection for studied list words indicated no significant effect of encoding condition, *F*(1, 76) = 0.49, *p* = .48, $\eta_p^2$ = .006, no effect of noise, *F*(1, 76) = 0.32, *p* = .57, $\eta_p^2$ = .004, and no interaction, *F*(1, 76) = 1.71, *p* = .20, $\eta_p^2$ = .02. Process based analyses of familiarity for studied list words indicated no significant effect of encoding condition, *F*(1, 76) = 0.06, *p* = .81, $\eta_p^2$ = .001, no effect of noise, *F*(1, 76) = 1.37, *p* = .25, $\eta_p^2$ = .01, and no interaction, *F*(1, 76) = 2.30, *p* = .13, $\eta_p^2$ = .02.

Process based analyses of recollection for the critical lures were also calculated by treating critical words from studied lists as “hits” and critical words from non-studied lists as false alarms. This produced a significant effect of encoding condition, *F*(1, 76) = 5.93, *p* = .0.02, $\eta_p^2$ = .07, no effect of noise, *F*(1, 76) = 1.27, *p* = .26, $\eta_p^2$ = .02, and a significant interaction, *F*(1, 76) = 4.32, *p* = .04, $\eta_p^2$ = .054. Analyses of simple main effects revealed a significant difference between the recollection estimates between picture conditions under SVN (*t*(38) = -2.97, *p* = .005, Cohen’s *d* = 0.14) but no difference under DVN (*t*(38) = -0.27, *p* = .78, Cohen’s *d* = 0.05, BF = 0.35). This effect was brought about by DVN increasing recollection estimates in the picture condition (*t*(38) = 2.41, *p* = .02, Cohen’s *d* = 0.74). No effect was found in the picture absent condition (*t*(38) = -0.64, *p* = .53, Cohen’s *d* = 0.20, BF = 0.71).

Process based analyses of familiarity for the critical lures produced no effects of encoding condition, *F*(1, 76) = 0.45, *p* = .50, $\eta_p^2$ = .006, no effect of noise, *F*(1, 76) = 2.52, *p* = .17, $\eta_p^2$ = .032, and no interaction, *F*(1, 76) = 0.01, *p* = .92, $\eta_p^2$ = < .001. Thus overall, analysis of process based estimates revealed similar findings to the raw proportion responses by showing an interaction between encoding and noise conditions for recollection estimates to critical lures.

## Discussion

The results of the current experiment replicate previous research on the distinctiveness effect, in that the presence of pictures reduced false memory for critical lures. At the same time, the presence of pictures did not influence memory for studied words. The most important finding is that the distinctiveness-based reduction in false memory was only found under SVN conditions. In the presence of a DVN field, distinctiveness effects were not only reduced but eliminated. Analyses revealed that this arose due to the increase in false memory effects in the presence of DVN. In fact, the proportion of yes responses to critical lures was almost the same as in the absence of pictures.

As the dynamic visual noise field was applied after encoding, the results cannot be dependent mechanisms involved in the initial reception, storage, or consolidation of that information. That DVN was applied during retrieval implicates retrieval or post-retrieval monitoring processes. In this case, the retrieval of pictures during testing provides a basis for the reduction of false memories through the application of post-retrieval monitoring processes (Israel & Schacter, 1997). In the introduction, the distinctiveness heuristic was noted as an example of metacognitive monitoring processes subsumed under the class of retrieval evaluation (Gallo & Lampinen, 2015), or diagnostic monitoring (Gallo, 2010). With evaluative/diagnostic monitoring, the subject possesses expectations about the type of information to be retrieved and responds accordingly.

When distinctive pictorial information has been encoded, the subject develops expectancies in-line with this information. Accordingly, the application this heuristic provides a basis for evaluating the retrieved content for the presence/absence of relevant distinctive information that can be matched against the retrieval criteria (Gallo & Lampinen, 2015). As such, the ability to generate visual information from the encoding phase can provide clues as to the study status of the test item. In particular, absence (vs. presence) of pictorial information can serve as a basis for rejecting (vs. accepting) the item on the test.

Consequently, the subject anticipates the retrieval of pictorial or visual information for studied information (Israel & Schacter, 1997; Schacter et al., 1999). As DVN (vs. SVN) increases the probability of false memories to word lists accompanied by pictorial information, then clearly dynamic visual noise in some way impacts upon the use of evaluative/diagnostic monitoring. Precisely how this is achieved requires further scrutiny. For example, it could be that subjects adopt alternative strategies for monitoring retrieved information and these are less useful or diagnostic for differentiating between studied and non-studied items. Alternatively, attempts to generate pictorial information could still continue, but simply fail in the face of interference. However, just because DVN is hypothesised to influence the diagnostic monitoring does not mean that DVN always acts in this manner. This will depend on the nature of the experimental task and retrieval demands. If other monitoring strategies are employed and these two invoke the generation of images, then memory performance should be expected to be influenced; this of course requires future work

Although the presence of pictures reduced false memory, at least under SVN conditions, they did not enhance retrieval of studied information. In other words, a picture superiority effect was not observed. This outcome is not unprecedented and previous experiments using the same paradigm have also found that the presence of pictures can dissociate true from false recognition (e.g., Budson, Droller, Dodson, Schacter, Rugg, Holcomb, & Daffner, 2005; Schacter, Israel & Racine, 1999). This raises the question as to why the retrieval of visual-imagistic information was useful for reducing false memory but not for enhancing true memory. One explanation for this is that the recognition test was verbal and presented in the auditory modality (Israel & Schacter, 1997). Earlier research has indeed shown that the benefits of studying pictures (vs. words) are reduced in magnitude when tested with words; this has been observed both in terms of both accuracy and response time measures (e.g., Sternberg, Radeborg, & Hedman, 1995). However, important also for producing picture superiority effects are the surface features of the pictures themselves. For example, the largest gains in memory are produced by detailed photographs with smaller gains from black and white line drawings (Gollin & Sharps, 1998; Madigan & Lawrence, 1980; Ritchey 1982). The pictorial stimuli used in the current study were relatively simple black and white line drawings; this may have been sufficient to reduce false memory but insufficient to enhance true memory. Perhaps greater effects on studied items would have been observed if more detailed pictures had been used. Essentially, such conditions as outlined above may serve to minimise the influence of pictorial information for studied items.

The use of the remember/know procedure also revealed some interesting findings. In particular, under SVN, the presence of pictorial information reduced the proportion of false remember responses and process-based estimates of false recollection. One explanation of this is that participants were able to use the absence of pictorial or visual-imagery information in order to avoid false recollections. Thus, in the absence of distinctive visual memories, a false remember response is much less likely to be given. False remember responses in the picture absent condition, could be related to the conscious activation of the critical lure or specific information linked to the associates that were presented during encoding (Lampinen, Meier, Arnal, & Leding, 2005; Roediger & McDermott, 1995).

When pictures had been studied, viewing the DVN field during retrieval, led to an increase in false remember responses and false recollection. Presumably, the presence of DVN reduced the effective generation of visual-imagery and the use of the distinctiveness heuristic. Consequently, the absence of imagery related information could not be employed to reduce false remembering. Instead, false remember responses under the DVN condition may be based upon similar processes that create such memories in the absence of pictures during encoding. That is, subjects may have based false remember responses on the encoding based activation of non-visual associative or lexical information.

Demonstrating an effect of DVN on false memory for critical lures provides some theoretical leverage on the nature in which pictorial information is represented or used to bring about false memory reduction. In particular, Quinn and McConnell (2006) theorize a distinction between a passive visual store, or visual buffer, and a *long-term* pattern activation system (e.g., Kosslyn, 1980, 1994). The pattern activation system is an associative memory store that comprises of abstract information (including visual codes) stored in long-term memory. By this account, the information stored in the pattern activation system is not the visual image as such. Rather, this system contains the required details needed to recreate the conscious visual image; this representation has been called the "compressed" visual image by Kosslyn (1994).

Others have also theorized a distinction between the visual buffer and other components of a *working memory* system; in particular, the visual cache (Logie, 1995; 2011). The visual cache serves the function of maintaining, over short periods, visual information derived either from perception or long-term stores. The contents of the visual cache are temporary representations of a more abstract nature produced after visual mental images have been generated or following a perceptual episode.

Neither the pattern activation system nor the visual cache directly supports visual mental imagery. The visual buffer however, is considered to generate and support the processing of conscious visual imagery. Across various accounts, the long/short-term storage and maintenance of visual information and the generation of conscious visual images are considered to be supported by different cognitive components that give rise to the dissociations observed between various visual memory and imagery tasks (Borst, Niven & Logie, 2012; Logie & Van der Meulen; 2009). For example, although DVN typically reduces performance in tasks requiring the generation of visual mental images, (e.g., Quinn & McConnell, 2006), it does not consistently impair performance on tasks of visual short-term memory (e.g., Andrade, Kemps, Werniers, May, & Szmalec, 2002)[2].

From these proposals, pictorial distinctiveness could be hypothesized to reduce false memory because of either (i) the activation of abstract visual information from the pattern activation store/visual cache or, (ii) the generation of conscious visual imagery in the visual buffer. However, because only the later is susceptible to disruption by DVN (Quinn & McConnell, 2006), then the conclusion that distinctiveness effects in false memory operate by attempts to retrieve visual-imagistic information appears to be warranted. This account suggests that distinctiveness-based false memory reduction arises when relevant imagistic information is retrieved or generated into the visual buffer. When this is prevented, for example by the use of a DVN field, then the generation of imagistic information is disrupted and false memories are increased.

In the context of the above, a distinction has often been made between generation and maintenance processes. Here, generation refers to the creation of images, and maintenance refers to the retention of that information over a time period such as a delay. With regard to visual imagery, it has typically been found that DVN disrupts performance only when applied during the generation stage at encoding or retrieval. When applied during a delay period, over which the same imagery information must be maintained, no effects of DVN are observed. Consequently, it could be argued that DVN is disrupting the actual *generation* rather than the *maintenance* of images; with the latter being consigned to long-term memory or the visual cache depending on the nature of the delay, stimulus and task (Logie and Van der Meulen; 2009). In spite of this claim, the visual buffer must clearly maintain imagery information over some period of time in order for it to be of use when performing various cognitive tasks that demand the use of imagery (Kosslyn, 1994; Kosslyn et al., 2006). Thus the question arises as to whether DVN can disrupt visual imagery once this has been generated, and subsequently impair performance. Unfortunately, this question cannot be answered from the results of the current study as the DVN field was present throughout the retrieval period. Instead DVN would need to be applied at various stages during the retrieval process such as prior to, or just after imagery has been generated. As applied to distinctiveness effects in false memory, this awaits further research.

The results of current study are interesting when considered within a broader perspective of research using electrophysiological recording techniques and neuroimaging. For example, Budson, et al., (2005), used event-related potentials (ERPs) to assess the impact of pictorial information on false memory. They found that for subjects who studied pictures (vs. words), a parietal based ERP component differentiated between studied and non-studied items from about 550 ms to 1000 ms. This was explained as arising from attempts to use the distinctiveness heuristic via attempts to recover pictorial information in order to discriminate between types of item on the recognition test (Budson et al., 2005).

Ganis, Thompson & Kosslyn (2004) argue visual imagery and perception share not only many cognitive features in common but also a great deal of overlap in their respective neural substrates. In some neuroimaging studies, over 90% of the activated voxels are shared between perception and imagery (Ganis et al., 2004). This is to be expected if similar processing mechanisms operate during both imagery and perception. These areas include the visual sensory regions such as the striate (area 17) and pre/extrastriate cortices (such as area 18) (Klein et al., 2004; Kosslyn, DiGirolamo, Thompson, & Alpert, 1998; Kosslyn, & Thompson, 2003; Thiron et al., 2006). At a more general level, it has been concluded that imagery tasks often lead to patterns of brain activity similar (although not always identical) to those during perception (Zimmer, 2008). Similarities observed earlier in the processing stream become more pronounced further down as the processing hierarchy is ascended (Pearson, Naselaris, Holmes & Kosslyn, 2015). Other neuroimaging work has revealed that recollection from long-term memory of the visual details from a study episode can lead to the reactivation of visual regions that were originally activated during encoding (e.g., Stokes, Thompson, Cusack, & Duncan, 2009; Wheeler, Peterson, & Buckner, 2000) and that these regions show differences between true and false memory (Slotnick & Schacter, 2004; Stark, Okado, & Loftus, 2010). Again, this should not be taken to indicate complete overlap between visual perception and visual retrieval, because sensory cortex activations are larger in magnitude during perception with increased involvement of frontal regions during retrieval (e.g., Lee, Kravitz, & Baker, 2013; Ranganath & Paller, 1999; Ranganath, Johnson, & D'Esposito, 2000; Stark, Okado, & Loftus, 2010). The visual buffer has been linked to the early visual processing stream (Kosslyn, & Thompson, 2003) indicating that these areas are of particular importance when the interface between perception, memory and imagery are considered. To date, we are not aware of any research that has directly examined the neural basis of DVN effects. However, neuroimaging studies that have made use of similar visual stimuli (flashing or alternating checkerboard patterns) show increased activity in areas 17 and 18 or the visual buffer (Huettel & McCarthy, 2000; Shigihara, Hoshi, & Zeki, 2016). In addition, processing in some of these sensory regions that are activated during imagery and visual retrieval can be selectively disrupted by external interference such as distraction brought about by the presentation of irrelevant visual input in the form of pictures (Clapp, Rubens, & Gazzaley, 2010; Wais, Rubens, Boccanfuso, & Gazzaley, 2010). Therefore perhaps such interference is acting at the level of the visual buffer. If so, then it could be argued that these regions are those disrupted by

DVN and thus play a role in attempts to retrieve pictorial details to reduce false memory. Further research will play a valuable role in clarifying the conditions in which visual imagery is used during memory and the mechanisms that underpin its usage.

## References

Andrade, J., Kemps, E., Werniers, Y., May, J., & Szmalec, A. (2002). Insensitivity of visual short-term memory to irrelevant visual information. *Quarterly Journal of Experimental Psychology,55A*, 753–774.

Brainerd, C. J., & Renya, V. F. (2005). *The science of false memory*. New York: Oxford University Press.

Borst , G., Niven, E., & Logie, R. H. (2012). Visual mental image generation does not overlap with visual short-term memory: A dual-task interference study. *Memory & Cognition*, *40*, 360-372.

Budson, A. E., Droller, D. B. J., Dodson, C. S., Schacter, D. L., Rugg, M. D., Holcomb, P. J., & Daffner, K. R. (2005). Electrophysiological dissociation of picture versus word encoding: The distinctiveness heuristic as a retrieval orientation. *Journal of Cognitive Neuroscience*, *17,* 1181 – 1193.

Clapp, W. C., Rubens, M. T., & Gazzaley, A. (2010). Mechanisms of working memory disruption by external interference. *Cerebral Cortex, 20,* 859 – 872.

Dean, G. M., Dewhurst, S. A., Morris, P. E., & Whittaker, A. (2005). Selective interference with the use of visual images in the symbolic distance paradigm. *Journal of Experimental Psychology: Learning, Memory & Cognition*, *31*, 1043 – 1068.

Dean, G. M., Dewhurst, S. A., & Whittaker, A. (2008). Dynamic visual noise interferes with storage in visual working memory. *Experimental Psychology, 55*, 283 - 289.

Dent, K. (2009). Dynamic visual noise affects visual short-term memory for surface color, but not spatial location. *Experimental Psychology*, *57*, 17 – 26.

Dienes, Z. (2011). Bayesian versus orthodox statistics: which side are you on? (2011). *Perspectives in Psychological Science*, *6*, 274-290.

Dienes, Z. (2014). Using Bayes to get the most out of non-significant results. Frontiers in Psychology, 5:781. doi: 10.3389/fpsyg.2014.00781

Dodson, C. S., & Schacter, D. L. (2002). When false recognition meets metacognition: The distinctiveness heuristic. *Journal of Memory & Language, 46*, 782 - 803.

Gallo, D. A., Roediger, H. L., & McDermott, K. B. (2001). Associative false recognition occurs without strategic criterion shifts. *Psychonomic Bulletin & Review, 8*, 579-586.

Ganis, G., Thompson, W. L., & Kosslyn, S. M. (2004). Brain areas underlying visual mental imagery and visual perception: An fMRI study. *Brain Research. Cognitive Brain Research, 20*, 226–241.

Gardiner, J. M., & Richardson-Klavehn, A. (2000). Remembering and knowing. In E. Tulving & F. I. M Craik (Eds.), *The Oxford handbook of memory* (pp. 229–244). Oxford: Oxford University Press.

Gollin, E.S., & Sharps, M.J. (1988). Facilitation of categorical blocking depends on stimulus type. *Memory & Cognition*, *16,* 539-544.

Hege, A. C. G., & Dodson, C. S. (2004). Why distinctive information reduces false memories: Evidence for both impoverished relational encoding and distinctiveness heuristic accounts. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *30*, 787-795.

Huettel, S. A., & McCarthy, G. (2000). Evidence for a refractory period in the hemodynamic response to visual stimuli as measured by fMRI. *Neuroimage*, *11*, 547-553.

Israel, L., & Schacter, D. L. (1997). Pictorial encoding reduces false recognition of semantic associates. *Psychonomic Bulletin & Review*, 4, 577-581.

Jacoby, L. L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory & Language, 30*, 513-541.

Jacoby, L. L. (1998). Invariance in automatic influences of memory: Towards a users guide for the process dissociation procedure. *Journal of Experimental Psychology: Learning, Memory & Cognition*, *24*, 3-26.

Jacoby, L. L., Begg, I. M., & Toth, J. P. (1997). In defence of functional independence: Violations of assumptions underlying the process-dissociation procedure? *Journal of Experimental Psychology: Learning, Memory & Cognition, 23,* 484 - 495.

Kemps, E., & Andrade, J. (2012). Dynamic visual noise reduces confidence in short-term memory for visual information. *Cognitive Processes, 13*, 183-188.

Klein, I., Dubois, J., Mangin, J. F., Kherif, F., Flandin, G., Poline, J. B., et al. (2004).

Retinotopic organization of visual mental images as revealed by functional magnetic resonance imaging. *Brain Research. Cognitive Brain Research, 22*, 26-31.

Kosslyn, S. M. (1980). *Image and mind*. Cambridge MA: Harvard University Press.

Kosslyn, S. M. (1994). *Image and Brain. The resolution of the imagery debate*. Cambridge MA: The MIT Press.

Kosslyn, S. M., DiGirolamo, G., Thompson, W. L., & Alpert, N. M. (1998). Mental rotation of objects versus hands: Neural mechanisms revealed by positron emission tomography. *Psychophysiology, 35,* 151–161.

Kosslyn, S. M., & Thompson, W. L. (2003). When is early visual cortex activated during visual mental imagery? *Psychological Bulletin, 129,* 723–746.

Kosslyn, S. M., Thompson, W. L., & Ganis, G. (2006). *The case for mental imagery*. New York: Oxford University Press.

Koutstaal, W., & Schacter, D. L. (1997). Gist-based false recognition of pictures in older and younger adults. *Journal of Memory & Language*, 37, 555-583.

Lampinen, J. M., Meier, C., Arnal, J. A., & Leding, J. K. (2005). Compelling untruths: Content borrowing and vivid false memories. *Journal of Experimental Psychology: Learning, Memory & Cognition*, *31*, 954 – 963.

Lee, S. H., Kravitz, D. J., & Baker, C. I. (2013). Goal-dependent dissociation of visual and prefrontal cortices during working memory. *Nature Neuroscience*, *16*, 997-999.

Logie, R. H. (1995). Visuo-spatial working memory. Hove, U.K.: Erlbaum.

Logie, R. H. (2011). The functional organisation and the capacity limits of working memory. *Current Directions in Psychological Science*, *20*, 240-245.

Madigan, S., & Lawrence, V. (1980). Factors affecting item recovery and hypermnesia in free recall. American *Journal of Psychology, 93*, 489-504.

McCabe, D. P., & Smith, A. D. (2002). The effects of warnings of false memories in young and older adults. *Memory & Cognition, 30*, 1065 – 1077.

McDermott, K. B., & Roediger, H. L. (1998). Attempts to avoid illusory memories: Robost false recognition of associates persists under conditions of explicit warnings and immediate testing. *Journal of Memory & Language, 39*, 508 – 520.

McConnell, J., & Quinn, J. G. (2000). Interference in visual working memory. *Quarterly Journal of Experimental Psychology, 53A*, 53 – 67.

McConnell, J., & Quinn, J. G. (2004). Complexity factors in visuospatial working memory. *Memory, 12*, 338 – 350.

Norman, K. A., & Schacter, D. L. (1997). False recognition in younger and older adults: Exploring the characteristics of illusory memories. *Memory & Cognition, 25,* 838 – 848.

Parker, A., & Dagnall, N. (2009). Concreteness effects revisited The influence of dynamic visual noise on memory for concrete and abstract words. *Memory, 17*, 397 – 410.

Pearson, J., Naselaris, T., Holmes, E.A., & Kosslyn, S. M. (2015). Mental imagery: functional mechanisms and clinical applications. *Trends in Cognitive Sciences, 19,* 590-602.

Quinn, J. G., & McConnell, J. (1996). Irrelevant pictures in visual working memory. *Quarterly Journal of Experimental Psychology, 49A*, 200 – 215.

Quinn, J. G., & McConnell, J. (2006). The interval for interference in conscious visual imagery. *Memory, 14*, 241 - 252.

Ranganath, C., & Paller, K. A. (1999). Frontal brain potentials during recognition are modulated by requirements to retrieve perceptual detail. *Neuron*, *22*, 605-613.

Ranganath, C., Johnson, M. K., & D'Esposito, M. (2000). Left anterior prefrontal; activation increases with demands to recall specific perceptual information. The *Journal of Neuroscience*, *20*, RC108.

Richardson-Klavehn, A., Gardiner, J. M., & Java, R. I (1996). Memory: Task dissociations, process dissociations, & dissociations of consciousness. In G. Underwood (Ed), *Implicit Cognition* (pp. 85-158). Oxford: Oxford University Press.

Ritchey, G. H. (1982). Pictorial Detail and Recall in Adults and Children. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 8, 139-141.

Roediger, H. L., & McDermott, K. B. (1995). Creating false memories: Remembering words not presented on lists. *Journal of Experimental Psychology: Learning, Memory & Cognition*, *21*, 803 - 814.

Roediger, H. L., Watson, J. M., McDermott, K. B., & Gallo, D. A. (2001). Factors that determine false recall: A multiple regression analysis. *Psychonomic Bulletin & Review*, *8*, 385 - 407.

Russell, W. A., & Jenkins, J. J. (1954). The complete Minnesota norms for responses to 100 words from the Kent-Rosonoff Word Association Test (Tech. Rep. No. II, Office of Naval Research). Minneapolis: University of Minnesota.

Schacter, D. L., Cendan, D. L., Dodson, C. S., & Clifford, E. R. (2001). Retrieval conditions and false recognition: Testing the distinctiveness heuristic. *Psychonomic Bulletin & Review, 8,* 827 – 833.

Schacter, D. L., Israel, L., & Racine, C. (1999). Suppressing false recognition in younger and older adults: The distinctiveness heuristic. *Journal of Memory & Language*, 40, 1-24.

Shigihara, Y., Hoshi, H., & Zeki, S. (2016). Early visual cortical responses produced by checkerboard patter stimulation. *Neuroimage, 134*, 532-539.

Seamon, J.G., Lee, I. A., Toner, S. K., Wheeler, R. H., Goodkind, M. S., & Birch, A. D. (2002). Thinking of critical words during study is unnecessary for false memory in the Deese, Roediger and McDermott procedure. *Psychological Science*, 13, 526-531.

Seamon, J. G., Luo, C. R., Kopecky, J. J., Price, C. A., Rothschild, L., Fung, N. S., & Schwartz, M. A. (2002). Are false memories more difficult to forget than accurate memories? The effects of retention interval on recall and recognition. *Memory & Cognition*, 30, 1054-1064.

Slotnick, S. D., & Schacter, D. L. (2004). A sensory signature that distinguishes true from false memories. *Nature Neuroscience,* 7, 664-672.

Stark, C. E. L., Okado, Y., & Loftus, E. F. (2010). Imaging the reconstruction of true and false memories using sensory reactivation and the misinformation paradigms. *Learning & Memory, 17,* 485 – 488.

Sternberg, G., Radeborg, K., & Hedman, L. R. (1995). The picture superiority effect in a cross-modality recognition task. *Memory & Cognition*, *23*, 425-441.

Stokes, M., Thompson, R., Cusack, R., & Duncan, J. (2009). Top-down activation of shape-specific population codes in visual cortex during mental imagery. *Journal of Neuroscience, 29,* 1565 – 1572.

Thapar, A., McDermott, K. B. (2001). False recall and false recognition induced by presentation of associated words: Effects of retention interval and level of processing. *Memory & Cognition*, *29*, 424 - 432.

Tulving, E. (1985). Memory & consciousness. *Canadian Psychologist*, *26*, 1-12.

Wais, P. E., Rubens, M. T., Boccanfuso, J., & Gazzaley, A. (2010). Neural mechanisms underlying the impact of visual distraction on retrieval of long-term memory. *The Journal of Neuroscience, 30,* 8541 – 8550.

Weldon, M. S., Roediger, H. L., III,& Challis, B. H. (1989). The properties of retrieval cues constrain the picture superiority effect. *Memory & Cognition, 17*, 95-105.

Wheeler, M. E., Peterson, S. E., & Buckner, R. L. (2000). Memory's vivid echo: Vivid remembering reactivates sensory-specific cortex. *Proceedings of the National Academy of Sciences, 97*, 11125 – 11129.

Yonelinas, A. P. (2002). The nature of recollection and familiarity: A review of 30 years of research. *Journal of Memory & Language*, *46*, 441-517.

Yonelinas, A. P., & Jacoby, L. L. (1995). The relation between remembering and knowing as bases for recognition: Effects of size congruency. *Journal of Memory & Language*, *34*, 622-643.

Yonelinas, A. P., Kroll, N. E. A., Dobbins, I., Lazzara, M., & Knight, R. T. (1998). Recollection and familiarity deficits in amnesia: Convergence of remember-know, process dissociation, and receiver operating characteristic data. *Neuropsychology, 12,* 323 – 339.

## Footnotes

1. The explanation of the effects of pictorial information on memory in this paper is based on the role of post-retrieval processing. This is not to discount effects that may result from disrupted encoding processes. For example, the presentation of pictures may demand additional processing resources that disrupt the encoding of relational information between words (e.g., Hege & Dodson, 2004). This notion could also apply to other instances in which attentionally demanding tasks reduce the processing of relational information. However, although this may occur to some extent, it does not fully explain the differences found by comparison of between and within-subject designs in which picture effects are found only for between-subject designs.
2. There are some exceptions to this in which DVN has been shown to impair the short-term retention of color or texture (e.g., Dean et al., 2008; Dent, 2010). Typically however, DVN does not interfere with the short-term retention of structured visual stimuli such as matrices.
3. The reported and analysed values are for the log-transformed scores. This is because of a slight positive skew for the β scores for true memory. The analyses for the raw scores did not alter the pattern of results nor the conclusions drawn from these results. The β scores for false memory showed less skew, but the log-transformed scores are shown and presented for the purpose of direct comparison. Once more, the pattern of results was not altered when the raw scores were used.

TABLE 1

Mean proportion (and SD) of hits, false alarms, & signal detection measures as a function of interference condition, item type and picture condition.

| Item Type & Picture Condition | Interference Condition: Static | Interference Condition: Dynamic |
|---|---|---|
| Hits | | |
| Picture | 0.73 (0.13) | 0.78 (0.12) |
| No Picture | 0.78 (0.09) | 0.80 (0.10) |
| False Alarms (Critical Lure from Presented Lists) | | |
| Picture | 0.35 (0.16) | 0.56 (0.12) |
| No Picture | 0.59 (0.22) | 0.61 (0.17) |
| False Alarms (Critical Lure from Non Presented Lists) | | |
| Picture | 0.11 (0.10) | 0.14 (0.17) |
| No Picture | 0.15 (0.21) | 0.16 (0.09) |
| False Alarms (Words from Non Presented Lists) | | |
| Picture | 0.12 (0.13) | 0.14 (0.10) |
| No Picture | 0.17 (0.15) | 0.18 (0.10) |
| Signal Detection True Memory | | |
| *d'* | | |
| Picture | 2.00 (0.59) | 2.03 (0.57) |
| No Picture | 1.91 (0.63) | 1.90 (0.62) |
| Log $\beta$ | | |
| Picture | 0.31 (0.35) | 1.15 (0.38) |
| No Picture | 0.21 (0.36) | 0.06 (0.27) |
| Signal Detection False Memory | | |
| *d'* | | |
| Picture | 0.79 (0.48) | 1.30 (0.61) |
| No Picture | 1.40 (0.74) | 1.35 (0.50) |
| Log $\beta$ | | |
| Picture | 0.27 (0.19) | 0.33 (0.24) |
| No Picture | 0.26 (0.26) | 0.19 (0.18) |

TABLE 2

Mean proportion (and SD) of remember, know & guess responses as function of interference condition, item type and picture condition.

| | Interference Condition | |
|---|---|---|
| Item Type & Picture Condition | Static | Dynamic |
| Studied Words from Presented Lists | | |
| Remember | | |
| Picture | 0.56 (0.18) | 0.54 (0.15) |
| No Picture | 0.51 (0.14) | 0.60 (0.16) |
| Know | | |
| Picture | 0.13 (0.10) | 0.19 (0.11) |
| No Picture | 0.19 (0.12) | 0.16 (0.16) |
| Guess | | |
| Picture | 0.04 (0.07) | 0.05 (0.09) |
| No Picture | 0.08 (0.10) | 0.05 (0.07) |
| Critical Lure from Presented Lists | | |
| Remember | | |
| Picture | 0.14 (0.17) | 0.28 (0.19) |
| No Picture | 0.36 (0.22) | 0.32 (0.17) |
| Know | | |
| Picture | 0.18 (0.13) | 0.24 (0.14) |
| No Picture | 0.16 (0.18) | 0.21 (0.15) |
| Guess | | |
| Picture | 0.03 (0.06) | 0.04 (0.09) |
| No picture | 0.09 (0.11) | 0.09 (0.10) |
| Critical Lure from Non Presented Lists | | |
| Remember | | |
| Picture | 0.02 (0.04) | 0.02 (0.05) |
| No Picture | 0.04 (0.07) | 0.04 (0.05) |
| Know | | |
| Picture | 0.05 (0.06) | 0.08 (0.13) |
| No Picture | 0.06 (0.09) | 0.08 (0.09) |
| Guess | | |
| Picture | 0.05 (0.08) | 0.05 (0.10) |
| No Picture | 0.05 (0.14) | 0.04 (0.07) |
| Words from Non Presented Lists | | |
| Remember | | |
| Picture | 0.01 (0.02) | 0.02 (0.03) |
| No Picture | 0.03 (0.04) | 0.05 (0.07) |
| Know | | |
| Picture | 0.05 (0.07) | 0.08 (0.09) |
| No Picture | 0.08 (0.08) | 0.08 (0.08) |
| Guess | | |
| Picture | 0.06 (0.09) | 0.05 (0.07) |
| No Picture | 0.05 (0.09) | 0.06 (0.07) |

TABLE 3

Mean proportion (and SD) of independence process based estimates of recollection and familiarity as a function of interference condition and word type and picture condition.

| | Interference Condition | |
|---|---|---|
| Item Type & Picture Condition | Static | Dynamic |
| Studied Words from Presented Lists | | |
| Recollection | | |
| Picture | 0.55 (0.19) | 0.53 (0.16) |
| No Picture | 0.48 (0.13) | 0.55 (0.18) |
| Familiarity | | |
| Picture | 0.28 (0.18) | 0.40 (0.20) |
| No Picture | 0.36 (0.17) | 0.34 (0.26) |
| Critical Lure from Presented Lists | | |
| Recollection | | |
| Picture | 0.13 (0.18) | 0.27 (0.18) |
| No Picture | 0.32 (0.23) | 0.28 (0.17) |
| Familiarity | | |
| Picture | 0.18 (0.14) | 0.23 (0.14) |
| No Picture | 0.16 (0.18) | 0.21 (0.16) |