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Chubala, Chrissy, Suprenant, Aimee, Neath, Ian et al. (1 more author) (2018) Does Dynamic Visual Noise Eliminate the Concreteness Effect in Working Memory? Journal of Memory and Language. pp. 97-114. ISSN 0749-596X

https://doi.org/10.1016/j.jml.2018.05.009

In Press: Journal of Memory and Language

Does Dynamic Visual Noise Eliminate the Concreteness Effect in Working Memory?

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Abstract

Dynamic visual noise (DVN), an array of squares that randomly switch between black and white, interferes with certain tasks that involve visuo-spatial processing. Based on the assumption that the representation of concrete words includes an imagistic code whereas that of abstract words does not, Parker and Dagnall (2009) predicted that DVN should disrupt visual working memory and selectively interfere with memory for concrete words. They observed a reversal of the concreteness effect in both a delayed free recall and a delayed recognition test. In six studies, we partially replicate and extend their work. In Experiments 1 (delayed free recall) and 2 (delayed recognition), DVN abolished, but did not reverse, the concreteness effect. Experiments 3 and 4 found no effect of DVN on a prototypical working memory task, immediate serial recall: concreteness effects were observed in both the control and DVN conditions. In contrast, Experiment 5 showed that DVN abolished the concreteness effect in an immediate serial recognition test. In the final experiment, subjects did not know whether they would receive an immediate serial recall or an immediate serial recognition test until after the list had been presented. Nonetheless, DVN had no effect on immediate serial recall but once again eliminated the concreteness effect on immediate serial recognition. The results (1) extend the effects of DVN on the concreteness effect to working memory tasks, (2) suggest that immediate serial recall and immediate serial recognition are more different than similar, and (3) have implications for theories of DVN, the concreteness effect, and models of memory.

Keywords: memory; visual working memory; concreteness effect; serial recall; free recall; recognition

Does Dynamic Visual Noise Eliminate the Concreteness Effect in Working Memory?

Although there are any number of manipulations an experimenter can use to disrupt performance on a memory test, it is those manipulations which cause selective impairment that are of primary theoretical interest. For example, if the experimenter unexpectedly pokes the subject at a critical time, performance on the memory test may suffer, but for uninteresting reasons. In contrast, a manipulation that selectively impairs memory for one class of items but has no effect on memory for a different class of items provides information that can be used to adjudicate between different theoretical accounts.

Parker and Dagnall (2009) reported a previously unknown example of selective interference: Dynamic visual noise eliminated the standard memory benefit for concrete words over abstract words. Whereas Parker and Dagnall argued that their results bore implications for theories of working memory, their examination of the interaction between dynamic visual noise and concreteness was limited to delayed free recall and delayed recognition tasks. Our first two experiments were replications of their two long-term memory experiments. Given Parker and Dagnall's explanation in terms of working memory, the remaining experiments examine whether the same pattern obtains in tasks more closely associated with working memory, immediate serial recall and immediate serial recognition.

The Concreteness Effect

The concreteness effect refers to the finding that lists of concrete words are generally better remembered than otherwise comparable lists of abstract words. This "standard" concreteness effect has been observed with many different tests, including immediate serial recall (Walker & Hulme, 1999), immediate free recall (Romani, McAlpine, & Martin, 2008), immediate serial recognition (Romani et al.), delayed free recall (Hamilton & Rajaram, 2001), delayed recognition (Groniger & Groniger, 1982), paired associates (Paivio, 1967), and reconstruction of order (Neath, 1997).

A number of different explanations for the concreteness effect have been offered, and we defer a more detailed review until the general discussion, but the most influential is based on Paivio's (1971, 1991, 2007) dual coding theory. The "dual" refers to a distinction between symbolic (verbal or propositional) systems and specific sensorimotor (imaginal or analog) systems. In terms of the concreteness effect, the specific sensorimotor system invoked is based on visual imagery, but this is just one of many possible types of imagery (e.g., auditory imagery, odor imagery, etc.). As applied to the concreteness effect, this view assumes that abstract words are represented in memory by a single verbal or linguistic code whereas concrete words have an additional form of "imagistic" representation. The reason for the superior memory for concrete words, then, is that if the verbal code is insufficient to support memory for the word, there is a second imagistic code available. In contrast, if the verbal code is insufficient to support memory for the abstract word, there is no other code to fall back on. Numerous studies provide support for this view. For example, subjects frequently self-report using visual imagery when processing concrete but not abstract words (Paivio, Smythe, & Yuille, 1968). This is consistent with dual-coding in that there is no specific image that can be generated for an abstract word. Generating visual images takes time, and therefore dual coding theory also predicts that if presentation of the to-be-remembered items is too rapid for the slower imagery processes to run to completion, then the concreteness effect should disappear; and it does (Paivio & Csapo, 1969). In contrast, other stimulus variables such as frequency and familiarity still produce effects even with tachistoscopic presentation (Paivio & O'Neill, 1970).

If the dual coding account of the concreteness effect is correct, manipulations that selectively interfere with visual processing should affect memory for concrete but not abstract words. Parker and Dagnall (2009) reasoned that a manipulation that interferes with the formation of the imagistic code should render memory for concrete words comparable to memory for abstract words because both would be restricted to a solely verbal code. They tested this by using dynamic visual noise, a procedure previously shown to interfere selectively with visual working memory.

Dynamic Visual Noise

Dynamic visual noise was developed by Quinn and McConnell (1996), following up on an earlier report by Logie (1986). In their study, Quinn and McConnell used a display of 320 × 320 squares, each of which was randomly set to black or white. Then, once per second, a random 291 of the 102400 squares changed from their initial color to the other. The to-be-remembered words were presented auditorily. Two conditions were tested. In the *rote instructions condition*, subjects were asked “to commit the words to memory by adding each word to the one heard previously and to repeat them subvocally” (p. 205). In the *visual mnemonic condition,* the subjects were asked to associate six concrete words with the number words (the pegwords) ‘one’ to ‘six’, respectively, which signaled each word’s position within the list, and to create a visual image of each word. Following a 10 s delay, each number was presented as a test cue in both conditions, beginning with 1, and the subject was asked to recall the word with which it was associated. The dynamic visual noise was presented throughout the study phase, the retention interval, and the recall test.

Quinn and McConnell (1996) found that memory performance in the rote instructions condition was unaffected by dynamic visual noise whereas performance in the visual mnemonic condition was impaired by dynamic visual noise. They replicated this result with two additional experiments and concluded that dynamic visual noise selectively interferes with imagistic processing. However, Quinn and McConnell did not vary the concreteness or abstractness of study words; study lists were restricted to words that were high on both imageability and concreteness. The deleterious effect of dynamic visual noise on memory for words using visual mnemonics has been replicated a number of times (e.g., Andrade, Kemps, Wernier, May, & Szmalec, 2002, Experiment 1; McConnell & Quinn, 2000; Quinn & McConnell, 1999).

Quinn and McConnell (1996) explained the effects of dynamic visual noise within the framework of working memory initially proposed by Baddeley and Hitch (1974). Within this framework, a distinction is made between the system that handles verbal information, the phonological loop, and the one that handles visuo-spatial information, the visuo-spatial sketchpad. In the verbal domain, irrelevant speech has been shown to interfere with verbal material assumed to be processed by the phonological loop (for a review, see Neath, 2000). Quinn and McConnell suggested that dynamic visual noise was an analog of irrelevant speech, interfering with visuo-spatial information assumed to be processed by the visuo-spatial sketchpad.

Whereas the initial paradigm involved dynamic visual noise throughout the entire task, Quinn and McConnell (2006) later demonstrated that no impairment occurred when dynamic visual noise was presented only during the retention interval. In contrast, when dynamic visual noise occurred only during encoding or only during recall, memory for words that were studied with a pegword visual mnemonic were impaired whereas those studied by rote were not. Other researchers report similar null results when the dynamic visual noise occurs only during the retention interval. For example, Andrade et al. (2002) found no effect of retention-interval dynamic visual noise on memory for items that should be processed visually, such as matrix patterns or Chinese characters (with subjects who did not know Chinese), and Avons and Sestieri (2005) similarly found that dynamic visual noise during the retention interval had no effect on short-term memory for matrices. In this respect, dynamic visual noise differs from irrelevant speech, which has been shown to affect memory performance when it occurs during the retention interval (Miles, Jones, & Madden, 1991; Norris, Baddeley, & Page, 2004).

Whereas the basic finding of Quinn and McConnell (1996) has been replicated, other experiments with different memory tests have not always found a detrimental effect of dynamic visual noise. For example, Ueno and Saito (2013) found that dynamic visual noise during encoding had a detrimental effect on memory for words studied as paired associates, but had no effect on the serial recall of individual words. One implication of these results is that “paired associate memory is more reliant on visual codes than serial-order memory” (p. 1870).

St. Clair-Thompson and Allen (2013, Experiment 3) found no effect of presenting dynamic visual noise during encoding on the immediate serial recall of digits, whether the recall direction was forward or backward. A subsequent experiment included dynamic visual noise during both the encoding and recall periods, and under these conditions, dynamic visual noise affected backward but not forward recall. It had previously been suggested that backward serial recall, in contrast to forward serial recall, might use a visuo-spatial representation (Li & Lewandowsky, 1995), which may account for the finding. St. Clair-Thompson and Allen noted a distinction between visual short-term memory and visual imagery, and suggested that dynamic visual noise affects the latter but not the former.

Taken together, the literature briefly reviewed above suggests that dynamic visual noise can disrupt memory for imagistic representations of words. The initial explanation invoked an analogy with irrelevant speech. One striking similarity is that both manipulations result in a larger decrement with a larger dose. For example, a number of researchers have shown that the more the dynamic visual noise changes, the larger its effect (Dean, Dewhurst, Morris, & Whittaker, 2005; McConnell & Quinn, 2000; Quinn & McConnell, 1999). In the irrelevant speech literature, a similar finding is the changing state effect, in which the more the irrelevant auditory items change, the larger the disruption (e.g., Beaman & Jones, 1997). However, there are a number of notable differences that call this analogy into question. First, in contrast to irrelevant speech, dynamic visual noise seems to have no effect if it occurs only during the retention interval. Second, and again in contrast to irrelevant speech, dynamic visual noise does not appear to affect performance on immediate serial recall tasks.

It may be the case that the analogy between irrelevant speech and dynamic visual noise fails because verbal/phonological information is processed differently than visuo-spatial information. A number of researchers who have not invoked irrelevant speech as an analog have nonetheless couched their account within the working memory framework. For example, Parker and Dagnall (2009; see also Ueno & Saito, 2013) proposed that dynamic visual noise selectively impacts the storage and processing of visual representations in working memory. By this view, there is no need for parallels with irrelevant speech. Rather, dynamic visual noise has particular and selective effects when the subject is actively using imagistic processing. This can account for many of the results noted earlier, including the lack of an effect of dynamic visual noise on concrete words when the subject is induced to use rote rehearsal (Quinn & McConnell, 1996).

Dynamic Visual Noise and Concreteness

At the time of Parker and Dagnall's (2009) paper, very little research directly compared the effects of dynamic visual noise on memory for both concrete and abstract words. Similar to

Paivio's dual coding theory, Parker and Dagnall (2009)'s account proposed that abstract words are represented only in one code (the phonological loop); that is, there is no imagistic component. In contrast, concrete words give rise to both a phonological representation and an imagistic visual representation based in visual working memory. If this is the case, Parker and Dagnall reasoned, then dynamic visual noise should selectively affect memory for concrete words but have no effect on memory for abstract words. They reported two experiments that tested this prediction.

Parker and Dagnall (2009) used auditory presentation of the to-be-remembered items, but instructed subjects to look at the dynamic visual noise. They used a relatively high rate of change in which a random 50% of the squares changed every 250 ms. In their Experiment 1, a list of 30 words (15 concrete and 15 abstract) was presented, followed by a 5-minute filler task. Subjects were then asked to freely recall as many of the words as possible. Half of the subjects saw static visual noise during study and the other half saw dynamic visual noise. In their Experiment 2, a list of 24 words (12 concrete and 12 abstract) was presented at study (along with 6 additional words to serve as primacy and recency buffers), followed by a 5-minute filler task. At test, subjects were given 48 words and were asked to indicate which words they had seen during study. Again, half of the subjects saw static visual noise during study and the other half saw dynamic visual noise. In both experiments, a typical concreteness effect was observed in the static condition: more concrete words were recalled and recognized than abstract words. Although the prediction was for the elimination of the concreteness effect in the presence of dynamic visual noise, Parker and Dagnall found it was reversed: dynamic visual noise impaired memory for the concrete words to such an extent that abstract words were now better recalled and recognized than concrete words.

The Current Experiments

The results reported by Parker and Dagnall (2009) raise two important issues. First, their finding that dynamic visual noise reversed the concreteness effect was unexpected. Although observed in two studies, the authors had predicted only the elimination of the concreteness effect, not its reversal. Second, it is not clear why tests of long-term memory were used to test the predictions of a visual working memory theory. In both experiments, memory was tested after a 5-minute filler task. Although working memory would be involved in the initial encoding of stimuli in delayed tests, a stronger test of Parker and Dagnall's hypothesis would have employed tasks that more directly tapped working memory rather than relying on long-term memory. For example, concreteness effects have previously been observed in both immediate serial recall (Walker & Hulme, 1999) and immediate serial recognition (Romani, McAlpine, & Martin, 2008). If the Parker and Dagnall/dual coding theory is correct, dynamic visual noise should similarly eliminate (or reverse) the concreteness effect in these working memory tasks.

The experiments in the current paper were designed to address these two issues. To address the first issue, Experiments 1 (delayed free recall) and 2 (delayed recognition) were designed as replications of Parker and Dagnall's Experiments 1 and 2, with the goal of examining the generalisability of their effects and, in particular, the reversed concreteness effect in the presence of dynamic visual noise. To address the second issue, the remaining experiments focused on tasks more closely associated with working memory to assess whether the same pattern is observable with immediate rather than delayed testing, given the putative short-term time course of visual working memory. Therefore, Experiments 3 and 4 used immediate serial recall; Experiment 5 used immediate serial recognition; and Experiment 6 used both immediate serial recall and immediate serial recognition.

Experiment 1 – Delayed Free recall

Experiment 1 was designed to replicate Experiment 1 of Parker and Dagnall (2009). Subjects saw 30 words, half of which were abstract and half of which were concrete, followed by a 4-minute distractor task of generating country names. This was then followed by a free recall test. There are two major differences between the current study and that of Parker and Dagnall. First, the words were presented visually rather than auditorily to ensure that subjects were looking at the screen and therefore seeing the dynamic visual noise. With auditory presentation, subjects could conceivably complete the task with their eyes closed, processing the to-be-remembered auditory stimuli while avoiding the effects of visual noise. The concreteness effect has been demonstrated with both modalities (e.g., Neath, 1997). Second, a large pool of words was generated using the recent Brysbaert, Warriner, and Kuperman (2014) norms for concreteness, and each subject saw a random subset of this pool.

Subjects

Sixty volunteers recruited from Prolific Academic (ProlificAC) participated in this study and were randomly assigned to one of two groups: control or dynamic visual noise. As in all subsequent studies, each was paid £8.00 per hour prorated to the time needed to complete each study. For this and all subsequent experiments, the following inclusion criteria were used: (1) Native speaker of English; (2) approval rating of at least 90% on prior submissions at ProlificAC; and (3) age between 19 and 39. The mean age was 31.12 (*SD* = 5.52, range 19-39); 27 subjects self-identified as female and 32 self-identified as male. The sample size was larger than the sample size of 44 of Parker and Dagnall (2009) because pilot data revealed slightly larger standard deviations than in the Parker and Dagnall study.

Design

There were two independent variables: (1) word type (abstract versus concrete), which was manipulated within subjects, and (2) study background (dynamic visual noise or control), which was manipulated between subjects.

Stimuli

The stimuli were 151 concrete (e.g., bear, drill, frost, mole, skate, tree) and 151 abstract (e.g., blame, debt, frisk, midst, scoot, trend) one-syllable nouns from Brysbaert et al. (2014). The set was constructed by initially selecting only those single syllable nouns that were known by all of the raters in Brysbaert et al.'s study to equate familiarity. The resulting pool was then reduced until the abstract and concrete words were equated for number of phonemes, frequency, orthographic neighbourhood size, and frequency of orthographic neighbours. Details are in the appendix. The full set of stimuli are published online as supplementary materials.

Procedure

Subjects first answered questions about their age and sex. After reading instructions on a computer screen, the subjects then clicked on a button to begin. Thirty words were shown one at a time for 2 s each, in white font against a black rectangle in the centre of the screen. Fifteen words were abstract and fifteen were concrete. The specific words used and the order of the words was randomly determined for each subject. Thus, a given subject saw only 15 of the 151 concrete and only 15 of the 151 abstract words.

In the control condition, no visual noise was present; the background was solid black. In the dynamic visual noise condition, an area of 800 × 500 pixels (width × height) was filled with squares 10 × 10 pixels in size. Each square was randomly set to either white or black. The middle of the screen, just large enough to display the words in 28 point Helvetica font, remained solid black so that the words could be seen in a white font. Every 250 ms, each square was again set randomly to either white or black. On average, then, half the squares changed from white to black or black to white every 250 ms. As in Parker and Dagnall (2009, Experiment 1), the dynamic visual noise was shown only during presentation of the study list. Figure 1 shows a static version of the display.

Following presentation of the 30 words, the subjects were given 4 minutes to type in as many names of countries as they could.[1] Following this, they were asked to type in as many words from Phase 1 as they could. There was no time limit on the test.

Results and Discussion

There was no difference in performance on the distractor task: The mean number of countries entered in the control group was 25.17 ($SD = 9.78$), compared to 27.67 ($SD = 12.71$) in the dynamic visual noise group, $t(58) < 1$.

As can be seen in Figure 2, dynamic visual noise abolished, but did not reverse, the concreteness effect (the means and standard deviations are shown in Table 1). The proportion of words recalled was analyzed by a 2 (word type: concrete vs. abstract) × 2 (noise condition: control vs. dynamic visual noise) mixed factorial ANOVA. The main effect of word type was significant, $F(1, 48) = 13.259$, $MSE = 0.007$, $\eta^2_p = 0.186$, $p < 0.01$, such that concrete words ($M = 0.258$, $SD = 0.202$) were better recalled than abstract words ($M = 0.202$, $SD = 0.185$). The main effect of noise condition was not significant, $F(1, 58) < 1$; the proportion of words recalled in the control condition ($M = 0.228$, $SD = 0.177$) did not differ from the dynamic visual noise condition ($M = 0.233$, $SD = 0.213$).

[1] Parker and Dagnall (2009) asked subjects to write down the names of towns and cities in the United Kingdom.

Importantly, a significant interaction between word type and noise condition was observed, $F(1, 58) = 4.899$, $MSE = 0.007$, $\eta^2_p = 0.078$, $p < 0.05$. As shown in Figure 2, there was a concreteness effect in the control group, with better recall of concrete ($M = 0.273$, $SD = 0.168$) than abstract ($M = 0.182$, $SD = 0.175$) words, $t(58) = 2.056$, $p < 0.05$. In contrast, there was no difference between recall of concrete ($M = 0.244$, $SD = 0.232$) and abstract ($M = 0.222$, $SD = 0.196$) words in the dynamic visual noise group, $t(58) < 1$.

These results confirm the original prediction of Parker and Dagnall (2009): in the absence of dynamic visual noise there was a standard concreteness effect, with concrete words better remembered than abstract words. In the presence of dynamic visual noise, however, there was no difference in recall of concrete and abstract words. The results differ in that Parker and Dagnall found that dynamic visual noise produced a reversal of the concreteness effect, whereas we found that dynamic visual noise merely eliminated the standard effect. We shall revisit this contrasting pattern of findings following exposition of Experiment 2, which was designed as a replication of their recognition experiment.

Experiment 2 – Delayed Old/New Recognition

Experiment 2 was designed to replicate Experiment 2 of Parker and Dagnall (2009). Subjects saw 30 words, half of which were abstract and half of which were concrete, followed by a 4-minute distractor task of generating names of countries. This was then followed by a recognition test. As in Experiment 1, we used visual rather than auditory presentation to ensure that subjects saw the dynamic visual noise.

Subjects

Sixty different volunteers from Prolific AC participated and were randomly assigned to one of two groups (control or dynamic visual noise). The mean age was 28.93 ($SD = 5.19$, range

19-38); 32 self-identified as male and 28 self-identified as female. Unlike with free recall, pilot studies with recognition showed no differences in variability and therefore the sample size was chosen to match that of Parker and Dagnall's (2009) Experiment 2 (n = 30 per condition).

Design

There were two independent variables: (1) word type (abstract versus concrete), which was manipulated within subjects, and (2) study background (dynamic visual noise or control), which was manipulated between subjects.

Stimuli

The stimuli were identical to those used in Experiment 1.

Procedure

With the exception of the initial instructions, the procedure was identical to that of Experiment 1 until the end of the 4-minute country naming task. Following this, subjects were given a recognition test. A prompt ("Was this word shown in Phase I?") and a word were shown, and the subjects were asked to click on a button labelled "Yes" or a button labelled "No". Sixty words were shown; 30 were old words from the study phase, and 30 were new words, of which half were abstract and half were concrete. The words chosen to be old and new items, and the order of the test items, were randomly determined for each subject.

Results

There was no difference in performance on the distractor task: The mean number of countries entered in the control group was 31.30 (SD = 9.35) compared to 31.13 (SD = 13.02) in the dynamic visual noise group, $t(58) < 1$.

Recognition performance was analyzed using two different measures of discriminability and bias: *d'* and *C*, and P_r and B_r.[2] Table 2 shows these values, along with hit and false alarm (FA) rates. As can be seen in Figure 3, dynamic visual noise abolished the concreteness effect as measured by both *d'* and P_r. For each measure of discriminability and bias, as well as for hits and false alarm rates, a 2 (word type: concrete vs. abstract) × 2 (noise condition: control vs. dynamic visual noise) mixed factorial ANOVA was conducted. We present the results for hit and false alarm rates, *d'* and *C* data, and P_r and B_r data in turn.

Hits and False Alarms. For the proportion of hits, there was no main effect of word type, $F(1, 58) < 1$, with equivalent hit rates for both concrete ($M = 0.637$, $SD = 0.167$) and abstract words ($M = 0.623$, $SD = 0.154$). There was likewise no main effect of noise condition, $F(1, 58) = 1.207$, $MSE = 0.037$, $\eta^2_p = 0.020$, $p > 0.25$, with equivalent hit rates for the control ($M = 0.611$, $SD = 0.173$) and the dynamic visual noise groups ($M = 0.650$, $SD = 0.145$). There was, however, a significant interaction, $F(1, 58) = 6.216$, $MSE = 0.013$, $\eta^2_p = 0.097$, $p < 0.05$. Whereas the hit rate was higher for concrete than abstract words in the control condition (0.644 vs. 0.578), $t(58) = 2.052$, $p < 0.05$, this was reversed for the dynamic visual noise condition (0.631 vs. 0.669), although this latter difference was not significant, $t(58) = 1.421$, $p > 0.15$.

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[2] Subjects who had a hit rate of 1 or false alarm (FA) rate of 0 were given scores of 0.99 and 0.01, respectively. P_r is also known as the corrected recognition score because it is calculated as the hit rate minus the false alarm rate. B_r is the probability of saying "old" to an item when uncertain and is simply *p*(FA)/(1- *Pr*) (see Feenan & Snodgrass, 1990). A value of 0.5 for *Br* indicates a neutral response, with smaller values indicating a conservative bias and larger values indicating a liberal bias.

The false alarm data showed a different pattern of results. There was a main effect of word type, $F(1, 58) = 5.198$, $MSE = 0.012$, $\eta^2_p = 0.082$, $p < 0.05$, with a higher false alarm rate for abstract words ($M = 0.258$, $SD = 0.164$) than for concrete words ($M = 0.212$, $SD = 0.153$). There was no effect of noise condition, $F(1, 58) = 1.709$, $MSE = 0.038$, $\eta^2_p = 0.029$, $p > 0.15$, with statistically equivalent false alarm rates in the control ($M = 0.212$, $SD = 0.146$) and the dynamic visual noise condition ($M = 0.259$, $SD = 0.170$). The interaction was not significant, $F(1, 58) < 1$.

***d′* and *C*.** For the *d′* data, there was a significant main effect of word type, $F(1, 58) = 5.949$, $MSE = 0.400$, $\eta^2_p = 0.093$, $p < 0.05$, with better performance for concrete words ($M = 1.407$, $SD = 0.943$) than abstract words ($M = 1.126$, $SD = 0.778$). The main effect of group was not significant, $F(1, 58) < 1$, with equivalent performance in the control ($M = 1.296$, $SD = 0.888$) and dynamic visual noise conditions ($M = 1.237$, $SD = 0.862$). Importantly, the interaction was significant, $F(1, 58) = 5.124$, $MSE = 0.400$, $\eta^2_p = 0.081$, $p < 0.05$. In the control condition, performance was better with concrete than with abstract words, $t(58) = 3.032$, $p < 0.01$, but in the dynamic visual noise condition there was no difference between the two types of words, $t(58) < 1$.

For the *C* data, the main effect of word type was not significant, $F(1, 58) = 1.660$, $MSE = 0.082$, $\eta^2_p = 0.028$, $p > 0.20$, with equivalent values for concrete ($M = 0.275$, $SD = 0.440$) and abstract words ($M = 0.202$, $SD = 0.402$). The main effect of group was likewise not significant, $F(1, 58) = 2.177$, $MSE = 0.254$, $\eta^2_p = 0.036$, $p > 0.10$, with comparable performance in the control group ($M = 0.307$, $SD = 0.410$) and the dynamic visual noise group ($M = 0.171$, $SD = 0.425$). The interaction was not significant, $F(1, 58) < 1$.

***P_r* and *B_r*.** Analyses of the P_r and B_r data revealed the same pattern as that observed in the *d'* and *C* data. For P_r, there was a significant main effect of word type, $F(1, 58) = 4.568$, $MSE = 0.102$, $\eta^2_p = 0.073$, $p < 0.05$, with better performance for concrete ($M = 0.425$, $SD = 0.217$) than abstract words ($M = 0.365$, $SD = 0.207$). The main effect of group was not significant, $F(1, 58) < 1$, with equivalent performance in the control ($M = 0.399$, $SD = 0.217$) and dynamic visual noise conditions ($M = 0.391$, $SD = 0.211$). Importantly, the interaction was significant, $F(1, 58) = 4.285$, $MSE = 0.024$, $\eta^2_p = 0.069$, $p < 0.05$. In the control condition, performance was better with concrete than with abstract words, $t(58) = 2.995$, $p < .01$, but in the dynamic visual noise condition there was no difference between the two types of words, $t(58) < 1$.

For the B_r data, the main effect of word type was not significant, $F(1, 58) = 1.288$, $MSE = 0.805$, $\eta^2_p = 0.022$, $p > 0.20$, with equivalent values for concrete ($M = 0.366$, $SD = 0.219$) and abstract words ($M = 0.398$, $SD = 0.192$). The main effect of group was not significant, $F(1, 58) = 2.093$, $MSE = 0.060$, $\eta^2_p = 0.035$, $p > 0.15$, with comparable performance in the control group ($M = 0.349$, $SD = 0.196$) and the dynamic visual noise group ($M = 0.414$, $SD = 0.212$). The interaction was not significant, $F(1, 58) < 1$.

Discussion

As in Experiment 1, the results of Experiment 2 confirm the original prediction of Parker and Dagnall (2009) that dynamic visual noise eliminated the mnemonic advantage for concrete words over abstract words. As in Experiment 1, the results of Experiment 2 did not replicate their reversed concreteness effect. The hit rate data came closest to showing a reversal of the concreteness effect, but the numerically higher hit rate for abstract over concrete words in the dynamic visual noise condition did not reach the adopted significance level. For the two measures of discriminability, *d'* and B_r, there was no evidence of a reversal.

There are two notable differences between the current experiments and those of Parker and Dagnall (2009) that may have led to the contrasting pattern of findings. The first is the change in presentation modality from auditory to visual. We chose visual presentation to ensure that subjects were looking at the dynamic visual noise. To our knowledge, all instances of dynamic visual noise occurring simultaneous with verbal stimulus presentation have involved auditory presentation. As a consequence, there are no previous comparable extant data. Nonetheless, it is not clear how or why presentation modality would alter the direction of the concreteness effect.

A second notable difference between the studies is the stimulus set. Parker and Dagnall (2009) used a small set of 15 concrete and 15 abstract nouns in their Experiment 1, and 24 concrete and 24 abstract words in Experiment 2. The abstract and concrete words had similar values for meaningfulness, frequency, number of syllables, and length, but could have varied on other dimensions. All subjects saw the same words. In contrast, we used a pool of 151 concrete and 151 abstract words that were equated on more dimensions, including contextual diversity and orthographic neighbourhood measures. Moreover, the norms used for frequency and concreteness were more recent than those employed by Parker and Dagnall. Each subject saw a random subset of words from the larger pool, a method that minimizes the possible effects of any odd or unusual words. It may be that their particular sample of concrete and abstract words led to the appearance of a reversal that is otherwise absent in broader stimulus sets.

It is also noteworthy that Parker and Dagnall (2009) were at something of a loss to explain their reversed concreteness effect, stating that “the reason for this [reversal] remains to be explored.” (p. 407). Nonetheless, they did speculate that the interference to the visual code of highly concrete words by dynamic visual noise “disrupts processing” of the corresponding word’s logogen. We revisit this issue in the General Discussion.

Experiment 3 – Immediate Serial Recall

Experiments 1 and 2 here, as well as the two experiments by Parker and Dagnall (2009), used delayed tests in which the role of visual working memory or short-term memory is minimized. Given that Parker and Dagnall’s proposed explanation emphasizes working memory, the purpose of Experiment 3 was to examine whether dynamic visual noise interacts with the concreteness effect when the task is more closely linked to working memory. The prototypical working memory task is immediate serial recall; in fact, the original theoretical account of working memory had its basis in four benchmark effects observed in immediate serial recall tests (Baddeley, 1986). Ueno and Saito (2013, Experiment 1) used a 2 (memory task: paired associates vs. immediate serial recall) × 2 (word type: high concreteness vs. low concreteness) × 2 (noise condition: presence vs. absence of dynamic visual noise) design. They found no interaction between dynamic visual noise and concreteness on the serial recall test. However, as noted above, a number of studies have found that the effects of dynamic visual noise increase when the rate of change increases (Dean et al., 2005; McConnell & Quinn, 2000; Quinn & McConnell, 1999). Ueno and Saito used the same slow and small percentage change that Quinn and McConnell (1996) used, only 291 squares in a 320 × 320 display changing once per second. It is possible that with 50% of the squares changing 4 times a second, an effect might have been observed. Therefore, Experiment 3 used the same dynamic visual noise manipulation as in Experiments 1 and 2, but manipulated dynamic visual noise within subjects, just as Ueno and Saito did. We used 6 item lists rather than 8 item lists based on past research in the lab to avoid floor effects, and we also used visual rather than auditory presentation to ensure that subjects in the dynamic visual noise condition could not help but process the noise.

Subjects

Thirty different volunteers from Prolific AC participated. The mean age was 27.77 (*SD* = 5.35, range 20-38); 16 subjects self-identified as male, 13 self-identified as female, and 1 did not answer the question. The sample size was half that of the previous experiments because of the change from a between- to a within-subjects design.

Design

The two independent variables, both manipulated within subjects, were the word type (abstract vs. concrete) and the background visible when the words were displayed (dynamic visual noise vs. control). The dependent variable was the proportion of words that were correctly recalled in order.

Stimuli

The stimuli were identical to those used in Experiments 1 and 2.

Procedure

Subjects first answered questions about their age and sex. After reading instructions on a computer screen, subjects then clicked on a button to start the first trial. A list of 6 words were shown one at a time for 1 s each. At the end of the list, the subject was prompted to type in the first word, then the second word, and so on. Subjects were instructed that they needed to make 6 responses before they could start the next trial, and that they should either guess if they were unsure, or else click on the “Skip” button to indicate they did not remember the word. The dynamic visual noise manipulation was the same as that described in Experiments 1 and 2.

There were 22 trials in total. The first two trials were unscored practice; one practice trial used abstract words whereas the other used concrete words, and one practice trial involved dynamic visual noise during encoding whereas the other was a control trial with no dynamic visual noise. The specific pairing of abstract/concrete with dynamic visual noise/control was determined randomly for each subject. For the remaining 20 trials, ten used abstract words and ten used concrete words. The specific words used in each list, the order of the words, and the order of the conditions was randomly determined for each subject. A given word could appear only once during the entire experiment.

Results and Discussion

The results are shown in the upper row of Figure 4: A concreteness effect was observed in both the control and the dynamic visual noise conditions. The overall mean proportion correct in each condition is shown in Table 1. The proportion of words correctly recalled in order was analyzed with a 2 (word type: concrete vs. abstract) × 2 (noise condition: control vs. dynamic visual noise) × 6 (serial position: 1 – 6) repeated measures ANOVA. There was a significant main effect of word type, $F(1, 29) = 20.038$, $MSE = 0.049$, $\eta^2_p = 0.409$, $p < 0.01$, with better memory for concrete ($M = 0.568$, $SD = 0.170$) than abstract words ($M = 0.494$, $SD = 0.194$). The main effect of noise condition was not significant, $F(1, 29) < 1$. The mean proportion of words correctly recalled in order was comparable in the control ($M = 0.526$, $SD = 0.181$) and dynamic visual noise conditions ($M = 0.537$, $SD = 0.185$). The main effect of position was significant, $F(5, 145) = 89.405$, $MSE = 0.049$, $\eta^2_p = 0.755$, $p < 0.01$. None of the interactions were reliable; the only interaction with $F > 1$ was word × position, $F(5, 145) = 1.979$, $MSE = 0.031$, $\eta^2_p = 0.065$, $p = 0.085$. Concrete and abstract words did not differ at the first or final positions, but did differ at other positions, although this trend was not sufficient to support a significant interaction.

The data were rescored using free recall rather than serial recall scoring. With free recall scoring, a correct response includes recalling a word from the list in an incorrect position. This increased the overall proportion correct in all conditions by approximately 10% but otherwise had no effect on the results. There was a significant main effect of word type, $F(1, 29) = 10.119$, $MSE = 0.054$, $\eta^2_p = 0.259$, $p < 0.01$, with better memory for concrete ($M = 0.654$, $SD = 0.148$) than abstract words ($M = 0.599$, $SD = 0.181$). The main effect of noise condition was not significant, $F(1, 29) < 1$. The mean proportion of words correctly recalled in any order was comparable in the control ($M = 0.624$, $SD = 0.159$) and dynamic visual noise conditions ($M = 0.628$, $SD = 0.171$). The main effect of position was significant, $F(5, 145) = 54.897$, $MSE = 0.062$, $\eta^2_p = 0.654$, $p < 0.001$. None of the interactions were reliable; all were $F < 1$. Thus, the pattern of results is identical regardless of whether strict serial recall or free recall scoring is used.

Dynamic visual noise did not eliminate the benefit for concrete over abstract words in an immediate serial recall task. This result replicates the null result of Ueno and Saito (2013) even though a more “powerful” manipulation of dynamic visual noise was used which had been found in Experiments 1 and 2 to affect memory for concrete items. It also replicates the null results of Castellà and Campoy (in press). However, there is one obvious difference, other than the test, between Experiment 3 and Experiments 1 and 2: In the first two experiments, dynamic visual noise was manipulated between-subjects whereas the third experiment used a within-subjects manipulation. Experiment 3 was run as a completely within-subjects design because that is the common design when exploring other working memory phenomena, such as the interaction between concurrent articulation and phonological similarity (e.g., V. Coltheart, 1993) or the interaction between concurrent articulation and word length (e.g., Baddeley, Lewis, & Vallar, 1984). Moreover, it was also the design used by Ueno and Saito (2013). A number of researchers have shown that manipulating dynamic visual noise within subjects does impair memory. For example, Dent (2010) found that dynamic visual noise manipulated within subjects affected memory for colours. Similarly, Dean et al. (2008) found that dynamic visual noise manipulated within subjects affected memory for textures. Nevertheless, it is possible that the failure to find an effect of dynamic visual noise in Experiment 3 was due to the design and therefore we conducted Experiment 4 to test this possibility. Like Experiment 3, Experiment 4 examined the effects of dynamic visual noise on immediate serial recall of concrete and abstract words. Unlike Experiment 3, however, the dynamic visual noise versus control conditions were run as a between-subjects manipulation, as they were in Experiments 1 and 2.

Experiment 4 – Immediate Serial Recall

Experiment 4 was nearly identical to Experiment 3 except that dynamic visual noise was manipulated between-subjects rather than within-subjects.

Subjects

Sixty different volunteers from Prolific AC participated. The mean age was 28.35 (*SD* = 5.87, range 19-38); 35 self-identified as male, 23 self-identified as female, and 2 did not respond to the question. The sample size was double that of Experiment 3 due to the change from a within- to a between-subjects manipulation of dynamic visual noise.

Design

The two independent variables were word type (abstract vs. concrete), which was manipulated within subjects, and the background visible when the words were displayed (dynamic visual noise vs. control), which was manipulated between subjects. The dependent variable was the proportion of words that were correctly recalled in order.

Stimuli

The stimuli were identical to those of Experiments 1-3.

Procedure

The procedure was nearly identical to that of Experiment 3, except for the following. There were 18 lists rather than 22; however, there were now 9 lists per condition (abstract or concrete), due to the between-subjects manipulation of dynamic visual noise.

Results and Discussion

The results are shown in the middle row of Figure 4 and are the same as those observed in Experiment 3: A concreteness effect was observed in both the control and the dynamic visual noise conditions. The overall mean proportion correct in each condition is shown in Table 1. The proportion of words correctly recalled in order was analyzed with a 2 (word type: concrete vs. abstract) × 2 (noise condition: control vs. dynamic visual noise) × 6 (serial position: 1 – 6) mixed ANOVA. There was a significant main effect of word type, $F(1, 58) = 25.234$, $MSE = 0.031$, $\eta^2_p = 0.303$, $p < 0.01$, with better memory for concrete ($M = 0.576$, $SD = 0.118$) than abstract words ($M = 0.510$, $SD = 0.110$). The main effect of noise condition was not significant, $F(1, 58) = 2.306$, $MSE = 0.337$, $\eta^2_p = 0.038$, $p > 0.10$, with comparable proportions of words correctly recalled in order in the control ($M = 0.576$, $SD = 0.159$) and dynamic visual noise conditions ($M = 0.510$, $SD = 0.176$).[3] The main effect of position was significant, $F(5, 290) = 128.622$, $MSE = 0.046$, $\eta^2_p = 0.689$, $p < 0.01$. As in Experiment 3, none of the interactions were significant; the only interaction with $F > 1$ was word × position, $F(5, 290) = 1.531$, $MSE = 0.015$, $\eta^2_p = 0.026$, p

[3] Reporting means of 0.576 and 0.510 for concrete and abstract (respectively) and also for control and dynamic visual noise (respectively) is not an error but a coincidence. As the text indicates, while the means are the same, the standard deviations differ.

> 0.15. Concrete and abstract words did not differ at the first position, but did differ at other positions, although this trend was not sufficient to support a significant interaction.

As in Experiment 3, the data were rescored using free recall criteria: If the subject reported a word from the list, it was counted as correct regardless of its position. There was a significant main effect of word type, $F(1, 58) = 22.191$, $MSE = 0.021$, $\eta^2_p = 0.277$, $p < 0.01$, with better memory for concrete ($M = 0.655$, $SD = 0.099$) than abstract words ($M = 0.605$, $SD = 0.092$). The main effect of noise condition was not significant, $F(1, 58) = 2.378$, $MSE = 0.241$, $\eta^2_p = 0.039$, $p > 0.10$, with comparable proportions of words correctly recalled in order in the control ($M = 0.658$, $SD = 0.134$) and dynamic visual noise conditions ($M = 0.602$, $SD = 0.150$). The main effect of position was significant, $F(5, 290) = 78.089$, $MSE = 0.134$, $\eta^2_p = 0.574$, $p < 0.01$. None of the interactions were significant. All had $F < 1$ except for word type × noise, $F(1, 58) = 1.143$, $MSE = 0.021$, $\eta^2_p = 0.019$, $p > 0.25$; and for word × position, $F(5, 290) = 1.119$, $MSE = 0.018$, $\eta^2_p = 0.019$, $p > 0.35$. As in Experiment 3, the pattern of results are the same regardless of whether serial recall or free recall scoring is used.

Thus, dynamic visual noise had no effect on memory for concrete or abstract words in an immediate serial recall task regardless of whether the dynamic visual noise was manipulated between subjects (Experiment 3) or within subjects (Experiment 4). These two null results replicate the null result reported by Ueno and Saito (2013).

Immediate serial recall differs from delayed free recall and delayed recognition in a number of ways, with the most obvious being the delay and the importance of order information. In order to assess whether these differences are the reason for the lack of an effect of dynamic visual noise, Experiment 5 also used an immediate test that requires order information: immediate serial recognition. In an immediate serial recognition test, subjects see a short list of words followed immediately by a second short list. The second list is either the same as the first or has two adjacent items transposed, and the subject's task is to indicate whether the lists are the same or different (see, e.g., Allport, 1984; Gathercole, Pickering, Hall, & Peaker, 2001; Kinsbourne, 1972).

Two prior studies have examined whether a standard concreteness effect obtains in immediate serial recognition. Walker and Hulme (1999) reported no concreteness effect, but they used a small set of items and analyzed only a span score based on the number of trials correct. Romani et al. (2008) used both a large and a small set of items, and observed a concreteness effect with the large pool but not with the small pool, but they analyzed only proportion correct as the measure.

Experiment 5 – Immediate Serial Recognition

Experiments 1 and 2 here, as well as the two experiments by Parker and Dagnall (2009), used delayed tests in which the role of visual working memory or short-term memory is minimized; in all four experiments, dynamic visual noise interacted with concreteness. Experiments 3 and 4 used an immediate serial recall test which is directly linked to working memory but found no effect of dynamic visual noise, replicating the results of Ueno and Saito (2013). The purpose of Experiment 5 was to use a different immediate test that, like immediate serial recall, also requires order information to assess whether the detrimental effects of dynamic visual noise are limited to delayed tests that de-emphasize order information.

Subjects

Sixty different volunteers from Prolific AC participated and were randomly assigned to one of two groups (control or dynamic visual noise). The mean age was 29.40 (*SD* = 5.50, range 18-38); 30 subjects self-identified as male and 30 self-identified as female.

Design

The two independent variables were word type (abstract vs. concrete), which was manipulated within subjects, and the background visible when the words were displayed (dynamic visual noise vs. control), which was manipulated between subjects.

Stimuli

The stimuli were identical to those of Experiments 1-4.

Procedure

Subjects first answered questions about their age and sex. After reading instructions on a computer screen, they then clicked on a button to start. Six words were shown one at a time for 1 s each in white font against a black rectangle in the centre of the screen. A prompt then appeared, “Is this the same order or a different order?” and then six words were again shown at the same rate. Half the time, the second list was identical to the first; the other half of the time, two adjacent items were transposed. The computer randomly transposed either items 2 and 3, items 3 and 4, items 4 and 5, or items 5 and 6. At the end of the second list, the subject clicked on either the “Same” or the “Different” button.

In the control condition, no visual noise was present; the background was solid black. In the dynamic visual noise condition, the noise accompanied presentation of the first list of 6 words but was not present for the second list. There were 32 lists, half of which were the same in both presentations and half of which were different across the two presentations. Sixteen lists had abstract words and sixteen had concrete words. The specific words used, the order of the words, and the order of the conditions was randomly determined for each subject.

Results

We first report proportion correct so that the results may be compared to those of Walker and Hulme (1999) and Romani et al. (2008). In addition, we classified correct decisions on *different* trials as hits, and correct decisions on *same* trials as correct rejections (MacMillan & Creelman, 2004). This allowed us to analyze not only hits and false alarms, but also two different measures of discriminability and bias: d' and C, and P_r and B_r. Table 3 shows these values, along with hit and false alarm rates. As can be seen in Figure 5, dynamic visual noise abolished the concreteness effect as measured by both d' and P_r. For each measure of discriminability and bias, as well as for proportion correct, hits and false alarm rates, a 2 word type (concrete vs. abstract) × 2 noise condition (control vs. dynamic visual noise) mixed factorial ANOVA was conducted. We discuss the results for proportion correct, hit and false alarm rates, d' and C data, and P_r and B_r data in turn.

Proportion Correct. For proportion correct, the main effect of word type just failed to reach the adopted significance level, $F(1, 58) = 3.567$, $MSE = 0.008$, $\eta^2_p = 0.058$, $p = 0.064$. The proportion correct for concrete words was 0.725 ($SD = 0.136$) compared to 0.694 ($SD = 0.133$) for abstract words. The proportion correct in the control condition ($M = 0.707$, $SD = 0.129$) was the same as in the dynamic visual noise condition ($M = 0.711$, $SD = 0.136$), $F(1,58) < 1$. However, the interaction was significant, $F(1, 58) = 4.058$, $MSE = 0.008$, $\eta^2_p = 0.065$, $p < 0.05$. In the control condition, the proportion correct was higher for concrete ($M = 0.740$, $SD = 0.133$) than abstract ($M = 0.675$, $SD = 0.119$) words, $t(29) = 3.346$, $p < 0.01$. In the dynamic visual noise condition, there was no difference between the proportion correct was for concrete ($M = 0.710$, $SD = 0.140$) and the proportion correct for abstract ($M = 0.713$, $SD = 0.146$) words, $t(29) = 0.077$, $p > 0.90$.

Hits and False Alarms. For the proportion of hits, there were no significant effects. The hit rate for concrete words (M = 0.681, SD = 0.192) did not differ from that for abstract words (M = 0.648, SD = 0.188), $F(1, 58) = 1.757$, MSE = 0.019, $\eta^2_p = 0.029$, $p > 0.15$. The hit rate in the control condition (M = 0.662, SD = 0.188) was the same as in the dynamic visual noise condition (M = 0.666, SD = 0.194), $F(1,58) < 1$. The interaction was not significant, $F(1, 58) = 2.757$, MSE = 0.019, $\eta^2_p = 0.045$, $p > 0.10$.

The false alarm data also showed no significant effects. The false alarm rate for concrete words (M = 0.232, SD = 0.162) did not differ from the false alarm rate for abstract words (M = 0.261, SD = 0.167), $F(1, 58) = 1.307$, MSE = 0.019, $\eta^2_p = 0.022$, $p > 0.25$. Similarly, the false alarm rate in the control condition (M = 0.249, SD = 0.173) did not differ from the false alarm rate in the dynamic visual noise condition (M = 0.245, SD = 0.157), $F(1, 58) < 1$. The interaction was not significant, $F(1,58) < 1$.

***d′* and *C*.** For the d' data, the main effect of word type just failed to reach the adopted significance level, $F(1, 58) = 3.515$, MSE = 0.494, $\eta^2_p = 0.057$, $p = 0.066$, although numerically performance was higher for concrete (M = 1.462, SD = 1.046) than abstract words (M = 1.222, SD = 0.959). The main effect of group was not significant, $F(1, 58) < 1$, with equivalent performance in the control (M = 1.309, SD = 0.942) and dynamic visual noise conditions (M = 1.375, SD = 1.074). Importantly, the interaction was significant, $F(1, 58) = 4.797$, MSE = 0.494, $\eta^2_p = 0.076$, $p < 0.05$. In the control condition, performance was better with concrete than with abstract words, $t(58) = 3.071$, $p < 0.01$, but in the dynamic visual noise condition there was no difference between the two types of words, $t(58) < 1$.

For the C data, both main effects and the interaction had $F(1,58) < 1$.

***P_r* and *B_r*.** The results of the analyses of the P_r and B_r data revealed the same pattern as was observed in the *d'* and *C* data. In the P_r data, the main effect of word type just failed to reach the adopted significance level, $F(1, 58) = 3.548$, $MSE = 0.032$, $\eta^2_p = 0.058$, $p = 0.065$, although numerically performance was again higher for concrete ($M = 0.448$, $SD = 0.270$) than abstract words ($M = 0.386$, $SD = 0.264$). The main effect of group was not significant, $F(1, 58) < 1$, with equivalent performance in the control ($M = 0.413$, $SD = 0.257$) and dynamic visual noise conditions ($M = 0.421$, $SD = 0.281$). Importantly, the interaction was significant, $F(1, 58) = 4.001$, $MSE = 0.032$, $\eta^2_p = 0.065$, $p = 0.05$. In the control condition, performance was better with concrete than with abstract words, $t(58) = 3.347$, $p < .01$, but in the dynamic visual noise condition there was no difference between the two types of words, $t(58) < 1$.

In the B_r data, as with the *C* data, both main effects and the interaction had $F(1,58) < 1$.

Discussion

When proportion correct was the measure, the control condition of Experiment 5 replicated the finding of Romani et al. (2008) of a concreteness effect with a large set size. Experiment 5 also found the same interaction between dynamic visual noise and concreteness in an immediate memory task as was found in the delayed free recall and delayed recognition tasks in Experiments 1 and 2. That is, dynamic visual noise eliminated the benefit for concrete over abstract words, as measured by proportion correct, *d'* and P_r. Thus, the detrimental effect of dynamic visual noise on the concreteness effect is not restricted to delayed tests that do not emphasize order information. This extends the findings of Parker and Dagnall (2009) and reveals that the interaction between dynamic visual noise and word concreteness is the same in both long-term and short-term memory tasks.

However, the results for serial recognition differ strikingly from those for serial recall (Experiments 3 and 4). Although the two tasks appear similar – they are both immediate tests that require order information – and have generally been treated as similar in the literature (Baddeley, Chincotta, Stafford, & Turk, 2002; Gathercole et al., 2001), they do differ in potentially important ways. For example, if subjects are aware that the test is immediate serial recall, they may encode and process the words differently than if the test is immediate serial recognition because in the recall task they have to actually generate and type in the words whereas in the recognition task they merely have to click on a button. The purpose of the final experiment was to determine if differential processing prior to test was playing a role in causing the different results for these two tests.

Experiment 6 – Immediate Serial Recall and Recognition

Experiment 5 used immediate serial recognition and found that dynamic visual noise eliminated the concreteness effect whereas Experiments 3 and 4 used immediate serial recall and found no effect of dynamic visual noise. The purpose of Experiment 6 was to assess whether knowledge of the type of up-coming test was a cause of the contrasting patterns of findings across the pervious experiments. Now, subjects saw lists of 6 concrete or 6 abstract words, but did not know the type of test until after the list had been presented. Such a manipulation was deemed important so as to examine the degree to which memory performance was dependent on selective processes deployed in expectation of a particular type of test (cf. Duncan & Murdock, 2000).

Subjects

Sixty different volunteers from Prolific.AC participated and were randomly assigned to either the control or the dynamic visual noise group. The mean age was 29.20 (*SD* = 4.70, range

20-38), 33 identified themselves as female, 26 identified themselves as male, and 1 did not respond to the question.

Design

The two independent variables were the type of word, abstract or concrete, which was manipulated within subjects, and the background visible when the words were displayed: no noise or dynamic visual noise, which was manipulated between subjects. Although type of test, immediate serial recall or immediate serial recognition, was manipulated within subjects, the purpose of the experiment was to compare performance with Experiments 3/4 and 5, respectively, rather than to compare serial recall with serial recognition.

Stimuli

A new set of stimuli were created because the additional trials in this experiment meant that a larger number of words was needed. The stimuli were generated in the same way and were equated on the same dimensions as in the previous experiments, and details of the 196 concrete and 196 abstract 1 syllable nouns are in the appendix.

Procedure

The procedure was almost identical to that in Experiment 4 (for the serial recall trials) and Experiment 5 (for the serial recognition trials). Both types of tests were described to the subject prior to the beginning of the experiment. On each trial, the subject did not know the type of test until after the final word had been shown. There were 64 lists, half of which were followed by a serial recognition test and half of which were followed by an immediate serial recall test. The 32 serial recognition tests were the same as in Experiment 5. The number of immediate serial recall trials was increased to 32 so that the two types of tests occurred equally often. The type of trial (concrete or abstract), the specific words, and the order of the tests were all randomized for each subject.

Results

Serial Recall. The results from the immediate serial recall trials are shown in the bottom row of Figure 4 and are the same as in Experiments 3 and 4: A concreteness effect was observed in both the control and the dynamic visual noise conditions. The overall mean proportion correct and standard deviations are shown in Table 1. The proportion of words correctly recalled in order was analyzed with a 2 (word type: concrete vs. abstract) × 2 (noise condition: control vs. dynamic visual noise) × 6 (serial position: 1 – 6) mixed ANOVA. There was a significant main effect of word type, $F(1,58) = 25.998$, $MSE = 0.015$, $\eta^2_p = 0.310$, $p < 0.01$, with better memory for concrete ($M = 0.572$, $SD = 0.200$) than abstract words ($M = 0.525$, $SD = 0.189$). The main effect of noise condition was not significant, $F < 1$, with the proportion of words correctly recalled in order in the control group 0.555 ($SD = 0.242$) the same as in the dynamic visual noise group 0.542 ($SD = 0.189$). The main effect of position was significant, $F(5,290) = 117.819$, $MSE = 0.033$, $\eta^2_p = 0.670$, $p < 0.01$. As in Experiments 3 and 4, none of the interactions were significant; the only interaction with $F > 1$ was word × group, $F(5,58) = 1.182$, $MSE = 0.015$, $\eta^2_p = 0.020$, $p > 0.25$.

As in the two previous serial recall experiments, the data were also scored according to free recall criteria and re-analyzed. There was a significant main effect of word type, $F(1,58) = 38.066$, $MSE = 0.013$, $\eta^2_p = 0.396$, $p < 0.01$, with better memory for concrete ($M = 0.644$, $SD = 0.176$) than abstract words ($M = 0.593$, $SD = 0.170$). The main effect of noise condition was not significant, $F < 1$, with the proportion of words correctly recalled in the control group 0.621 ($SD = 0.181$) the same as in the dynamic visual noise group 0.616 ($SD = 0.168$). The main effect of position was significant, $F(5,290) = 77.101$, $MSE = 0.035$, $\eta^2_p = 0.571$, $p < 0.01$. None of the interactions were significant; the only interaction with $F > 1$ was word × group, $F(5,58) = 2.559$, $MSE = 0.013$, $\eta^2_p = 0.042$, $p > 0.10$. The pattern of results with free recall scoring was therefore the same as with serial recall scoring, as in the two previous experiments.

Serial Recognition. As can be seen in Figure 6, dynamic visual noise abolished the concreteness effect as measured by proportion correct and by both d' and P_r, just as was found in Experiment 5. The proportion correct, hit and false alarm rates, and each measure of discriminability and bias, were analyzed with a 2 word type (concrete vs. abstract) × 2 noise condition (control vs. dynamic visual noise) mixed factorial ANOVA. We discuss the results for each measure in turn.

Proportion Correct. For proportion correct, the main effect of word type was not significant, $F(1, 58) = 2.765$, $MSE = 0.008$, $\eta^2_p = 0.046$, $p > 0.10$. The proportion correct for concrete words was 0.773 ($SD = 0.158$) compared to 0.746 ($SD = 0.142$) for abstract words. The proportion correct in the control condition ($M = 0.749$, $SD = 0.158$) was the same as in the dynamic visual noise condition ($M = 0.770$, $SD = 0.143$), $F(1,58) < 1$. However, the interaction was significant, $F(1, 58) = 9.424$, $MSE = 0.008$, $\eta^2_p = 0.140$, $p < 0.01$. In the control condition, the proportion correct was higher for concrete ($M = 0.788$, $SD = 0.154$) than abstract ($M = 0.710$, $SD = 0.155$) words, $t(29) = 3.178$, $p < 0.01$. In the dynamic visual noise condition, there was no difference between the proportion correct was for concrete ($M = 0.758$, $SD = 0.164$) and the proportion correct for abstract ($M = 0.781$, $SD = 0.121$) words, $t(29) = 0.991$, $p > 0.15$.

Hits and False Alarms. For the proportion of hits, there were no significant main effects. The hit rate for concrete words ($M = 0.704$, $SD = 0.261$) did not differ from that for abstract words ($M = 0.682$, $SD = 0.213$), $F(1, 58) < 1$. The hit rate in the control condition ($M = 0.684$, *SD* = 0.255) was the same as in the dynamic visual noise condition (*M* = 0.702, *SD* = 0.220), $F(1,58) < 1$. The interaction was not significant, $F(1, 58) = 1.823$, $MSE = 0.015$, $\eta^2_p = 0.016$, $p > 0.15$. This is the same pattern as in Experiment 5.

For the false alarm data, there was one difference from the results in Experiment 5. In that experiment, there were no significant effects whereas in this experiment, the interaction was significant. The false alarm rate for concrete words (*M* = 0.164, *SD* = 0.158) did not differ from the false alarm rate for abstract words (*M* = 0.194, *SD* = 0.176), $F(1, 58) = 1.872$, $MSE = 0.015$, $\eta^2_p = 0.031$, $p > 0.15$. Similarly, the false alarm rate in the control condition (*M* = 0.191, *SD* = 0.186) did not differ from the false alarm rate in the dynamic visual noise condition (*M* = 0.167, *SD* = 0.147), $F(1, 58) < 1$. However, the interaction was significant, $F(1, 58) = 9.577$, $MSE = 0.015$, $\eta^2_p = 0.142$, $p < 0.01$. As can be seen from the means in Table 4, the false alarm rate was higher for abstract words in the control group, but was lower for abstract words in the dynamic visual noise group.

d′ and C. For the *d′* data, there was a significant main effect of word type, $F(1,58) = 5.195$, $MSE = 0.625$, $\eta^2_p = 0.082$, $p < 0.05$, with better performance for concrete (*M* = 2.069, *SD* = 1.401) than abstract words (*M* = 1.740, *SD* = 1.314). The main effect of group was not significant, $F(1,58) < 1$, with equivalent performance in the control (*M* = 1.833, *SD* = 1.400) and dynamic visual noise conditions (*M* = 1.976, *SD* = 1.134), $d = 0.105$. Importantly, the interaction was significant, $F(1,58) = 7.684$, $MSE = 0.625$, $\eta^2_p = 0.117$, $p < 0.01$. In the control condition, performance was better with concrete than with abstract words, $t(58) = 2.075$, $p < .05$, $d = 0.535$, but in the dynamic visual noise condition there was no difference between the two types of words, $t(58) < 1$, $d = 0.053$. This is almost the same as in Experiment 5, except there the main effect of word type just failed to reach the adopted significance level.

For the *C* data, there were no significant main effects and the interaction was not significant, all $F(1,58) < 1$. This is the same as in Experiment 5.

P_r and B_r. The results of the analyses of P_r and B_r were almost the same as that of *d′* and *C.* The only difference was that for P_r, the main effect of word type was not significant, $F(1,58) = 2.645$, $MSE = 0.031$, $\eta^2_p = 0.044$, $p > 0.10$, although numerically the pattern was the same as for *d′* with numerically higher performance for concrete ($M = 0.540$, $SD = 0.312$) than abstract words ($M = 0.488$, $SD = 0.281$). The main effect of group was not significant, $F(1,58) < 1$, with equivalent performance in the control ($M = 0.493$, $SD = 0.311$) and dynamic visual noise conditions ($M = 0.535$, $SD = 0.282$). Importantly, the interaction was significant, $F(1,58) = 8.654$, $MSE = 0.031$, $\eta^2_p = 0.140$, $p < 0.01$. In the control condition, performance was better with concrete than with abstract words, although not significantly better, $t(58) = 1.923$, $p = .059$, whereas in the dynamic visual noise condition, the pattern was reversed, but again the difference was not significant, there was no difference between the two types of words, $t(58) < 1$. This is the same pattern of results as seen in Experiment 5.

In the B_r data, as with the *C* data, both main effects and the interaction had $F(1,58) < 1$, the same pattern seen in Experiment 5.

Cross-Experiment Comparisons. We noticed that the overall level of performance on the serial recognition task was higher in Experiment 6 than in Experiment 5. The two experiments were not run at the same time, and therefore caveats apply to the following analyses. When the only test was serial recognition (Experiment 5), overall performance as measured by *d′* was 1.342 compared to 1.904 in Experiment 6, $t(118) = 2.904$, $p < 0.01$. The same holds for performance as measured by P_r: 0.417 vs. 0.514, $t(118) = 2.126$, $p < 0.05$. In contrast, there was no difference in the overall proportion correct in the serial recall tests in Experiment 4 and 6, 0.543 vs. 0.548, $t(118) = 0.172$, $p > 0.85$. One possible explanation for this is when subjects were aware of the possibility of a serial recall test (as in Experiment 6) they concentrated more during list presentation than when merely expecting a test of item order because of the potential requirement to produce the words if the test were serial recall. This produced a particular benefit in performance for word lists in Experiment 6 that were tested via serial recognition compared to the same lists in Experiment 5. Despite this increase in the overall level of performance, however, dynamic visual noise still eliminated the mnemonic advantage of concrete over abstract words.

Discussion

The results of Experiment 6 are clear-cut and two findings are key. First, the results of the serial recognition data in Experiment 6 replicate those of Experiment 5. In the control conditions – in the absence of dynamic visual noise – the standard concreteness effect emerged, and this effect was abolished when dynamic visual noise was present during the presentation of the lists. Second, the standard concreteness effect emerged in the serial recall data regardless of whether dynamic visual noise was presented. This absence of an interaction between the presence vs. absence of dynamic visual noise and the size of the concreteness effect has been found whenever immediate serial recall has been tested (Experiments 3, 4, and 6).

In Experiment 6, the subjects did not know the type of test until after list presentation, and yet the results are the same as when the subjects did know. This suggests that the contrasting patterns of findings across Experiment 5 on the one hand and Experiments 3 and 4 on the other cannot be attributable to some form of difference in processing prior to test, and in particular, suggests that processing was equivalent during the time the dynamic visual noise was presented. In addition, although overall levels of performance in the serial recognition task varied according to the different task constraints, the key findings show that whereas dynamic visual noise deleteriously affected memory for concrete words on tests of immediate serial recognition, it produced no such corresponding effects on tests of immediate serial recall. This suggests that contrary to the standard treatment in the literature, immediate serial recall and immediate serial recognition may be more different than is currently acknowledge.

General Discussion

Parker and Dagnall (2009) hypothesized that if concrete words are better remembered because they elicit an imagistic code in addition to a verbal/linguistic code, then dynamic visual noise should selectively interfere with memory for concrete words. They reported delayed free recall and delayed recognition experiments in which presenting dynamic visual noise during list presentation not only eliminated the concreteness effect, but actually reversed it such that memory for concrete words became *worse* than memory for abstract words. One initial aim of the present work was to further explore these findings. Experiment 1 used delayed free recall and Experiment 2 used delayed old/new recognition. In both cases standard concreteness effects obtained in the absence of dynamic visual noise but these were abolished when dynamic visual noise occurred during list presentation. In neither case, however, did the presence of dynamic visual noise reverse the concreteness effect, contra the findings of Parker and Dagnall (2009).

Because Parker and Dagnall's (2009) explanation focused on working memory, Experiments 3 and 4 used tasks more directly related to working memory than delayed free recall or delayed recognition. In Experiments 3 and 4, we used an immediate serial recall task but found no effect of dynamic visual noise. These null results replicate the similar findings reported by Ueno and Saito (2013) and Castellà and Campoy (in press) but contrast with the results of Experiments 1 and 2, which used delayed tests which did not emphasize order information.

Experiment 5 used a different immediate test of order information, namely, immediate serial recognition, and once again we found that dynamic visual noise interacted with concreteness. This extends the results of Parker and Dagnall (2009) from the long-term to the short-term, and also from designs in which both abstract and concrete words appear in the same list to one in which only pure lists are presented. However, this result is striking given the lack of an effect of dynamic visual noise for immediate serial recall. In order to assess whether differential processing during list presentation caused the different pattern of results, the subjects in Experiment 6 did not know whether they would receive a serial recognition or a serial recall test until after list presentation. Nonetheless, the results were clear-cut and in accord with the previous findings: when memory was tested via immediate serial recognition the occurrence of dynamic visual noise during list presentation abolished the concreteness effect, but there was no comparable effect of dynamic visual noise when tests of serial recall were administered.

In all of the current cases where dynamic visual noise has been shown to influence word memory (Experiments 1, 2, 5, and the serial recognition condition of Experiment 6), the result has been to eliminate the concreteness effect rather than to reverse it: the significantly better performance with the concrete items relative to the abstract items in the control condition is eliminated such that there is no difference in the dynamic visual noise condition. It remains plausible that the reversed effect reported by Parker and Dagnall (2009) arose through their use of a smaller sample of stimulus words. Given that we have been unable to replicate the reversed concreteness effect reported by Parker and Dagnall (2009), we feel that further speculation is unwarranted and that that future work could be used to explore this directly.

The results from the six experiments have implications for theoretical accounts of both dynamic visual noise and the concreteness effect, and also has implications for models of memory. We address each in turn.

Dynamic Visual Noise

In assessing theories of dynamic visual noise, the key results of the current experiments are that dynamic visual noise affects immediate serial recognition but not immediate serial recall. If there were an effect on both tests, the basic account of Parker and Dagnall (2009) and Ueno and Saito (2013) could address the results. Under their interpretation, presentation of concrete words results in the formation of a visual image. When dynamic visual noise is present, it affects this image and therefore reduces memory for concrete items. Because there is no image for abstract words, dynamic visual noise has no effect. This account applies not only to the immediate tests but also to delayed free recall and delayed recognition.

Similarly, this view could offers an explanation for why dynamic visual noise might have had no effect on both immediate serial recognition and immediate serial recall. In immediate serial recall, it is likely that subjects use sub-vocal rehearsal. Even though the dynamic visual noise might affect the image of a given item, when that item is rehearsed, a second image could be generated. To the extent that this rehearsal occurs after the dynamic visual noise ends, there would be little if any impact of the noise because the image has been, as it were, refreshed. Given the similarity of both tasks, a similar line of reasoning applies to serial recognition. In contrast, it is not plausible to assume rehearsal of this type takes place in delayed recall or delayed recognition when there is a distractor task.

The problem for this view is that although immediate serial recall and immediate serial recognition are similar procedures, they produced different outcomes in our experiments.

Concreteness effects in the absence of dynamic visual noise were observed in both tasks in the current paper, and have also been reported by others in both tasks (Romani et al., 2008; Walker & Hulme, 1999). According to both dual coding theory and the visual working memory account of concreteness effects, the presence of a concreteness effect indicates the presence of an image. Both tasks in question emphasize memory for order. The task in serial recall is to reproduce the studied words in order, a feat that requires both item and order information. In serial recognition, the task is to distinguish whether two lists were presented in the same order or different orders. Although order is emphasized, the task is possible only to the extent that the subject also has memory for the specific items.

Ueno and Saito (2013) suggested that dynamic visual noise will have its effect only when the imagistic representation is in visual working memory during the presentation of the dynamic visual noise. For tasks in which the imagistic representation can be offloaded to long-term memory, they predict no effect of dynamic visual noise. However, they offer no a priori prediction of when such offloading will occur, and given the similarities between serial recall and serial recognition, it is not clear why one would lead to offloading, and thus to no effect of dynamic visual noise (serial recall), while the other would not lead to offloading and thereby allow an effect of dynamic visual noise (serial recognition).

Although both forms of test implicate item order information, they do so in different ways. In serial recall it is critical to remember the list position of each item in turn. There are a number of ways this could be accomplished, but one way is by associating each stored word with its ordinal position (see e.g., Burgess & Hitch, 1999). In contrast, such strict positional coding is not required to complete serial recognition; the task can be completed by instead recovering the ordered pairwise positions of adjacent words. The results of Experiment 6, in which the type of upcoming test was unknown to participants, show that the effects of dynamic visual noise are manifest at the time of test. If the test primarily taps into mechanisms concerned with recovery of an item's list position, perhaps by using a positional code to recover an item's identity (e.g., serial recall), then such processes are immune to the influence of dynamic visual noise. By contrast, if the test taps primarily into item recovery or inter-item associations (e.g., serial recognition), then dynamic visual noise can disrupt performance.

Concreteness Effects

Theoretical accounts beyond dual coding theory and the very similar working memory-based accounts may provide an alternate explanation for the pattern of results observed. One prominent alternative is the context availability model, which posits a single semantic processing system for all words, regardless of a word's level of concreteness or imageability (Schwanenflugel, 1991). In this account, the benefit for concrete words emerges from the fact that concrete words have richer semantic representations: they can more readily be associated with a larger number of semantic contexts than can abstract words (see also Jones, 1988). In support of this view, subjects' ratings of the ease with which they can retrieve contextual information for words better predict lexical decision latencies than do imageability or concreteness ratings (Schwanenflugel, Harnishfeger, & Stowe, 1988). However, as with dual coding theory, the context availability model cannot account for our observed dissociation by task. There is no apparent reason why dynamic visual noise should eliminate the benefits of increased contextual availability in delayed recall, delayed recognition, and immediate serial recognition, but not in immediate serial recall.

As a second alternative, there has been some suggestion that the concreteness effect is most robust when the memory task demands retrieval of item information rather than order information (Roche, Tolan, & Tehan, 2011; Romani et al., 2008). However, in our experiments the dynamic visual noise manipulation was sufficient to eliminate the concreteness effect in free recall and recognition, which have minimal demands for order information, but insufficient to eliminate it in serial recall, which requires order information.

A final alternate account is based on the relative differences in the processing of relational and distinctive information (Marschark & Hunt, 1989). The basic assumption is that episodic memory tasks require a combination of relational processing, to link a particular item to an episode, as well as distinctive processing, to discriminate between items within a set of potential retrieval candidates. Marschark & Hunt argued that the concreteness effect requires that stimuli are processed relationally and that the relational information is activated at retrieval. Concrete words, moreover, give rise to an image that helps primarily distinctive information (although it is acknowledged that imagery can be used to enhance relational processing under different circumstances). Given equivalent relational processing, which affects the set of items to be considered as potential targets, the additional distinctive information in the concrete words gives them an advantage. Although this view has not been applied to dynamic visual noise, it could be readily extended. To the extent that a concrete word results in the generation of an image, the dynamic visual noise could degrade that image. As an analogy, consider how static can affect the image shown on a television screen. This would remove the concreteness advantage.

However, it might be assumed that relational processing is not equivalent across tasks. To the extent that success in serial recall depends upon the association between an item and its position, it can be said to invoke relational processing that is subsequently activated by the position cues at test. It is possible that this relational processing protects the serial recall task from the detrimental effects of dynamic visual noise, thereby preserving the concreteness effect. By contrast, delayed free recall and delayed recognition involve little relational processing and are thereby not protected from dynamic visual noise. However, this view is complicated by the results of our experiments on immediate serial recognition. It could be argued that serial recognition involves both relational processes (i.e., inter-item associations) and discriminative processes (i.e., individual item information), but it is not immediately clear why this task would not be similarly protected from the detrimental effects of dynamic visual noise.

We think that the pattern of results precludes a unidimensional explanation, either of (1) concreteness effects, which were observed in all tasks, or of (2) the disruptive effect of dynamic visual noise, which was observed in both a delayed and an immediate task, in both a recall and a recognition task, and in tasks that both emphasized and minimized order information. The puzzle concerns the relationship between immediate serial recall and immediate serial recognition, a consideration of which is beyond the scope of the current manuscript. What is clear is that despite their surface similarity, the relationship between the two tasks is more complicated than typically assumed. If neither task had been affected, or if both had been affected, by dynamic visual noise, then the whole pattern of results could be readily accommodated. The observed pattern suggests a more complex interaction between dynamic visual noise, the concreteness effect, and task demands, which future research should aim to untangle. Other research in our laboratory, currently in preparation, aims to elucidate the nature of the relationship between the two tasks.

Models of Memory

The results have important implications for a number of models of memory. There is no model of memory that addresses recognition, free recall, serial recall, and serial recognition and therefore there is no single model that could account for the data reported here. Space precludes considering most models, in part because they do not address concreteness effects or because they apply to only one test and not multiple tests, or both. However, we can discuss the implications for one model of serial recall that does propose an explanation of the concreteness effect, as well as for the one model of serial recognition.

There are a number of different models of immediate serial recall (for a comparison, see Nairne & Neath, 2013), but most do not address the concreteness effect. However, the Feature Model has recently been extended to include the concreteness effect (Neath, Surprenant, Gabel, & Seffinga, 2016). As with many models of memory, the Feature Model includes both a sampling and a recovery stage. By analogy, sampling is like finding a book in the library and recovery is like determining whether the book contains the information that is sought. The model proposes that the advantage accrues to the concrete words during the recovery stage. This allows the Feature Model to account for the fact that concurrent articulation has no effect on the concreteness effect (Romani et al., 2008). Within the Feature Model, concurrent articulation is seen as adding noise and occurs prior to the sampling and recovery stages. However, it is not clear how dynamic visual noise would be added to the Feature Model, primarily because it is a model of serial recall and dynamic visual noise does not appear to affect serial recall. However, if applied during list presentation, the model could account for the preservation of the concreteness effect because, as with concurrent articulation, the stage at which concrete items have an advantage occurs after the noise has ended.

Most papers that have used serial recognition have either implicitly or explicitly assumed it to be like serial recall except that the role of item information is minimized (e.g., Baddeley, et al., 2002; Gathercole et al., 2001). The results here clearly show that the tests are not as similar as the literature takes them to be. Conclusions made on the basis of this assumption may need to be re-evaluated.

To our knowledge, there is only one model of serial recognition. Farrell and McLaughlin (2007) proposed a unidimensional matching model in which items are represented by the time of encoding. These temporal values drift or perturb, building on Estes' (1972, 1997) perturbation model. At test, the representation of the first list is temporally noisy, whereas the representation of the second list is temporally veridical. Adopting ideas from Ratcliff's (1981) perceptual matching model, Farrell and McLaughlin propose that whether the two lists match depends on the difference between the two lists. Essentially, a difference score is calculated between the placement of an item in the two sequences, and these distances are then summed over all items. If this summed distance exceeds a criterion, the response is *different* otherwise the response is *same*. Note that this is very different from how models of serial recall are assumed to work. The Farrell and McLaughlin model does not explicitly include a description of how item information is represented, because their experiments used only the digits 1 to 9. However, if it is assumed that dynamic visual noise affects the concrete items more than the abstract – either by increasing the rate of perturbation or by otherwise increasing the disparity between the two lists – then the model could account for detrimental effect of dynamic visual noise observed here.

Summary

Dynamic visual noise was found to eliminate the mnemonic advantage for concrete over abstract words delayed free recall and delayed recognition, replicating results reported by Parker and Dagnall (2009). In addition, the same pattern was found when the test was immediate serial recognition. Strikingly, dynamic visual noise had no effect on immediate serial recall, despite its apparent similarity to immediate serial recognition. The overall pattern of results has implications for theoretical explanations of the concreteness effect, dynamic visual noise, as well as placing constraints on models of memory.

References

Allport, D. A. (1984). Auditory-verbal short-term memory and conduction aphasia. In H. Bouma & D. G. Bouwhuis (Eds.), *Attention and performance X: Control of language processes* (pp. 313–326). Hove, UK: Erlbaum.

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. doi: 10.1080/02724980143000541

Avons, S. E., & Sestieri, C. (2005). Dynamic visual noise: No interference with visual short-term memory or the construction of visual images, *European Journal of Cognitive Psychology, 17*, 405-424, doi:10.1080/09541440440000104

Baddeley, A. (1986). *Working memory*. New York: Oxford.

Baddeley, A., Chincotta, D., Stafford, L., & Turk, D. (2002). Is the word length effect in STM entirely attributable to output delay? Evidence from serial recognition. *Quarterly Journal of Experimental Psychology, 55A*, 353-369. doi:10.1080/02724980143000523

Baddeley, A. D., & Hitch, G. J. (1974). Working memory. In G. Bower (Ed.), *Recent advances in learning and motivation*, *Vol. 8* (pp. 47-90). New York: Academic Press.

Baddeley, A. D., Lewis, V., & Vallar, G. (1984). Exploring the articulatory loop. *Quarterly Journal of Experimental Psychology, 36A*, 233-252. doi:10.1080/14640748408402157

Balota, D. A., Yap, M. J., Cortese, M. J., Hutchison, K. A., Kessler, B., Loftis, B., Neely, J. H., Nelson, D. L., Simpson, G. B., & Treiman, R. (2007). The English Lexicon Project. *Behavior Research Methods, 39*, 445-459. doi:10.3758/BF03193014

Beaman, C. P., & Jones, D. M. (1997). Role of serial order in the irrelevant speech effect: Tests of the changing-state hypothesis. *Journal of Experimental Psychology: Learning, Memory, And Cognition*, *23*(2), 459-471. doi:10.1037/0278-7393.23.2.459

Brysbaert, M., & New, B. (2009). Moving beyond Kučera and Francis: A critical evaluation of current word frequency norms and the introduction of a new and improved word frequency measure for American English. *Behavior Research Methods, 41,* 977-900. doi:10.3758/BRM.41.4.977

Brysbaert, M, Warriner, A. B., & Kuperman, V. (2014). Concreteness ratings for 40 thousand generally known English word lemmas. *Behavior Research Methods, 46*, 904-911. doi:10.3758/s13428-013-0403-5

Burgess, N., & Hitch, G. J. (1999). Memory for serial order: A network model of the phonological loop and its timing. *Psychological Review, 106*, 551-581. doi:10.1037/0033-295X.106.3.551

Castellà, J., & Campoy, G. (in press). The (lack of) effect of dynamic visual noise on the concreteness effect in short-term memory. *Memory*. doi:10.1080/09658211.2018.1476550

Coltheart, M. (1981). The MRC Psycholinguistic Database. *Quarterly Journal of Experimental Psychology, 33A*, 497-505. doi:10.1080/14640748108400805

Coltheart, V. (1993). Effects of phonological similarity and concurrent irrelevant articulation on short-term-memory recall of repeated and novel word lists. *Memory & Cognition, 21,* 539-545. doi:10.3758/BF03197185

Dean, G. M., Dewhurst, S. A., & Whittaker, A. (2008). Dynamic visual noise interferes with storage in visual working memory. *Experimental Psychology*, *55*, 283-289. doi:10.1027/1618-3169.55.4.283

Dent, K. (2010). Dynamic visual noise affects visual short-term memory for surface color, but not spatial location. *Experimental Psychology*, *57*, 17-26. doi:10.1027/1618-3169/a000003

Duncan, M., & Murdock, B. B. (2000). Recognition and recall with precuing and postcuing. *Journal of Memory and Language, 42*, 301-313. doi:10.1006/jmla.1999.2690

Estes, W. K. (1972). An associative basis for coding and organization in memory. In A. W. Melton & E. Martin (Eds.), *Coding processes in human memory* (pp. 161-190). Washington, DC: Winston.

Estes, W. K. (1997). Processes of memory loss, recovery, and distortion. *Psychological Review, 104*, 148-169. doi:10.1037/0033-295X.104.1.148

Farrell, S., & McLaughlin, K. (2007). Short-term recognition memory for serial order and timing. *Memory & Cognition, 35*, 1724-1734. doi:10.3758/BF03193505

Feenan, K. & Snodgrass, J.G. (1990). The effect of context on discrimination and bias in recognition memory for pictures and words. *Memory & Cognition, 18*, 515-527. doi:10.3758/BF03198484

Gathercole, S. E., Pickering, S. J., Hall, M., & Peaker, S. M. (2001). Dissociable lexical and phonological influences on serial recognition and serial recall. *Quarterly Journal of Experimental Psychology*, *54A*, 1-30. doi:10.1080/02724980042000002

Groninger, L. D., & Groninger, L. K. (1982). Function of images in the encoding-retrieval process. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *8*, 353-358. doi:10.1037/0278-7393.8.4.353

Hamilton, M., & Rajaram, S. (2001). The concreteness effect in implicit and explicit memory tests. *Journal of Memory and Language*, *44*, 96-117. doi:10.1006/jmla.2000.2749

Jones, G. V. (1988). Images, predicates, and retrieval cues. In M. Denis, J. Englekamp, & J. T. E. Richardson (Eds.), *Cognitive and neuropsychological approaches to mental imagery* (pp. 89-98). Dordrecht: Martinus Nijhoff.

Kinsbourne, M. (1972). Behavioral analysis of the repetition deficit in conduction aphasia. *Neurology, 22*, 1126-1132. doi:10.1212/WNL.22.11.1126

Li, S., & Lewandowsky, S. (1995). Forward and backward recall: Different retrieval processes. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *21*, 837-847. doi:10.1037/0278-7393.21.4.837

Logie, R. H. (1986). Visuo-spatial processing in working memory. *The Quarterly Journal of Experimental Psychology*, *38A*, 229-247. doi:10.1080/14640748608401596

Macmillan, N. A., & Creelman, C. D. (2004). *Detection theory: A user's guide.* New York: Psychology Press.

Marschark, M., & Hunt, R. R. (1989). A reexamination of the role of imagery in learning and memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *15*, 710-720. doi:10.1037/0278-7393.15.4.710

McConnell, J., & Quinn, J. G. (2000). Interference in visual working memory. *Quarterly Journal of Experimental Psychology, 53A*, 53-67. doi:10.1080/713755873

Medler, D. A., & Binder, J. R. (2005). *MCWord: An on-line orthographic database of the English language*. Retrieved from http://www.neuro.mcw.edu/mcword/

Miles, C., Jones, D. M., & Madden, C. A. (1991). Locus of the irrelevant speech effect in short-term memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17*, 578-584. doi:10.1037/0278-7393.17.3.578

Nairne, J. S., & Neath, I. (2013). Sensory and working memory. In A. F. Healy & R. W. Proctor (Eds.), *Comprehensive handbook of psychology, second edition, Vol. 4: Experimental Psychology* (pp. 419-445). New York: Wiley.

Neath, I. (1997). Modality, concreteness, and set-size effects in a free reconstruction of order task. *Memory & Cognition, 25,* 256-263. doi:10.3758/BF03201116

Neath, I. (2000). Modeling the effects of irrelevant speech on memory. *Psychonomic Bulletin & Review, 7*, 403-423. doi:10.3758/BF03214356

Neath, I., Surprenant, A. M., Gabel, A. J., & Seffinga, C. P. (2016). *What secondary tasks reveal about immediate serial recall*. Paper presented at the International Meeting of the Psychonomic Society, Grenada, Spain, May 2016.

Norris, D., Baddeley, A. D., & Page, M. P. A. (2004). Retroactive effects of irrelevant speech on serial recall from short-term memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30*, 1093-1105. doi:10.1037/0278-7393.30.5.1093

Paivio, A. (1967). Paired-associate learning and free recall of nouns as a function of concreteness, specificity, imagery, and meaningfulness. *Psychological Reports, 20*, 239-245. doi:10.2466/pr0.1967.20.1.239

Paivio, A. (1971). *Imagery and verbal processes*. Oxford, UK: Rhinehart, & Winston.

Paivio, A. (1991). Dual coding theory: Retrospect and current status. *Canadian Journal of Psychology*, *45*, 255-287. doi:10.1037/h0084295

Paivio, A. (2007). *Mind and its evolution: A dual coding theoretical approach*. Mahwah, NJ: Erlbaum.

Paivio, A., & Csapo, K. (1969). Concrete-image and verbal memory codes. *Journal of Experimental Psychology, 80*, 279–285. doi:10.1037/ h0027273

Paivio, A., & O'Neill, B. J. (1970). Visual recognition thresholds and dimensions of word meaning. *Perception & Psychophysics*, *8*, 273-275. doi:10.3758/BF03212591

Paivio, A., Smythe, P. C., & Yuille, J. C. (1968). Imagery versus meaningfulness of nouns in paired-associate learning. *Canadian Journal of Psychology, 22*, 427-441. doi:10.1037/h0082782

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. doi:10.1080/09658210902802967

Quinn, J. G., & McConnell, J. (1996). Irrelevant pictures in visual working memory. *Quarterly Journal of Experimental Psychology*, *49A*, 200-215. doi:10.1080/027249896392865

Quinn, J. G., & McConnell, J. (1999). Manipulation of interference in the passive visual store. *European Journal of Cognitive Psychology, 11*, 373-389. doi:10.1080/713752322

Quinn, J. G., & McConnell, J. (2006). The interval for interference in conscious visual imagery. Memory, 14, 241-252. doi:10.1080/09658210500210019

Ratcliff, R. (1981). A theory of order relations in perceptual matching. *Psychological Review, 88,* 552-572. doi:10.1037/0033-295X.88.6.552

Roche, J., Tolan, G. A., & Tehan, G. (2011). Concreteness effects in short-term memory: A test of the item-order hypothesis. *Canadian Journal of Experimental Psychology*, *65*, 245-253. doi:10.1037/a0024693

Romani, C., McAlpine, S., & Martin, R. C. (2008). Concreteness effects in different tasks: Implications for models of short-term memory. *The Quarterly Journal of Experimental Psychology*, *61*, 292-323. doi:10.1080/17470210601147747

Schwanenflugel, P. (1991). Why are abstract concepts hard to understand? In P. J. Schwanenflugel (Ed.), *The psychology of word meanings* (pp. 223 250). Hillsdale, NJ: Erlbaum.

Schwanenflugel, P. J., Harnishfeger, K. K., & Stowe, R. W. (1988). Context availability and lexical decisions for abstract and concrete words. *Journal of Memory and Language*, *27*(5), 499-520. doi:10.1016/0749-596X(88)90022-8

St. Clair-Thompson, H. L., & Allen, R. J. (2013). Are forward and backward recall the same? A dual-task study of digit recall. *Memory & Cognition, 41,* 519-532. doi:10.3758/s13421-012-0277-2

Ueno, T., & Saito, S. (2013). The role of visual representations within working memory for paired-associate and serial order of spoken words. *Quarterly Journal of Experimental Psychology, 66*, 1858-1872. doi:10.1080/17470218.2013.772645

Walker, I., & Hulme, C. (1999). Concrete words are easier to recall than abstract words: Evidence for a semantic contribution to short-term serial recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 25*, 1256-1271. doi:10.1037/0278-7393.25.5.1256

Author Notes

This research was supported, in part, by grants from the Canadian Natural Sciences and Engineering Research Council to IN and AMS. Portions of this research were presented at the International Meeting of the Psychonomic Society, Amsterdam, May 2018. The raw data are available in the supplementary materials and also via email from the corresponding author.

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Appendix

Details of the stimuli used in Experiments 1-5.

	CNC	IMG	CNC.M	FAM	NPHN	NSYL	FREQ	LgWF	LgCD	Orth	OrthZ	OrthF	OLD20	OLDF
Abstract														
Mean	329.95	400.98	2.43	515.29	3.66	1.00	36.49	2.68	2.53	5.94	-0.02	60.69	1.62	8.02
SD	42.25	49.98	0.39	53.46	0.66	0.00	57.15	0.69	0.64	4.39	0.72	141.73	0.25	0.43
N	93	96	151	96	151	151	151	151	151	151	151	151	151	151
t =	31.73	22.15	53.72	0.71	0.66	--	0.06	0.56	0.50	0.92	0.49	0.37	0.63	0.95
p =	0.00	0.00	0.00	0.48	0.51	--	0.95	0.57	0.61	0.36	0.63	0.71	0.53	0.34
Concrete														
Mean	555.08	557.23	4.56	520.75	3.72	1	36.05	2.73	2.50	6.41	0.02	54.96	1.60	7.97
SD	55.40	49.48	0.29	55.58	0.72	0	70.90	0.61	0.57	4.53	0.69	127.89	0.25	0.49
N	103	103	151	105	151	151	151	151	151	151	151	151	150	150

Details of the stimuli used in Experiment 6.

	CNC	IMG	CNC.M	FAM	NPHN	NSYL	FREQ	LgWF	LgCD	Orth	OrthZ	OrthF	OLD20	OLDF
Abstract														
Mean	341.68	410.98	2.77	525.73	3.35	1	75.76	3.16	2.93	7.64	0.09	92.72	1.53	8.21
SD	37.96	50.85	0.61	51.48	0.70	0	84.86	0.75	0.64	5.47	0.80	266.94	0.30	0.51
N	196	196	196	196	196	196	196	196	196	196	196	196	196	196
t =	47.36	30.19	38.52	0.98	0.56	--	0.70	0.21	0.60	0.88	0.63	0.92	0.62	0.27
p =	0.00	0.00	0.00	0.33	0.58	--	0.49	0.83	0.55	0.38	0.53	0.36	0.54	0.79
Concrete														
Mean	559.11	563.18	4.64	530.98	3.39	1	68.36	3.18	2.89	8.14	0.14	73.02	1.51	8.19
SD	51.86	48.94	0.29	54.13	0.74	0	122.07	0.59	0.50	5.67	0.81	138.64	0.31	0.52
N	196	196	196	196	196	196	196	196	196	196	196	196	196	196

Note: CNC = concreteness, IMG = imageability, FAM = familiarity, NPHN = number of phonemes, NYSL = number of syllables (from M. Coltheart, 1981); CNC.M = concreteness (from Brysbaert et al. 2014); FREQ = CELEX frequency, ORTH = number of orthographic neighbours, OrthF = frequency of the orthographic neighbours (from Medler & Binder, 2005); OrthZ = a *z* score based on ORTH (calculated by the authors); LgWF = log base 10 frequency in $SUBTLEX_{US}$ corpus; LgCD = log base 10 contextual diversity in $SUBTLEX_{US}$ corpus (from Brysbaert & New, 2009); OLD20 = orthographic Levenshtein distance; OLDF = frequency of the Levenshtein neighbors (from Balota et al., 2007). *N* indicates the number of words for which that measure was available, and *t* and *p* are the *t*-test value and associated probability (rounded to two decimal places) of whether the abstract and concrete words differ on that measure. For those words in the first set where there was both a rating of concreteness in Coltheart and in Brysbaert et al., the correlation between the two measures was *r* (194) = 0.950; for all 392 words in the second set there were values from both Coltheart and in Brysbaert et al., and *r*(391) = 0.924. A full listing of all the stimuli is available at https://memory.psych.mun.ca/research/stimuli/j74-dvn.shtml or from the corresponding author.

Table 1. Mean proportion correct (and standard deviation) for correct recall in Experiments 1, 3, 4, and 6,

	Control	Dynamic Visual Noise
Experiment 1: Delayed Free Recall		
Concrete	0.273 (0.168)	0.244 (0.232)
Abstract	0.182 (0.175)	0.222 (0.196)
Experiment 3: Immediate Serial Recall		
Concrete	0.564 (0.177)	0.572 (0.187)
Abstract	0.487 (0.206)	0.502 (0.206)
Experiment 4: Immediate Serial Recall		
Concrete	0.611 (0.169)	0.540 (0.195)
Abstract	0.540 (0.162)	0.480 (0.173)
Experiment 6: Immediate Serial Recall		
Concrete	0.584 (0.208)	0.560 (0.196)
Abstract	0.526 (0.199)	0.523 (0.183)

Table 2. Means and standard deviations for measures of recognition performance in Experiment 2.

	Control				Dynamic Visual Noise			
	Concrete		Abstract		Concrete		Abstract	
	M	SD	M	SD	M	SD	M	SD
p(Hit)	0.644	0.190	0.578	0.151	0.631	0.143	0.669	0.146
p(FA)	0.186	0.143	0.238	0.148	0.239	0.161	0.278	0.179
d'	1.567	1.049	1.024	0.594	1.247	0.809	1.227	0.926
C	0.317	0.442	0.296	0.383	0.234	0.442	0.108	0.404
Pr	0.458	0.233	0.340	0.186	0.392	0.199	0.390	0.226
Br	0.346	0.219	0.353	0.174	0.385	0.221	0.443	0.202

Table 3. Means and standard deviations for measures of serial recognition performance in Experiment 5.

	Control				Dynamic Visual Noise			
	Concrete		Abstract		Concrete		Abstract	
	M	SD	M	SD	M	SD	M	SD
p(Hit)	0.699	0.186	0.625	0.186	0.662	0.199	0.670	0.192
p(FA)	0.222	0.183	0.275	0.162	0.243	0.141	0.247	0.173
d'	1.570	1.050	1.048	0.750	1.355	1.049	1.395	1.116
C	0.147	0.488	0.163	0.400	0.151	0.414	0.155	0.438
Pr	0.477	0.265	0.350	0.237	0.419	0.277	0.423	0.288
Br	0.423	0.250	0.426	0.200	0.436	0.223	0.418	0.244

Table 4. Means and standard deviations for measures of serial recognition performance in Experiment 6.

	Control				Dynamic Visual Noise			
	Concrete		Abstract		Concrete		Abstract	
	M	SD	M	SD	M	SD	M	SD
p(Hit)	0.711	0.275	0.658	0.235	0.698	0.251	0.658	0.189
p(FA)	0.142	0.140	0.240	0.213	0.186	0.173	0.148	0.116
d′	2.197	1.419	1.468	1.300	1.941	1.408	2.012	1.293
C	0.305	0.700	0.254	0.657	0.217	0.600	0.242	0.427
Pr	0.569	0.302	0.418	0.307	0.512	0.323	0.558	0.237
Br	0.403	0.302	0.384	0.269	0.414	0.308	0.369	0.226

Figure 1: Example of screen. Every 250 ms, each 10 x 10 pixel square would change from black to white or from white to black with a probability of 0.50. The to-be-remembered stimuli were shown in the center area, which remained solid black.

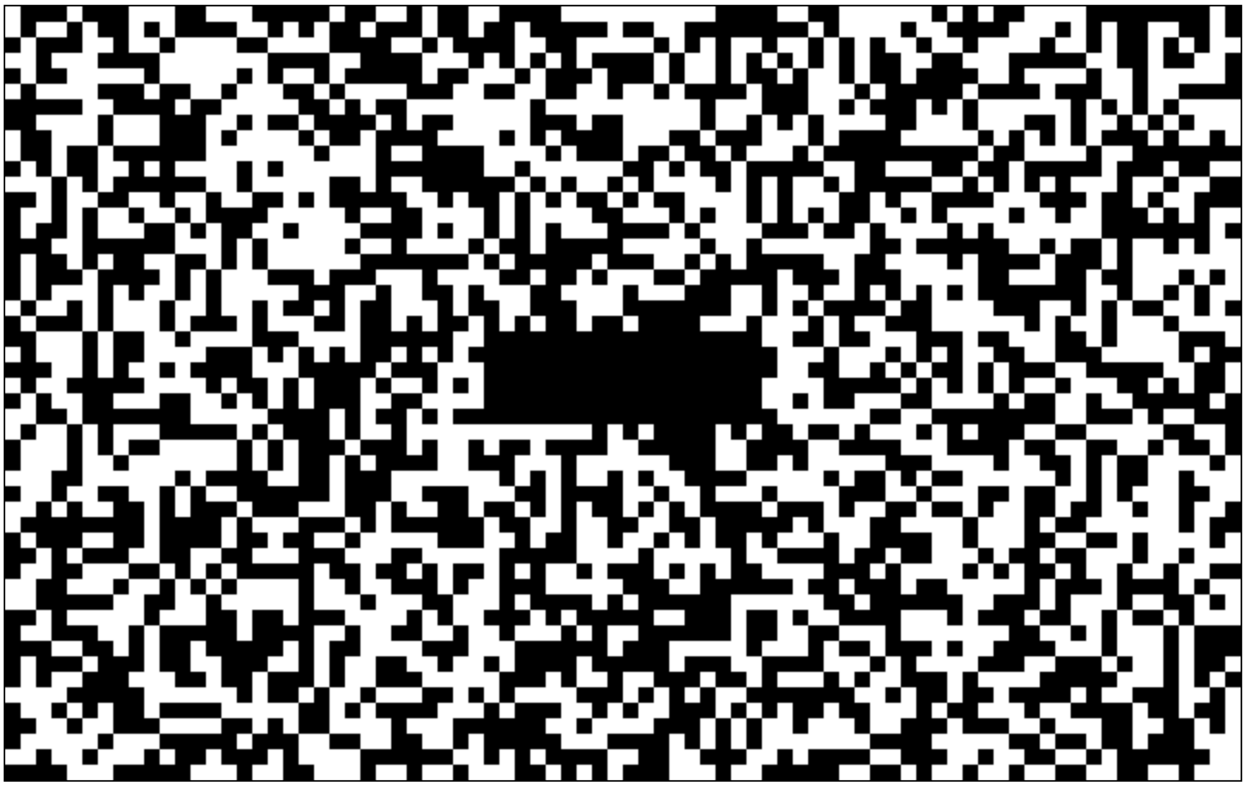


Figure 2. The proportion of abstract and concrete words recalled in the control and dynamic visual noise conditions in Experiment 1, which used delayed free recall. Error bars show the standard error of the mean.

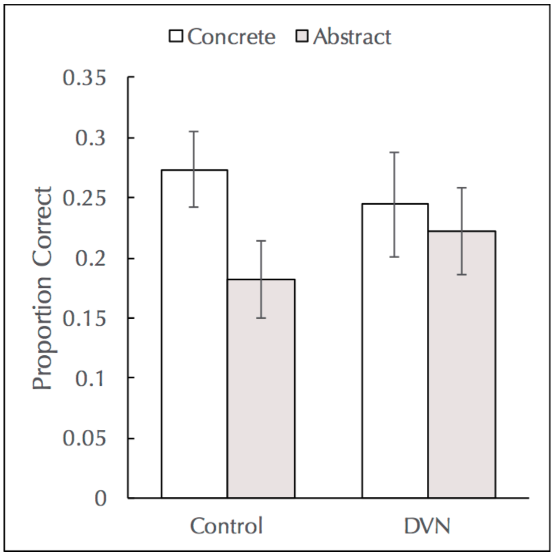


Figure 3: Hit rate (top left) and false alarm rate (top right); *d′* (middle left) and *C* (middle right); and *Pr* (bottom left) and *Br* (bottom right) in Experiment 2, which used delayed recognition. Error bars show the standard error of the mean.

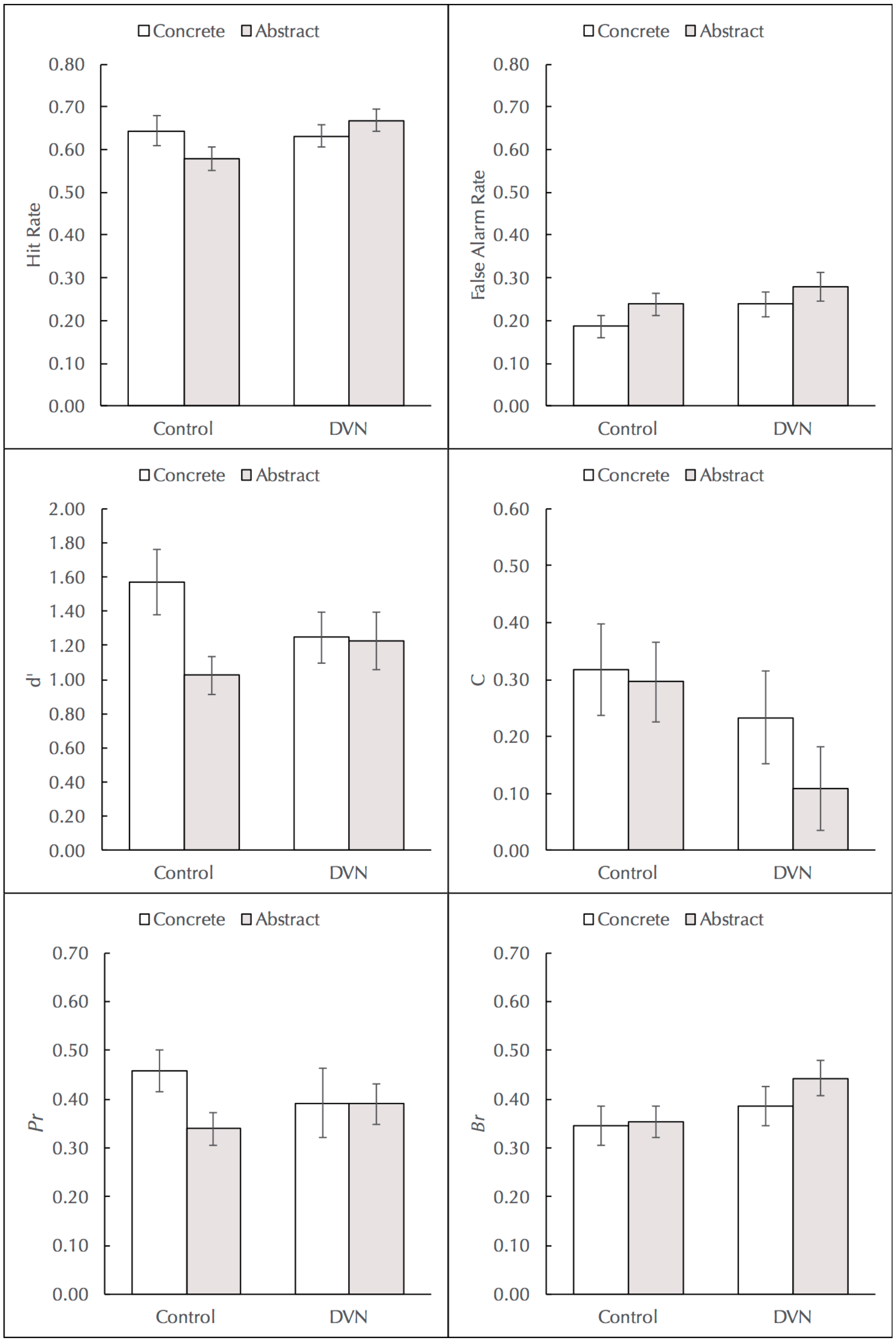
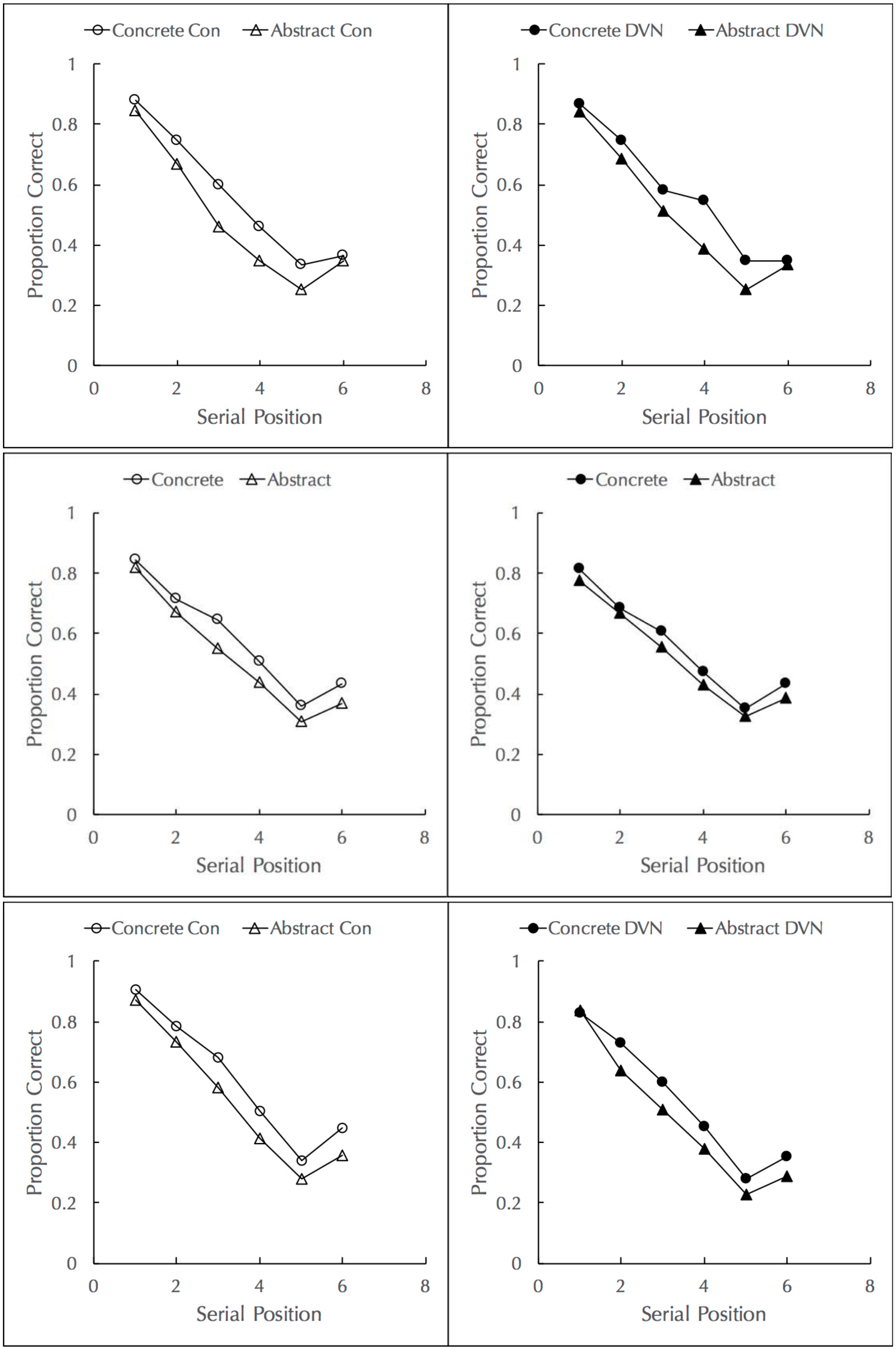


Figure 4: Top row: Proportion of words correctly recalled in order in the control condition (top left panel) and in the dynamic visual noise condition (top right panel) from Experiment 3, in which DVN was manipulated within subjects. Middle row: Proportion of words correctly recalled in order in the control condition (middle left panel) and in the dynamic visual noise condition (middle right panel) from Experiment 4, in which DVN was manipulated between subjects. Bottom row: Proportion of words correctly recalled in order in the control condition (bottom left panel) and in the dynamic visual noise condition (bottom right panel) from the serial recall conditions in Experiment 6, in which the type of test was not known until list presentation was over.


Concrete Con
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Concrete DVN
Abstract DVN
Proportion Correct
Serial Position

Figure 5: Hit rate (top left) and false alarm rate (top right); *d'* (middle left) and *C* (middle right); and *Pr* (bottom left) and *Br* (bottom right) in Experiment 5, which used immediate serial recognition. Error bars show the standard error of the mean.

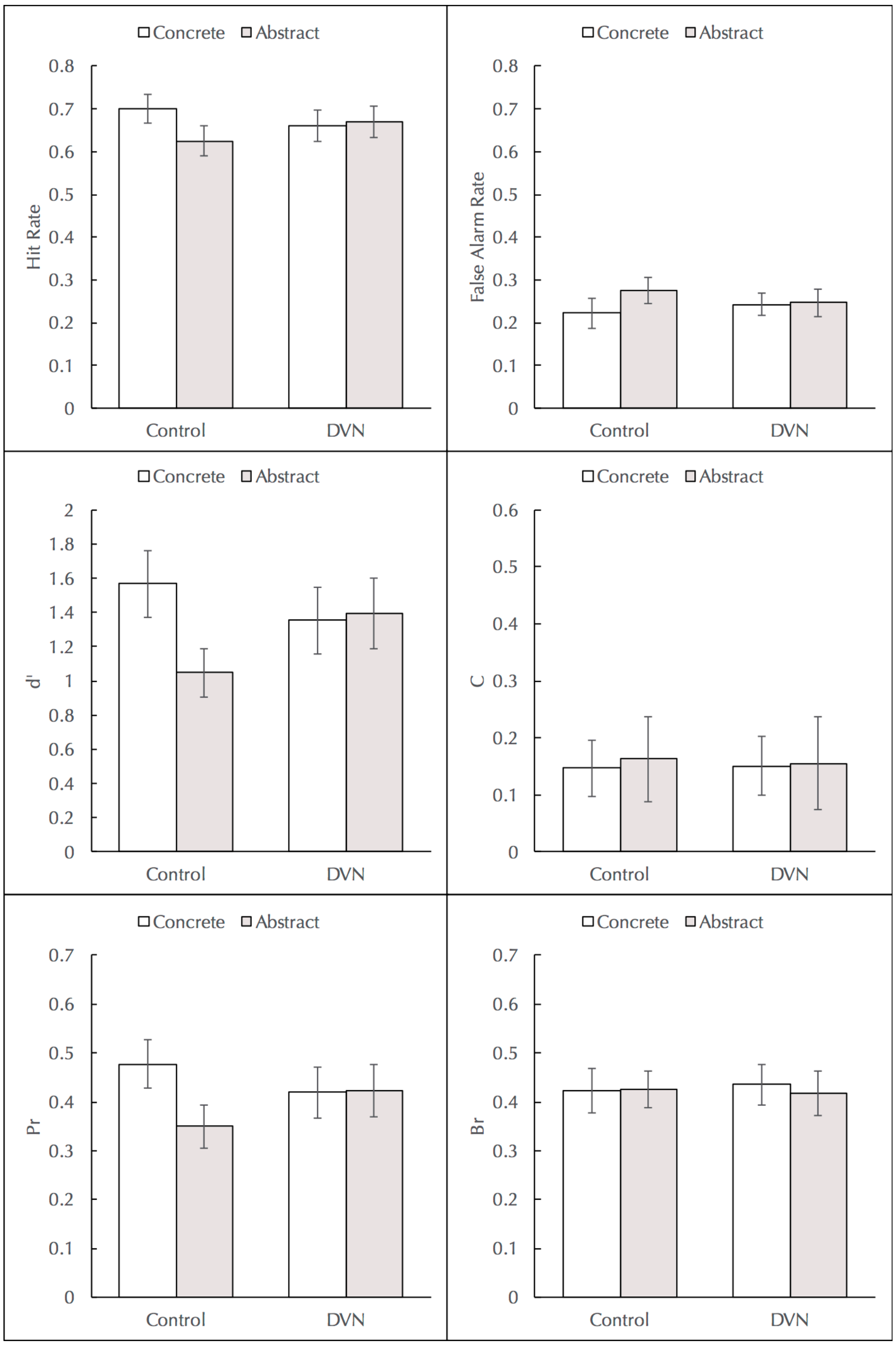

Figure 6: Hit rate (top left) and false alarm rate (top right); *d'* (middle left) and *C* (middle right); and *Pr* (bottom left) and *Br* (bottom right) from the serial recognition conditions in Experiment 6, in which the type of test was unknown until after list presentation. Error bars show the standard error of the mean.