What factors underlie associative and categorical memory illusions? The roles of Backward Associative Strength and inter-item connectivity

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Abstract

Factors that affect categorical and associative memory illusions were investigated in two experiments. In Experiment 1, Backward Associative Strength (BAS) from the list word to the critical lure and inter-item connectivity were manipulated in Deese/Roediger-McDermott (DRM) and category list types. For both recall and recognition tasks, the likelihood of producing DRM and category false memories was greater for lists with high BAS and low inter-item connectivity. In Experiment 2, DRM and category lists with high BAS showed similar indirect priming effects in a word stem completion task. With low BAS, category lists, unlike DRM lists, showed no priming effect. We discuss the role of BAS, inter-item connectivity, and associate level differences in implicit and explicit measures of false memory production.

Keywords:

DRM paradigm

False memories

Backward associative strength

Indirect priming

Category lists

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Deese (1959a) and Roediger and McDermott (1995) developed a procedure for the experimental investigation of false memories. In what is now referred to as the Deese/Roediger-McDermott (DRM) paradigm, participants are presented with semantically-related words lists (e.g., *thread, pin, eye,* and *sewing*), all of which are related to a nonpresented critical lure (e.g., *needle*). A false memory occurs when the participant later incorrectly recalls or recognizes the critical lure at test. The DRM paradigm shows reliable false memory effects with levels of false memory typically equalling or exceeding levels of correct memory (see Gallo 2006).

Recent research has shown that false memories occur not only for the DRM paradigm but also for material that is categorically related. Here participants study lists of words from taxonomic categories (e.g., animals, vehicles) with the most common exemplar acting as the unpresented critical lure (e.g., Smith, Ward, Tindell, Sifonis, & Wilkenfeld, 2000). The two list types differ in that category lists are restricted to only one level of association, that is taxonomy (e.g., different *animals, plants, drinks*), whereas DRM lists usually consist of multiple associative relations (for example, *hot* and COLD are antonyms, *freeze* and COLD are synonyms, *Arctic* and COLD share a situational association, etc.). Interestingly, despite differences in types of associates (taxonomic vs. multiple associations) false memories occur in both list types. However the extent to which DRM and category lists produce similar levels of false memories, and the theoretical implications involved, have been the topic of recent debate (Dewhurst, Bould, Knott, & Thorley, 2009; Howe, Wimmer, & Blease, 2009; Knott & Dewhurst 2007; Smith, Gerken, Pierce and Choi, 2002).

It is clear that paradigms using these lists provide a robust mechanism for producing false memories, however it is less clear what the underlying mechanisms are that account for the production of these false memories. There has been considerable debate over the role of associative connections and thematic relations in the production of false memories. Fuzzy trace theory (FTT) predicts that these false memories rely on the processing of 'gist' memories that connect meaning across different words, therefore placing the importance on across list thematic or semantic relations for the generation of false memories (Brainerd & Reyna, 2005). Associative activation theory (Howe 2006; Howe et al. 2009) and the activation monitoring account (Roediger, Watson, McDermott, & Gallo, 2001) stress the importance of associative relations between list items and critical lures in the production of false memories. Indeed there is a growing consensus for the role of associative strength, associative relations between list items and the critical lure having previously been shown to be the key factor in the production of false memories when using the DRM paradigm (Deese, 1959a; McEvoy, Nelson, & Komatsu, 1999; Roediger et al., 2001). Furthermore findings have also shown that across item gist or inter-item connectivity (typically seen to be high in category lists) have led to an increase in veridical recall but a decrease in false memories (Deese, 1959b; McEvoy et al., 1999). Although theories based on gist extraction would expect false memories to increase with associative strength if the latter also increased gist activation, they would not predict a decrease in false memory production with stronger thematic relations and inter-item connectivity (see Howe 2006, for a review).

Studies have used both DRM and category based lists to investigate the mechanisms involved in false memory production. For example, Smith et al. (2002), in their first three experiments found that associative responses and indirect priming effects occurred when using DRM but not category lists. In their final experiment a priming effect was seen with category lists, but only when participants were given intentional instructions to complete stems with words from the previously studied lists. Smith et al. (2002) concluded that memory illusions produced by DRM lists were caused primarily by associative processes at encoding, whereas memory illusions produced by category lists were caused primarily by semantic confusions at retrieval.

Although not directly controlled for, Smith et al. (2002) argued that high backward associative strength (BAS) between list items and the critical lure was the key. Typically, DRM lists have higher BAS than category lists. However, few studies have provided independent manipulations of both associative strength (or indeed inter-item connectivity) and list type (e.g., DRM vs. category). Hutchison and Balota (2005) demonstrated that when level of association varied (items converged on a single meaning or on multiple meanings of a homophone), but BAS was held constant, adults' false recognition rates did not differ. Howe et al. (2009) manipulated BAS within DRM and category lists with children. Findings indicated that false memories varied with changes in BAS but this occurred independently of type of association (e.g., DRM vs. category).

To summarize, there is considerable evidence to suggest that BAS and, to a certain extent, inter-item connectivity (in a negative direction) are key factors for the occurrence of false memories in list-based procedures, finding that supports an associative activation account of false memory production. One question that arises, based on the findings reported by Smith et al. (2002), is whether this link between BAS, inter-item connectivity, and false memories is dependent on type of association. That is, is false memory production driven by multiple associative connections or single semantic or thematic relations across list items? More recent studies (e.g., Howe et al., 2009; Hutchison & Balota, 2005) have gone some way to answering this question by showing that false memories are driven by BAS independent of type of association (i.e., DRM vs. category). However, neither of these studies manipulated both BAS and inter-item connectivity between DRM and category lists.

The purpose of the present study was to further examine the extent to which false memories are driven by BAS and inter-item connectivity independent of type of association (i.e., DRM or category). In Experiment 1 we examined whether false memories produced by category lists were similarly affected by changes in BAS and inter-item connectivity as false memories produced by DRM lists, and whether DRM and category lists matched on these factors produced similar quantitative levels of explicit false recall and recognition. In Experiment 2, we incorporated a implicit stem completion test similar to that used by Smith et al. (2002) that emphasises the role of associative processes at study in the production of false memories. Although Smith et al. concluded that higher BAS for DRM lists was the likely factor for the indirect priming effect in their studies, this was never directly investigated. The aim of Experiment 2 was to examine the role of BAS (and inter-item connectivity) on the indirect priming effect reported by Smith et al. and to examine whether this effect was independent of list type**.**

Experiment 1

The aim of Experiment 1 was to compare levels of false recall and recognition using DRM and category lists with manipulated levels of inter-item connectivity and BAS. McEvoy et al. (1999) manipulated BAS and inter-item connectivity in two separate experiments. In the present study we manipulated both factors in a within subjects design, though list type (DRM vs. category) was tested between participants.

Method

Participants

Fifty undergraduate students from Lancaster University participated in Experiment 1. All participants were native English speakers between the ages of 18-24. They were tested at individual workstations in groups of 2-4 and received £4 for their participation.

Design and Stimuli

The experiment followed a 2(List type: DRM vs. Category) x 2(BAS: high vs. low) x 2(Inter-item connectivity: high vs. low) design with repeated measures on all but the first factor. As list type was a between participants factor, half the participants received DRM-like lists and half received category lists.

Thirty-two DRM lists and thirty-two category lists were constructed for this experiment. Twenty-six of the DRM lists were taken from Roediger et al. (2001). The remaining lists were designed following the same procedure used by Roediger et al. with associative strength indexes taken from Nelson, McEvoy, & Schreiber (1998). Category examples were taken from Van Overschelde, Rawson, and Dunlosky (2004) and McEvoy and Nelson (1982). As mentioned earlier, DRM lists typically consist of a number of different relations between items (synonyms, antonyms, property relations, concept relations, subordinate relations etc.) but category lists consist of only one level of association (taxonomy). The highest frequency exemplar was typically used as the critical lure for each category list. Backwards associative strength values for each of the category lists were taken from Nelson et al. (1998). Lists were constructed such that, for each list type, there were sixteen lists with a high average BAS and of those lists, eight were constructed with a low inter-item connectivity and eight with a high inter-item connectivity. The remaining sixteen lists were constructed with a low average BAS, with eight of those lists also having a low inter-item connectivity and eight with a high inter-item connectivity. The thirty-two lists in each list type were then split in to two sets of sixteen (4 high BAS/high connectivity, 4 high BAS/low connectivity, 4 low BAS/high connectivity, 4 low BAS/low connectivity). All lists contained 10 items. Participants were presented with one set of lists. Presentation of list sets was counterbalanced across participants and the order of lists presented within the set was randomised.

As mentioned earlier, BAS norms were taken from Nelson et al. (1998) and inter-item connectivity was calculated using connectivity matrices (see McEvoy, Nelson, & Komatsu, 1999, for procedure). All lists were matched across list type depending on BAS and connectivity condition (see Appendix A). Critical lures and list items were also matched, to the extent possible, across connectivity and BAS conditions on a concreteness rating and printed word frequency[1].

The final recognition test consisted of 64 items. The items consisted of the 16 critical lures for each list, 16 unrelated items (taken from the unseen lists from the alternative set), and 32 target items (two from each studied list).

Procedure

Participants were presented with 16 lists. Each word was presented individually on a computer screen at a rate of 1.5 s, with a gap of 1 s. After the presentation of a word list, participants were instructed to answer multiplication problems, and after 20 s recall the just-studied list. The recall task was self-paced and the sequence was repeated for all 16 lists. At the end of the recall task, participants were then given a 5-minute distractor task (multiplication problems) after which the recognition test was presented. Each item in the recognition test remained on the screen until the participant pressed a response key indicating an *old* or a *new* decision.

Results and Discussion

Table 1 shows the mean proportions of correct and false recall and recognition as a function of list type (category vs. DRM), and list condition (BAS and connectivity levels). Data were analysed in a 2(List type: DRM vs. Category) x 2(BAS: high vs. low) x 2(Inter-item connectivity: high vs. low) mixed factor analysis of variance (ANOVA) with repeated measures on all but the first factor. Alpha was set at .05 for this and all subsequent analyses unless otherwise stated.

False recall and recognition

The data from Experiment 1 (see Table 1) indicated that false recall was more likely when BAS was high than when it was low, $F(1, 50) = 13.24$, $MSE = .02$, $?_p^2 = .21$. There was a marginally significant main effect of Inter-item connectivity, $F(1, 50) = 3.02$, $MSE = .04$, $?_p^2 = .06$, with higher false recall with low connectivity. These main effects were qualified by a significant BAS x connectivity interaction, $F(1, 50) = 5.14$, $MSE = .03$, $?_p^2 = .09$. Pairwise comparisons revealed that false recall was higher when lists were designed with high BAS and low connectivity compared to high BAS and high Connectivity ($p < .05$). There was no difference in false recall if BAS was low, regardless of connectivity. Importantly, there was no reliable main effect of List type and no interactions involving list type (all, *F*s < 1).

The pattern was similar on the final recognition test. Although there was no significant main effect of BAS, $F < 1$, there was a marginally significant decrease in false recognition with high compared to low Inter-item connectivity, $F(1, 50) = 3.90$, $MSE = .08$, $?_p^2 = .07$, and a significant BAS x connectivity interaction, $F(1, 50) = 6.60$, $MSE = .05$, $?_p^2 = .12$. Pairwise comparisons revealed that false recognition was higher for high BAS and Low connectivity lists compared to high BAS and high connectivity. There was no difference in false recognition if BAS was low, regardless of connectivity.

Correct recall and recognition

Analysis of correct recall for studied items indicated that more words were recalled from high compared to low connectivity lists, *F*(1, 50) = 17.09, *MSE* = .01, $?_p^2$ = .26. There were no other reliable main effects or associated interactions. For correct recognition there was a significant main effect of connectivity, *F*(1, 50) = 11.55, *MSE* = .02, $?_p^2$ = .19, with better studied item recognition for high compared to low list connectivity. There were no other significant main effects, however there were significant List type x connectivity, *F*(1, 50) = 5.54, *MSE* = .02, $?_p^2$ = .10 and BAS x List type x connectivity interactions, *F*(1, 50) = 7.51, *MSE* = .02, $?_p^2$ = .13.

To further analyze the three-way interaction, separate 2(BAS: high vs. low) x 2(Inter-item connectivity: high vs. low) repeated measures ANOVAs for DRM and category lists were calculated. For DRM lists, there was a significant main effect of connectivity, *F*(1, 25) = 12.97, *MSE* = .02, $?_p^2$ = .34, whereby studied items were better recognised with high compared to low connectivity lists. There was no main effect of BAS or BAS x connectivity interaction (both *F*s < 1). For category lists, there were no reliable main effects but there was a significant interaction, *F*(1, 25) = 7.91, *MSE* = .02, $?_p^2$ = .24. Pairwise comparisons revealed that there was no difference in correct recognition for high BAS lists, regardless of connectivity, but recognition was higher for low BAS lists when connectivity was high compared to low ($p < .05$).

Results from Experiment 1 show that regardless of list type, those designed with high BAS but low inter-item connectivity produced the highest levels of false recall and recognition. For correct recall and recognition of studied items, the most important factor appeared to be inter-item connectivity. For both list types, the more dense the connectivity, the greater the recall. The one exception to this finding came from a three-way interaction in the recognition data that showed recognition to be greater for high connectivity, but only for category lists with low BAS. For DRM lists, recognition was greater with high connectivity regardless of BAS. This was an unexpected finding but one possible explanation could come from the differences in associative relations between DRM and category lists. That is, category lists consist of category examples linked together by a subordinate theme with the most frequently occurring exemplar used as the critical lure. DRM lists instead, consist of semantic free associations to the critical lure on the same coordinate level. Although factors important for false memory production are matched, correct recognition may be more sensitive to these subtle changes.

Experiment 2

As mentioned earlier, Smith et al. (2002) argued that the indirect priming effect was likely a result of higher BAS that led to associative processes activating the prime for DRM lists but not for category lists. By comparing DRM and category lists that have been matched for BAS and inter-item connectivity, this claim can be tested.

Method

Participants

There were 144 participants in Experiment 2. All were between the ages of 18-25 with English as their first language. They were tested at individual workstations in a group testing lab and received £3 or one course credit for their participation.

Stimuli and Design

The second experiment followed a 2(BAS: high vs. low) x 2(Inter-item connectivity: high vs. low) x 2(List type: DRM vs. Category) x 2(Priming: Primed vs. Not primed) design with repeated measures on the final two factors. Priming for lists was counterbalanced so that each list was primed (seen at study) in half the conditions and not primed (not seen in the prior study phase) in the other conditions.

All lists were taken from Experiment 1. Due to design constraints BAS and inter-item connectivity were treated as between subjects factors. Therefore, participants were divided into four groups and presented with either high BAS/high connectivity, high BAS/low connectivity, low BAS/high connectivity, or low BAS/low connectivity lists. As list type was a repeated measures factor, participants studied four lists, consisting of two category and two DRM lists. All lists taken from the first experiment were counterbalanced and seen equally often. Participants were presented with a booklet in which to respond to the various tasks during the experiment. All tasks were presented on an Apple Macintosh computer using an experimental generator program called Psyscript.

Procedure

Participants were presented with 4 word lists and were instructed to learn the words for a later recall task. Each word was presented individually on a computer screen at a rate of 1.5 s, with a gap of 1 s. The four chosen lists (2 DRM and 2 category) were presented in a random order. After the study phase, participants were told that they had to carry out a series of unrelated filler tasks before they would be tested on their memory for the presented lists. The number counting and letter counting tasks were the first and third filler tasks, and taken from Smith et al. (2002). The second task was stem-completion. There were 28 stems, each presented for 1 s with a 5 s interval to record an answer. Participants were instructed to complete the stems with the first word that came to mind. No stems could be completed by list items, and no reference to the lists was made. Eight of the stems corresponded to the critical lures. Primed stems corresponded to the 4 critical lures relating to the just studied lists, with not primed stems relating to the four lists not used at study.

To justify the purpose of the study to the participants, after completing all filler tasks, a free recall test was given. Participants were instructed to recall as many of the original list items as they could[2].

Results and discussion

Table 2 shows stems completed by critical items as a function of List type and priming. Indirect priming was analysed using a 2(BAS: high vs. low) x 2(Inter-item connectivity: high vs. low) x 2(List type: DRM vs. Category) x 2(Priming: Primed vs. Not primed) ANOVA with repeated measures on the final two factors and critical item stem completion as the dependent variable.

Stem completion

Results showed an indirect priming effect, *F*(1, 140) = 10.47, *MSE* = .11, $?_p^2$ = .07, whereby stems were more likely to be completed by critical lures associated with the studied lists (primed, *M* = .39), compared to critical lures from nonstudied lists (not primed, *M* = .30). In addition, there were three interactions, however only one qualified the significant main effect of priming. There was a significant Connectivity X BAS interaction, *F*(1, 140) = 7.68, *MSE* = .08, $?_p^2$ = .05. Here the analysis of SMEs indicated that with low BAS, *F*(1, 70) = 7.36, *MSE* = .09, $?_p^2$ = .10, stems were completed more often when connectivity was also high (*M* = .40) compared to low (*M* = .30). There was no difference when BAS was high (*F* = 1.23). A List type x Connectivity interaction also emerged, *F*(1, 140) = 7.68, *MSE* = .07, $?_p^2$ = .05. Analysis of SMEs indicated that with high Connectivity there was no difference in completion rates between DRM and category lists (*F* = .1.66), however with low Connectivity, *F*(1, 70) = 6.83, *MSE* = .07, $?_p^2$ = .09, more stems were completed with DRM (*M* = .37) compared to category (*M* = .29) critical lures. It is important to note that although these interactions demonstrate significant differences, they do not qualify the priming effect.

The only significant interaction to qualify the main effect of priming was a three-way List type x priming x BAS interaction, *F*(1, 140) = 4.12, *MSE* = .11, $?_p^2$ = .03. To interpret this interaction we split the analysis by BAS. For high BAS, there was a significant priming effect, *F*(1, 70) = 13.49, *MSE* = .09, $?_p^2$ = .16, but no main effect of list or reliable interaction (*F* < 1, for both). For low BAS, there were no significant main effects of List type or priming, but the List type x Priming interaction was significant. *F*(1, 70) = 5.48, *MSE* = .08, $(_p{}^2$ = .07. Analysis of pairwise comparisons indicate a prime effect for DRM lists (prime, *M* = .42 and no prime, *M* = .30, *p* = .02), but no prime effect for category lists ((prime, *M* = .32 and no prime, *M* = .34, *p* = .54). That is, when BAS is low, DRM lists still produce an indirect priming effect on the stem completion task, however, this is not the case for category lists.

The results of Experiment 2 show that, regardless of BAS or inter-item connectivity, DRM lists produce typical indirect priming effects in a word stem completion task, (e.g., McDermott, 1997; Smith et al., 2002). For category lists, however, the story appears to be more complicated. When category lists more closely resemble DRM lists, with high BAS, the indirect priming effect occurs but for category lists with low BAS the priming affect is no longer reliably present.

Therefore, although we have shown a priming effect with category lists, it appears only when lists have high BAS. This pattern can be seen as consistent with the findings of Smith et al. (2002). Although Smith et al. did not report BAS values for their lists, they did imply in the discussion that BAS levels were low. The findings of Experiment 2 also support the results from Smith et al.'s (2002) Experiment 3. Although DRM and category lists produced similar levels of false recall, a priming effect was observed only for DRM lists.

General Discussion

The premise of the current study was that DRM and category lists would produce equivalent levels of false recall and recognition, and equivalent priming effects in a stem completion task, when the lists were matched for BAS and connectivity. Results from Experiment 1 showed that regardless of list type, increasing the strength of connections from list items to critical lures and decreasing the strength of interconnections among list items increased the probability of falsely recalling the critical lures. A similar effect was also found in the final recognition test (but see McEvoy et al. for opposite findings with recognition). The current findings suggest that even when lists vary in their associative relations (i.e., category exemplars linked together by only one level of association vs. list of items that consist of a number of associative relations) the major predictors of false recall and recognition are a strong association between the CL and the list item and weak associations between the list items themselves.

Smith et al. (2002) also argued that category lists produced false memories on tests that emphasized recollection (i.e., recall) but not on tests in which recollection was minimized (indirect priming). For Experiment 2, as Smith et al. predicted the key to producing an implicit priming effect with DRM and category lists appeared to be mean BAS. The current findings show that, regardless of list type, a priming effect was evident in the stem completion task when lists had high BAS. However, for category but not DRM lists with low BAS, the priming effect disappeared. The current findings explains why Smith et al. did not find a priming effect with category lists due to their typically low BAS, but the question still remains as to why DRM lists with low BAS still produce the priming effect?

Although our investigation does not provide a conclusive answer to this question, the one remaining fundamental difference in these lists is their levels of associative links. DRM lists typically consist of multiple relations between concepts whereas category lists are restricted to categorical relations. The current findings show that explicit measures of recognition and recall are not influenced by these variations. However, these factors do appear to influence performance on the implicit task of stem completion. Whatever the explanation, it is evident that there are differences between DRM and category lists, other than BAS and connectivity, which are only picked up by indirect priming tasks.

Results confirm and extend findings by Deese (1959a, 1959b), McEvoy et al. (1999), Roediger et al. (2001), and Howe et al. (2009), that BAS and inter-item connectivity are the key factors in determining false recall and false recognition in the DRM paradigm. Furthermore, even though list items may vary in their underlying semantic relations, the overall likelihood of eliciting false memories in category lists is also governed by these factors (although see Park, Shobe & Kihlstrom, 2005, for opposing results[3]). These results fit well with theories that emphasize the role of associative relations in the production of false memories (e.g., Howe et al., 2009; Roediger & McDermott, 1995). Furthermore, the finding that high inter-item connectivity increased true recall but decreased false recall supports the role of monitoring processes in false memory production. High inter-item connectivity may allow for better encoding of list items, making them more distinguishable from the critical lure (see Roediger et al., 2001 for more detail).

Of course the alternative FTT account would be that false memories were not a product of associative activation, but of gist extraction from semantically related material (Brainerd & Reyna, 2005). This is not to say that BAS would be discounted, but rather that BAS is an index of gist. As Howe et al. (2009) argued, lists high in BAS can also be seen as ‘gist rich’, with many different relationships (in DRM lists) compared to lists that converge on only one theme (category lists). However if gist extraction is required for false memory production, then it could be argued that if a single theme was repeated multiple times (during category list presentation), gist would be easier to extract than if different themes were activated across the different list items (during DRM list presentation).

Whatever the theoretical interpretation, the findings from the current study indicate that, when DRM and category lists are matched for BAS and inter-item connectivity, they produce equivalent levels of false memory on explicit memory tasks that rely on both the activation of associative networks at study and subsequent monitoring errors at test. In contrast, indirect priming effects on a word stem completion task occur for both DRM and category lists when BAS is high, but only for DRM lists when BAS is low. It is likely that differences in the types of associative links may be a further factor in explaining differences in the levels of false memory produced by DRM and category lists.

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Appendix A

Mean values for frequency and concreteness across list items

[pic]BAS	High		Low	
Connectivity	High	Low	High	Low
[pic]				
DRM lists				
Frequency				
CL	2.02 (.26)	1.66 (.72)	1.50 (.63)	1.84 (.65)
List item	1.36 (.18)	1.09 (.45)	1.37 (.31)	1.32 (.32)
Concreteness				
CL	5.09 (.93)	4.69 (1.23)	5.36 (.99)	5.26 (1.74)
List item	5.22 (.81)	4.85 (.87)	5.21 (.62)	5.06 (.79)
[pic]**Category lists**				
Frequency				
CL	1.72 (.74)	1.86 (.58)	1.58 (.44)	1.62 (.62)
List item	1.26 (.42)	.90 (.30)	1.09 (.33)	1.03 (.18)
Concreteness				
CL	5.23 (1.13)	6.22 (.26)	5.86 (.73)	5.96 (.43)
List item	5.04 (1.29)	5.89 (.40)	5.66 (.38)	5.82 (.37)
[pic]				

Note. SD's in parentheses

Appendix B

DRM and category lists used in Experiment 1

DRM lists

BAS: High/Connectivity: High

chair (.27, 2.7)	*cold* (.37, 2.6)	*king* (.30, 2.6)	*sweet* (.23, 3.0)
table	hot	queen	sour
seat	chill	crown	candy
stool	warm	dictator	sugar
desk	winter	emperor	bitter
couch	ice	throne	tangy
sit	snow	monarch	tart
bench	heat	rule	dessert
cushion	freeze	royal	chocolate
sofa	frost	leader	cake
wood	cool	England	taste
child (.23, 2.6)	*funny* (.28, 2.6)	*music* (.28, 2.6)	*doctor* (.29, 2.7)
kid	hilarious	band	nurse

adult	comedy	concert	physician
adolescent	humour	violin	stethoscope
toy	clown	jazz	surgeon
parent	serious	orchestra	medical
baby	silly	symphony	patient
juvenile	ridiculous	sing	hospital
infant	amuse	cello	medicine
youth	joke	instrument	clinic
sibling	laugh	song	sick

BAS: High/Connectivity: Low

slow (.26, .8)	*sleep* (.31, .9)	*needle* (.25, .8)	*smell* (.33, 1.1)
fast	bed	thread	nose
lethargic	nap	pin	sniff
snail	rest	sewing	aroma
turtle	snooze	sharp	nostril
quick	blanket	prick	scent
sluggish	yawn	thimble	fragrance
swift	dream	haystack	perfume
slug	relax	injection	salts
stall	lazy	knitting	rose
delay	quiet	pine	stench

spider (.24, .7)	*soft* (.24, 1.0)	*old* (.31, 1.1)	*window* (.27, .9)
web	hard	new	door
insect	pillow	ancient	glass
arachnid	plush	age	pane
crawl	velvet	used	ledge
tarantula	cotton	worn	sill
bug	fluffy	mature	curtain
widow	silk	ancestor	frame
ant	tender	wise	view
creepy	fur	tradition	shutter
poison	smooth	wisdom	house

BAS: Low/Connectivity: High

thief (.09, 3.2)	*army* (.13, 2.1)	*bread* (.11, 2.2)	*chemistry* (.11, 2.8)
steal	navy	butter	beaker
robber	soldier	toast	element
burglar	military	eat	lab
cop	march	sandwich	physics
bad	captain	jam	molecule
rob	war	milk	electron
jail	uniform	biscuit	biology

crime	pilot	jelly	experiment
theft	officer	cheese	science
fraud	marine	margarine	chemical

cloth (.11, 2.2)	*round* (.13, 2.5)	*river* (.12, 2.9)	*trash* (.11, 2.2)
fabric	oval	creek	garbage
material	circle	stream	dump
linen	sphere	brook	litter
wash	square	lake	waste
rag	globe	canal	refuse
towel	ball	current	can
nylon	shape	valley	scrap
sew	curve	otter	junk
felt	cycle	sea	bag
silk	object	water	alley

BAS: Low/Connectivity: Low

cup (.11, .6)	*pen* (.09, .8)	*smoke* (.11, .8)	*anger* (.09, 1.1)
mug	pencil	cigarette	mad
saucer	fountain	tobacco	fear
glass	highlight	blaze	hate
tea	scribble	ashes	temper
coaster	crayon	fire	wrath
handle	tip	habit	mean
straw	marker	nicotine	fury
jug	ruler	flames	fight
soup	cap	stain	happy
lid	letter	billows	emotion

city (.10, .3)	*man* (.14, .8)	*flag* (.12, .5)	*rough* (.10, 1.0)
town	woman	banner	smooth
crowded	husband	salute	tough
capital	moustache	symbol	bumpy
slum	lady	pole	rigid
street	male	national	course
cab	mate	pride	grit
pollution	strong	country	road
village	friend	parade	rocks
county	beard	nation	uneven
noisy	person	England	gravel

Category lists

BAS: High/Connectivity: High

car (.26, 2.1)	*cat* (.28, 2.4)	*leg* (.2, 2.3)	*math* (.36, 2.1)
vehicle	dog	arm	arithmetic
van	mouse	thigh	calculus
limousine	kitten	knee	algebra
truck	tiger	ankle	trigonometry
bus	leopard	limb	geometry
caravan	panther	hip	add
taxi	lion	foot	subtraction
bike	rat	bone	addition
motorcycle	rabbit	body	multiply
train	animal	hand	divide

pants (.3, 2.8)	*sad* (.31, 2.6)	*day* (.19, 2.3)	*square* (.27, 2.4)
trousers	unhappy	night	rectangle
slacks	happy	week	circle
shirt	depressed	month	triangle
vest	sorrow	calendar	cube
shorts	grief	year	pyramid
skirt	upset	date	oval
dress	despair	hour	sphere
jeans	glad	evening	cone
suit	worry	afternoon	cylinder
belt	angry	time	prism

BAS: High/Connectivity: Low

doctor (.25, .6)	*chair* (.26, 1.1)	*shoes* .25, .5)	*rock* (.27, 1.3)
physician	table	socks	boulder
nurse	recliner	sneakers	stone
surgeon	stool	boots	granite
dentist	desk	slippers	pebble
scientist	couch	sandals	molten
lawyer	furniture	platform	coral
professional	sofa	flipflops	mineral
sergeant	bench	hiking	marble
professor	hammock	tap	lava
biologist	bookcase	clogs	fossil

gun (.23, .9)	*boat* (.24, .9)	*bug* (.24, 1.1)	*church* (.22, .5)
pistol	yacht	beetle	cathedral
weapon	ship	termite	chapel
rifle	canoe	roach	synagogue
cannon	cruise	mosquito	temple
piston	raft	fly	monastery
laser	vessel	cricket	gathering
tank	motor	spider	convent

missile	tug	wasp	parish
knife	submarine	moth	retreat
bomb	steam	ant	mosque

BAS: Low/Connectivity: high

diamond (.15, 2.3)	*wine* (.06, 2.3)	*rain* (.11, 2.3)	*blue* (.08, 2.6)
gem	champagne	cloud	red
ruby	brandy	sunshine	green
jewel	beer	lightning	pink
emerald	port	hurricane	purple
sapphire	whisky	thunder	navy
crystal	bourbon	snow	yellow
pearl	liquor	typhoon	brown
gold	scotch	fog	violet
silver	gin	storm	orange
jade	ale	tornado	maroon

apple (.10, 2.8)	*uncle* (.11, 2.5)	*dollar* (.08, 2.3)	*star* (.08, 2.3)
pear	aunt	buck	comet
fruit	nephew	cent	asteroid
banana	cousin	penny	moon
orange	niece	quarter	universe
cherry	relative	bill	meteor
peach	mother	money	planet
plum	father	coin	meteorite
grape	grandma	pound	Uranus
tangerine	grandfather	dime	rocket
strawberry	sister	euro	sun

BAS: Low/Connectivity: Low

mountain (.10, .8)	*hammer* (.13, 1.4)	*spoon* (.08, 1.1)	*guitar* (.07, 1.2)
hill	nail	fork	violin
valley	chisel	bowl	bass
cliff	saw	silverware	banjo
canyon	wrench	knife	drum
waterfall	screwdriver	spatula	saxophone
cave	pliers	scoop	fiddle
woods	screw	plate	keyboard
volcano	sander	cup	viola
glacier	drill	pan	organ
forest	axe	whisk	trumpet

book (.13, 1.0)	*president* (.08, .8)	*cow* (.15, 1.3)	*mouth* (.12, 1.3)

magazine	candidate	calf	tongue
encyclopaedia	leader	bull	teeth
comic	treasurer	horse	lip
journal	dictator	goat	nose
publication	chairperson	buffalo	cheek
dictionary	mayor	pig	gums
diary	senator	ewe	throat
thesaurus	congress	sheep	moustache
atlas	democrat	chicken	eyes
note	vice	lamb	chin

Note. Values in parentheses represent the mean BAS followed by the mean inter-item connectivity for each word list.

Table 1. Mean proportions of free recall and final recognition for critical lures and studied list items as a function of List type, BAS, and inter-item connectivity in Experiment 1.

[pic]

List Type	DRM				Category			
BAS	High		Low		High		Low	
Connectivity	High	Low	High	Low	High	Low	High	Low
Dependent measure:								
Free recall								
Studied items	.75 (.02)	.70 (.02)	.73 (.02)	.70 (.02)	.73 (.03)	.68 (.03)	.74 (.02)	.69 (.03)
CL’s	.11 (.03)	.22 (.04)	.10 (.03)	.11 (.03)	.16 (.04)	.24 (.06)	.14 (.05)	.13 (.04)
Final Recognition								
Studied items	.89 (.02)	.76 (.04)	.91 (.02)	.83 (.03)	.84 (.03)	.89 (.02)	.91 (.02)	.82 (.03)
CL’s	.47 (.05)	.65 (.06)	.52 (.05)	.50 (.06)	.44 (.05)	.58 (.05)	.51 (.06)	.52 (.06)

[pic]

Table 2. Mean proportions of Priming and free recall for critical lures and studied list items as a function of List type, BAS and inter-item connectivity in Experiment 2.

[pic]

List Type	DRM				Category			
BAS	High		Low		High		Low	
Connectivity	High	Low	High	Low	High	Low	High	Low
Priming								
Primed	.36 (.05)	.44 (.06)	.40 (.04)	.43 (.05)	.44 (.06)	.39 (.05)	.42 (.06)	.22 (.04)
Not Primed	.26 (.04)	.33 (.05)	.33 (.04)	.26 (.05)	.22 (.04)	.26 (.05)	.43 (.05)	.28 (.06)
Indirect priming	.10	.11	.07	.17	.22	.13	-.01	-.06
Final Free recall								

Studied items	.47 (.03)	.33 (.03)	.41 (.03)	.41 (.03)	.53 (.03)	.41 (.03)	.58 (.03)	.48 (.03)
CL’s	.33 (.05)	.46 (.07)	.24 (.05)	.33 (.06)	.33 (.06)	.46 (.07)	.29 (.07)	.32 (.05)

[pic]

Footnotes

[1] Concreteness ratings and log frequencies across list types, scores were analysed separately in 2(List type: DRM vs. Category) x 2(BAS: high vs. low) x 2(Inter-item connectivity: high vs. low) mixed factor analysis of variance (ANOVA)s with repeated measures on all but the first factor. Analysis showed that category lists (M = 5.60) rated higher than DRM lists (M = 5.18) on concreteness scores, F(1, 14) = 6.94, MSE = .63, ?$_p^2$ = .33, but rated lower (M = 1.07 and M = 1.28, respectively) on log frequency, F(1, 14) = 6.48, MSE = .11, ?$_p^2$ = .32. There were no differences in log frequency and concreteness ratings across DRM and category lists matched for BAS and connectivity. A similar analysis of concreteness and frequency values for Critical lures was also conducted. For frequency values, there were no significant main effects or related interactions (all, ps > .05). For concreteness values there was a significant main effect of List type, F(1, 14) = 7.33, MSE = .1.13, ?$_p^2$ = .34, with higher values for category critical lures (M = 5.82) than DRM critical lures (M = 5.10). However, there were no other significant main effects or interactions (see Appendix A for all list variable values).

[2] The final free recall task was provided to validate the study phase. Participants recalled as many items as they could from all four lists. Recall therefore differs from Experiment 1 in that participants recalled 40 items from four different lists after a significant delay, in comparison to a short delay and recall for only one 10-item list. Results are reported in Table 2. To summarize, category, compared to DRM lists produced more accurate true recall, F(1, 140) = 31.64, MSE = .02, ($_p^2$ = .18, and lists with high inter-item connectivity produced more accurate recall, F(1, 140) = 14.73, MSE = .04, ($_p^2$ = .10. There were fewer falsely recalled critical lures when list connectivity was high (M =.30), compared to low (M =.39), F(1, 140) = 4.31, MSE = .14, ($_p^2$ = .03. There was also more critical lures recalled with high (M = .40) compared to low (M = .30) BAS lists, F(1, 140) = 4.97, MSE = .14, ($_p^2$ = .03.

[3] Park et al. (2005) reported that even when lists were matched for BAS, categorical lists still produced fewer false memories than associative lists. They argued that the crucial reason for lower false memory production in category lists was the type of associations involved, with false memories readily occurring as long as the associations are coordinate rather than subordinate in structure. The critical difference between the study of Park et al. and the current study is the design of the category lists. Park et al. used the category label as the critical lure. The current study, however, used the highest frequency exemplar as the critical lure (see also Smith et al., 2002). Therefore, similar to DRM lists, the CL's for category lists were from the same subordinate level.