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Learning to Selectively Attend From Context-Specific Attentional Histories: A Demonstration and Some Constraints

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Multiple lines of evidence from the attention and performance literature show that attention filtering can be controlled by higher level voluntary processes and lower-level cue-driven processes (for recent reviews see Bugg, 2012; Bugg & Crump, 2012; Egner, 2008). The experiments were designed to test a general hypothesis that cue-driven control learns from context-specific histories of prior acts of selective attention. Several web-based flanker studies were conducted via Amazon Mechanical Turk. Attention filtering demands were induced by a secondary one-back memory task after each trial prompting recall of the last target or distractor letter. Blocking recall demands produced larger flanker effects for the distractor than target recall conditions. Mixing recall demands and associating them with particular stimulus-cues (location, colour, letter, and font) sometimes showed rapid, contextual control of flanker interference, and sometimes did not. The results show that subtle methodological parameters can influence whether or not contextual control is observed. More generally, the results show that contextual control phenomena can be influenced by other sources of control, including other cue-driven sources competing for control.

Keywords: selective attention, learning, memory, contextual control

The environment is a multipurpose cognitive aid. We set alarm clocks to wake up on time, write grocery lists to remember the butter, and tell other people to remind us about important things in case we forget. Some uses of the environment are less intentional, but similarly effective as cognitive aids. For example, I recently forgot why I went to the living room and then returned to the kitchen and remembered my plan to find my glasses. Reinstating the context of the kitchen cued the retrieval of an intention previously formed in that environment. There are now many laboratory demonstrations showing that environmental cues can trigger the reinstatement of various psychological and neurobiological processes. For example, classical conditioning shows that expectations can be elicited by associated stimulus cues (Pavlov, 1927), and that control over these expectations can be context-dependent (i.e., occasion setting; Holland, 1992). In memory, recall performance is better when retrieval attempts are made in the encoding environment (Godden & Baddeley, 1975). In perception, colour aftereffects can be controlled by context cues (Siegel, Allan, & Eissenberg, 1992). Environmental context can even modulate drug-tolerance to heroin (Siegel, Hinson, Krank, & McCully, 1982).

This work focuses on contextual control influences in the domain of selective attention, where there are several laboratory demonstrations that contextual cues reinstate various attention operations. For example, visual search is faster for repeated displays, showing that specific distractor contexts can cue the location of a target (Chun & Jiang, 1998). Negative priming for an ignored object can be reinstated by presenting the object up to 1 month after the initial selection experience (DeSchepper & Treisman, 1996). Task-sets can be associated to and reinstated by particular items on a long-term basis (Waszak, Hommel, & Allport, 2003), and task-switching costs can be reduced when the requirement to perform specific tasks is predicted by the location contexts in which they appear (Mayr & Bryck, 2007). Additionally, classic interference effects (e.g., Stroop, flanker) measuring selective attention can be modulated by contextual cues associated with different proportions of congruent versus incongruent items (for reviews see, Bugg, 2012; Bugg & Crump, 2012).

General Memory Hypothesis of Contextual Control

Environmental cues can reinstate a variety of associated processes. However, it remains unclear whether the variety of contextual control phenomena can be explained by a single general process. Stepping toward that larger issue, this work was designed to test a general memory hypothesis of contextual control in the domain of selective attention.

The hypothesis is that context-specific reinstatement of psychological processes is the result of a memory process that (a) preserves details of how prior experiences were processed, and (b) reinstates the parameters of prior processing by a cue-driven retrieval process. Retrieval works by similarity: experiences are more likely to be retrieved when they are similar to the present set of cues. Thus, environmental cues retrieve the processing parameters associated with similar prior experiences and reinstate them to augment parameters of processing unfolding in the present

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moment. These assumptions are consistent with global memory theories (Eich, 1982; Hintzman, 1984; Murdock, 1993), which assume that details of specific experiences are stored, and that retrieval is cue- and similarity-driven. Computational versions of global memory theories commonly give the details of experiences more "noun-like" than "verb-like" representation. For example, feature vectors are created to code objects in past experiences, but not the variety of processing actions occurring in the presence of those objects. Nevertheless, the idea that memory could represent the details of prior processing has been seeded for some time; for example, in Kolers and Roediger's (1984) procedures of mind, or Estes' (1972) control units. Last, the notion of processing developed here refers broadly to the psychological and neurobiological processes listed previously that can be contextually controlled.

In the domain of selective attention, memory would preserve the processing details for selecting relevant from irrelevant information in the representation of individual experiences (Crump & Milliken, 2009; Crump, Vaquero, & Milliken, 2008). The attentional control settings for selection would become associated with contextual cues from the environment where they were formed and used. As a result, when those contexts recur they trigger the retrieval and reinstatement of the attentional control settings used in those contexts in the past. Contextual control over selective attention would be advantageous whenever selection demands are consistent within environments. For example, appropriate attentional control settings would require less preparation or maintenance because they would be obligatorily retrieved by environmental cues. However, contextual control has the potential to interfere with other sources of control, including other sources of contextual control. For example, when goals for selection change but the environment remains familiar, contextual control would retrieve attentional control settings that may no longer be relevant to the new goal. Or, when environments present multiple cues associated with different selection demands, contextual control may retrieve competing attentional control settings.

Two aspects of the general memory hypothesis are considered in the present work. First, the potential for contextual control of selective attention should exist whenever specific attention filtering operations occur in particular contexts. Cue-driven retrieval processes are assumed to be obligatory, so it possible that reinstating particular contexts in the present moment always leads to contextual control of selective attention. However, it is not clear whether other sources of control can override, supersede, compete, or otherwise interfere with contextual control. For example, contextual influences may or may not be observed in the presence of volitional sources of control. For example, when a difficult task requires sustained attention voluntary control may be given higher priority and override potential influences from contextual control. Or, one contextual influence may or may not be observed in the presence of other contextual influences. For example, some cues may be more or less strongly associated with control settings, and competition between cues could determine which control settings are reinstated by context. The present work examines these ideas using a novel design inspired by contextual control phenomena described in the proportion congruent literature. This literature is reviewed followed by the aims and logic of the current experiments.

Review of Proportion Congruent Effects

Selective attention processes are commonly investigated in interference paradigms such as Stroop (1935), or flanker (Eriksen & Eriksen, 1974) tasks, where subjects identify a target while ignoring response-congruent or -incongruent distractors. Responses are typically faster and more accurate for congruent than incongruent items, a difference termed congruency, compatibility, or interference effects. The size of congruency effects can be used to index selective attention operations. Large congruency effects show ineffective filtering of distracting information. Small congruency effects show effective filtering of distracting information. Processes controlling attention filtering may then be measured by factors controlling the size congruency effects. The proportion congruent manipulation (for reviews see, Bugg, 2012; Bugg & Crump, 2012) is one popular tool for modulating the size of congruency effects, and has been used to show contextual control of attention filtering.

There are three major classes of proportion congruent manipulations: list-wide, item-specific, and context-specific. List-wide proportion congruent (LWPC) designs contain blocks of trials that are mostly congruent (e.g., 75% congruent) or mostly incongruent (25% congruent), and show that Stroop effects are larger for mostly congruent than mostly incongruent blocks. LWPC effects have been explained by strategic control (Logan, 1980; Logan & Zbrodoff, 1979). Subjects in mostly congruent blocks become aware that the distractor often predicts the target and then prepare to attend to distracting information. This speeds performance on congruent trials but produces large interference effects on incongruent trials. Subjects in mostly incongruent blocks become aware that the distractor usually does not predict the target and prepare to ignore distracting information. This reduces facilitation from the distractor on congruent trials and interference on incongruent trials, producing overall smaller congruency effects.

In the item-specific proportion congruent (ISPC) design items are split into sets that receive different levels of proportion congruent, and then mixed together in the same blocks of trials (Jacoby, Lindsay, & Hessels, 2003). For example, Stroop items made out of red-blue combinations could be 75% congruent, whereas yellow-green combinations could be 25% congruent. When these item-types are randomly mixed together the overall list-wide PC is 50% congruent, so subjects are unable to predict whether an upcoming trial is likely to be congruent or incongruent. Nevertheless, ISPC effects are observed, with larger congruency effects for mostly congruent than mostly incongruent item types. The ISPC effect is an example of context-driven reinstatement of selective attention operations, with the item acting as a cue for retrieving prior attention filtering operations typical of that item.

In the context-specific proportion congruent (CSPC) design, items appear in different contexts associated with different levels of proportion congruent (Corballis & Gratton, 2003). For example, Stroop items above fixation could be mostly congruent and those appearing below could be mostly incongruent. As with ISPC designs, the overall list-wide PC is 50%, and items are mixed randomly between contexts across trials. The typical CSPC effect shows larger congruency effects in the mostly congruent than incongruent context (Crump, Gong, & Milliken, 2006). The CSPC effect suggests that processing of context features can rapidly cue the application of attention filters used in those contexts on previous occasions. CSPC effects have been replicated many times in Stroop (Bugg, Jacoby, & Toth, 2008; Crump & Milliken, 2009; Crump, Vaquero, & Milliken, 2008), flanker (Wendt, Kluwe, & Vietze, 2008; Wendt & Luna-Rodriguez, 2009), and task-switching paradigms (Crump & Logan, 2010; Leboe, Wong, Crump, & Stobbe, 2008) using different kinds of contextual features as cues (see Bugg & Crump, 2012).

Accounts of Proportion Congruent Effects

The range of proportion congruent effects have implications for theories of cognitive control because they cannot be explained by accounts relying solely on higher level voluntary processes or lower level stimulus-response learning processes. ISPC and CSPC phenomena license consideration of contextual control, a process that blurs the conventional distinction between controlled and automatic processes (Shiffrin & Schneider, 1977). No single account has successfully explained all PC effects, and multiple processes may contribute to all PC effects. Indeed, many PC designs are inherently confounded and so allow multiple interpretations of the processes driving PC effects (see Bugg & Crump, 2012). There are several accounts of PC effects and each are described in turn.

Contextual Control

Proportion congruent effects are consistent with the general memory hypothesis of contextual control over selective attention. To reiterate, encoding processes representing stimulus-response mappings also represent associations between stimuli (context cues) and attention filtering demands. In this way, environmental context can cue the reinstatement of attention filters applied in the past.

This hypothesis is sufficient but not necessary to explain most list-wide and ISPC effects, and is sufficient to explain ISPC and CSPC effects. The novel and most controversial aspect of this hypothesis is the prospect that learning processes code stimulus-attention associations and not only stimulus–response associations. One aim of this article is to test assumptions of the memory account for explaining how external cues acquire the ability to control selective attention. For example, contextual control could be acquired passively by associations between context and selective attention operations occurring in those contexts in the past. To give one alternative, contextual control could also develop via a learning process sensitive to response conflict demands inherent to particular items. For example, conflict monitoring processes could provide a nonvoluntary control signal for automatically adjusting attention settings (Botvinick, Braver, Barch, Carter, & Cohen, 2001). Additionally, Blais, Robidoux, Risko, and Besner (2007) have accounted for ISPC effects with a computational model that implements conflict monitoring at the level of specific items.

Frequency-Driven Learning

An alternative that has driven debate in the literature assumes that PC effects can be entirely explained by learned stimulus–response associations (Schmidt & Besner, 2008). It is convenient to summarise this view in terms of a learning process sensitive to the frequency of particular items and responses to those items (e.g., Logan, 1980). Many list-wide, ISPC, and CSPC designs vary the frequency with which particular items are presented. Here, items refer collectively to the features (e.g., colour and word, or target and distractor letters) of a stimulus, the context in which it appears (e.g., location, colour, font), and the correct response to that stimulus. Frequency learning accounts assume that reaction times (RTs) will generally be faster for high than low frequency items, and that modulations to the size of interference effects for high versus low proportion congruent items reflect an additive influence of item frequency. This hypothesis is sufficient to explain most list-wide, ISPC, and CSPC effects, but does not explain PC effects for frequency-unbiased items. For example, Crump and Milliken (2009) showed that CSPC effects were observed for a set of frequency unbiased transfer items that appeared in high or low proportion congruent contexts.

Voluntary Control

The voluntary control account assumes that weighting of target versus distractor processing is set voluntarily (Logan & Zbrodoff, 1979). This account is sufficient, but not necessary, to explain list-wide PC effects, where subjects are assumed to adopt general block-wide strategies for selectively attending to all items. It is possible that voluntary setting of attention filters could explain ISPC and CSPC effects, but this proposal requires two additional assumptions. First, that subjects are aware of the PC manipulation for different items or contexts. Second, that subjects can rapidly adjust attention filtering demands in a voluntary fashion at the time of stimulus onset.

However, in CSPC designs that have measured awareness (Crump et al., 2006), subjects were unable to report which contexts were high or low proportion congruent, and when subjects are made aware of the CSPC manipulation they did not show CSPC effects, and were prone to forgetting which context was high or low proportion congruent (Crump et al., 2008). However, voluntary accounts are not viable accounts of existing ISPC and CSPC effects.

Priming of Control

The priming of control account assumes that attention filtering demands set during trial n-1 carry forward and prime attention operations for trial n. The priming of control hypothesis could account for list-wide, ISPC, and CSPC effects, but has been primarily forwarded as an account of CSPC effects. For example, King, Korb, and Egner (2012), showed that location-based CSPC effects in a face-based flanker task were only observed when location contexts repeated from trial-to-trial, and were not observed when location contexts switched between trials. This finding fits with the notion that recent attention filtering demands can prime the setting of current attention filters, and also suggests that contextual cues are important for controlling whether or not priming occurs. At the same time, location-based CSPC effects in a Stroop task did not depend on context repetitions (Crump, Gong, & Milliken, 2006), so the priming of control does not provide a full account of the available data.

Overview of Experiments

The general memory hypothesis of contextual control maintains that attention filtering settings along with context cues from previous processing experiences are encoded in memory, and that current attention filtering settings can be adjusted by the presence of context cues that reinstate prior settings preserved by association in memory. On this view, contextual control should develop in at least one straightforward manner. Control over attention filtering would initially rely on voluntary or strategic processes that create, deploy, and monitor selection demands for the task at hand.

When consistent attention filtering demands occur in consistent environmental contexts, the repeated pairings between context and attention demands accrue enough memorial support for context cues to contribute to control over attention filtering. In other words, contextual control should learn from the history of voluntary control operations, or indeed the history of any consistently applied control operations.

ISPC and CSPC designs do not provide a good test of this hypothesis because the history of selective attention operations applied to particular items or contexts is generally unclear. For example, because subjects are unaware of the PC manipulation (Crump, Gong, & Milliken, 2006; Crump, Vaquero, & Milliken, 2008), the history of their attentional control strategies for each item in each context is uncertain.

The aim of the present experiments was to determine whether experience with known and manipulated attention filtering demands in specific contexts can be learned to support later contextual control over attention filtering. All of the experiments use modified versions of a flanker task and take their inspiration from CSPC studies, but are novel and extend those designs in two important respects.

First, proportion congruent was not varied between contexts. For all experiments proportion congruent was 50% congruent and incongruent, and all responses were made with equal frequency. As a result, any modulations to the flanker effect cannot be explained by frequency learning accounts (Schmidt & Besner, 2008).

Second, the history of attention filtering demands was crafted in a consistent, context-specific fashion, by secondary task demands. On each trial, the primary task was always to identify a central target letter as quickly and accurately as possible. The secondary task always immediately followed the primary task, and involved cues to recall either the identity of the target or distractors that were just presented. The primary task flanker effect was expected to be larger when the secondary task consistently cued recall of the distractors rather than the target.

The experiments are divided into three parts. Experiments 1A, 1B, and 1C validate the secondary task method for modulating flanker effects. Experiment 1A shows that experiment-wide secondary task demands to recall target or distractor identity change the size of flanker effects on the primary task. Experiments 1B and 1C associated the secondary target versus distractor recall tasks to different location contexts where flanker items appeared in a random fashion from trial-to-trial. The aim was to determine whether flanker effects would be modulated by context, with smaller flanker effects in the location paired with the secondary task of target versus distractor recall. These experiments failed to show context-specific control over flanker effects.

Experiments 2A, 2B, 2C, and 2D were conducted as follow-up designs to strengthen the potential for and realisation of contextual control over flanker interference. They all involved a similar two phase design with separate blocks of practice with each context paired with a particular secondary task, followed by a mixed phase where flanker items appeared randomly in either context. All of these experiments failed to show context-specific control over flanker effects in the mixed phase.

Finally, Experiments 3A, 3B, and 4C report a design that successfully demonstrates contextual control of flanker effects in the mixed phase. These findings show that experience with consistent attentional filtering demands induced by a secondary task, in a particular context, can lead to contextual control over distractor interference in a flanker task.

The fact that such contextual control was not observed in several of the earlier experiments raises important questions about how contextual control works together with other sources of control. These issues as well as additional analyses are elaborated upon further in the general discussion. For example, Bayesian estimates of the posterior probabilities of accepting the null or positive evidence for contextual control across experiments are discussed (following the method provided by Masson, 2011). Additionally, trial-to-trial sequential analyses are reported that constrain interpretation of the processes driving contextual control.

All subjects in each experiment were recruited via Amazon's Mechanical Turk (AMT), an online crowd-sourcing website. The experiments were programmed in JavaScript and HTML and run locally in subjects' web browsers. Crump, McDonnell, and Gureckis (2013) have validated this online method as tool for conducting behavioral experiments requiring millisecond precision for measuring RTs (see also Barnhoorn, Haasnoot, Bocanegra, & van Steenbergen, 2014; Reimers & Maylor, 2005; Reimers & Stewart, 2015; Schubert, Murteira, Collins, & Lopes, 2013; Simcox & Fiez, 2014).

Experiments 1A (Blocked), 1B, and 1C (Mixed)

Experiment 1A was conducted to verify that secondary task demands to recall the identity of a previous target or distractor are sufficient for modulating distractor interference as measured by the flanker effect from the primary task. The goal of Experiment 1B and C was to determine whether context cues paired with those secondary task demands would support contextual control over distractor interference (see Figure 1).

In all experiments, the primary task was to identify a central target letter (e.g., H) flanked on the left and right by congruent (e.g., H H H) or incongruent (e.g., F H F) distractor letters. In Experiment 1A, secondary task demands were manipulated between subjects. For all subjects, a single flanker item appeared randomly above or below fixation on each trial. All flanker trials in one location were followed by a memory task, and all trials in the other location were not. Two groups of subjects were given the task to recall the target or distractor letter from the most recent primary flanker item.

These memory demands were intended to induce different attentional sets that would modulate distractor interference on the primary flanker task. For example, the target recall demand should encourage subjects to adopt an attentional set that narrows spatial attention toward the target letter, thereby diminishing processing

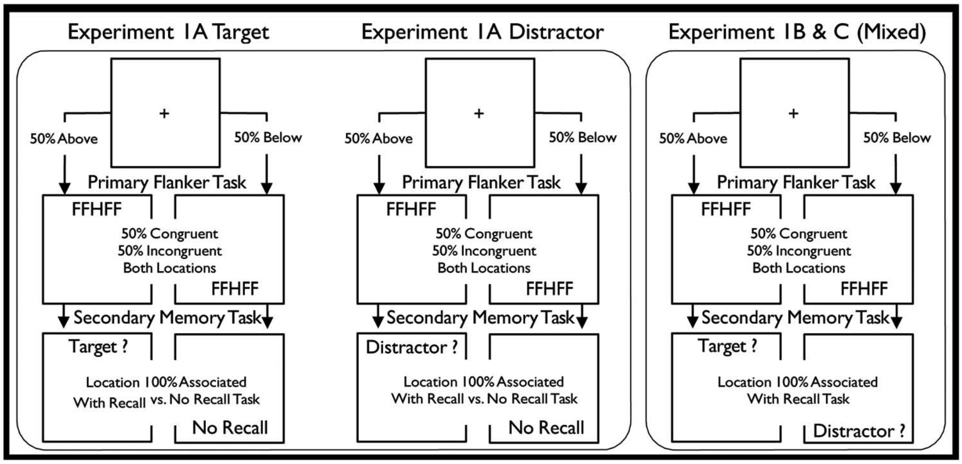

Figure 1. Each panel shows a single trial for Experiments 1A, 1B, and 1C. Subjects viewed a fixation cross, then a flanker item (randomly above or below fixation). The primary task was to identify the centre letter. For the secondary task, in 1A, different groups performed target versus distractor recall immediately followed by flanker trials appearing in one location; the other location was never followed by the recall task. In 1B and 1C the secondary task was performed in both locations, locations were mixed randomly, and each location was consistently paired with either the target or distractor recall demands.

of distractor information in the periphery and decreasing the size of the flanker effect. The distractor recall demand should encourage subjects to adopt an attentional set that broadens spatial attention across all letters in the display, thereby enhancing processing of distractor information in the periphery and increasing the size of the flanker effect.

Experiments 1B and 1C were similar to 1A, except the secondary task demands were manipulated in a mixed within-subject design. Flanker items appeared randomly in one of two locations. One location was associated with the target recall task and the other with the distractor recall task. If subjects learn associations between location contexts and the attentional sets induced by the secondary task, and the appearance of contextual cues reinstates those sets, then flanker effects should be smaller in the target than distractor recall locations. The size of the response set was manipulated from four to two between Experiments 1B and 1C, respectively.

Method

Participants. All subjects were recruited from AMT and compensated $1.50 for participating. For each experiment, the number of HITs (Human intelligence tasks, an Amazon term for a work-unit) refers to the number of subjects who initiated the study. Subjects were included in the study if they completed all trials. For Experiment 1A, 120 HITS were posted and 49 subjects completed all trials in the target focus condition, 55 subjects completed the distractor focus condition. For Experiment 1B, 60 HITs were posted, and 50 subjects completed all trials. For Experiment 1C, 30 HITs were posted and a total of 22 subjects completed all trials. Demographic information was collected and is reported in the Appendix.

Apparatus and stimuli. The experiment was programmed using JavaScript and HTML. The program allowed subjects to complete the task only if they were running Safari, Google Chrome, or Firefox web browsers. For Experiments 1A and 1B the letters used for the flanker stimuli were D, F, H, and J presented in 50-point Helvetica font. For 1C, the letters were F and H. Each experiment ran as a pop-up window that filled the entire screen. The background was black, and stimuli were presented randomly in red or green (see Experiment 2C for an explanation). Letters were spaced five screen pixels apart.

Design. Experiments 1A used a mixed $2 \times 2 \times 2$ design with congruency (congruent vs. incongruent) and location (recall vs. no recall) as within-subject factors and memory task (recall target vs. distractor) as the between-subjects factor. The location assigned to the recall or no recall conditions was counterbalanced across subjects.

Experiments 1B and 1C used a 2×2 within-subject design with congruency (congruent vs. incongruent) and memory task (recall target vs. distractor) as factors. The location assigned to the target or distractor recall tasks was counterbalanced across subjects.

For all experiments, congruent items were presented on 50% of the trials and incongruent items were presented on 50% of the trials. In addition, 50% of items appeared above fixation, and 50% appeared below fixation. All trials were fully randomized for each subject.

There were 384 trials in Experiment 1A, with 192 congruent and 192 incongruent trials; 96 congruent and 96 incongruent trials appeared in the recall location and were followed by the secondary memory task. Similarly, 96 congruent and 96 incongruent trials appeared in the no recall location.

There were 384 trials in Experiments 1B and 1C, with 192 congruent and 192 incongruent trials; 96 congruent and 96 incongruent trials appeared in the target recall location, and 96 congruent and 96 incongruent trials appeared in the distractor recall location.

Procedure. All subjects were AMT workers who found the experiment using the AMT system. The subject recruitment procedure and tasks were approved by the Brooklyn College Institutional Review Board. Each subject read a short description of the task and gave consent by pressing a button acknowledging they had read the displayed consent form. Subjects then completed a short demographic survey, and proceeded to the main task, which was displayed as a pop-up window. Subjects were instructed to identify the centre letter on each trial as quickly and accurately as possible by pressing the corresponding key on the computer keyboard. They were also instructed that trials may be followed by a secondary recall task, and that they should follow the prompt to recall the target or distractor letter from the centre letter identity trial they just completed. They were told their primary task was to identify the central letter, and that the secondary task was unspeeded. Throughout the course of the experiment the upper left corner of the display showed progress through the experiment, indicating the number of completed and remaining trials, as a well as an instruction reminder button that displayed the instructions in a new pop-up window.

Each trial began with a white fixation cross presented in the centre of the screen for 1,000 ms, followed by a blank ISI of 500 ms. Next, a flanker stimulus appeared above or below fixation and remained onscreen until a response was made.

Feedback indicating whether the answer was correct or incorrect was given after each response. If the response time was greater than 1,500 ms, then the message "respond faster" appeared to encourage speeded responding. On recall trials, a memory prompt was then presented. The target recall prompt read, "What was the centre letter?" and the distractor recall prompt read, "What were the side letters?" Underneath the prompt, all letters from the response set were listed as response options. The next trial was triggered automatically after the response to the recall question. For the no recall trials in 1A, the next trial was triggered automatically following the feedback display.

Results

Subjects with mean error rates on the flanker task greater than .2 were not included in the analysis. This criterion was applied to all remaining analyses. For 1A, this eliminated one subject in the target focus and two subjects in the distractor focus conditions. One subject was eliminated in 1B, and one subject was eliminated in 1C. For all remaining subjects, the RTs from correct trials in each condition were submitted to an outlier rejection procedure (Van Selst & Jolicoeur, 1994) that eliminated an average of 2%, 2%, and 3% of the observations in each condition for Experiments 1A, 1B, and 1C, respectively. The same nonrecursive version of the outlier procedure was applied to all remaining analyses. The resulting mean RTs and error rates were submitted to the following analyses, and an alpha criterion of .05 was adopted for all statistical tests.

Experiment 1A. The primary question of interest was whether flanker effects were modulated by the memory task demands. To address this question, mean RTs and error rates were submitted to a mixed analysis of variance (ANOVA) with congruency (congruent vs. incongruent) and location (recall vs. no recall) as within-subject factors, and memory task (target recall vs. distractor recall) as the between-subjects factor. Mean RTs and error rates for all conditions, and mean flanker effects are shown in Table 1.

The main effect of congruency was significant, $F(1, 99) = 461.94$, $MSE = 5496.25$, $p < .001$, $\eta_p^2 = .82$. RTs were faster for congruent (926 ms) than incongruent (1,082 ms) trials.

The more important result was a significant interaction between congruency and memory task, $F(1, 99) = 51.21$, $MSE = 5496.25$, $p < .001$, $\eta_p^2 = .34$. Flanker effects were larger for trials in the distractor recall (209 ms) than target recall (103 ms) conditions. This validates the secondary memory task as a method for modulating distractor interference.

The three-way interaction between congruency, memory task, and location was also significant, $F(1, 99) = 6.15$, $MSE = 1725.95$, $p < .015$, $\eta_p^2 = .06$. For the target recall group, flanker effects were not statistically different between the recall and no recall locations, $F < 1$. However, for the distractor recall group, flanker effects were significantly larger in the recall (226 ms) than no recall (191 ms) locations, $F(1, 52) = 6.10$, $MSE = 2638.64$, $p < .017$, $\eta_p^2 = .10$. This shows initial support for contextual control over distractor interference driven by associations from context-specific secondary task requirements. However, the remaining experiments will place numerous constraints on the interpretation of this result.

Table 1
Mean RTs, Error Rates, SEs, and Flanker Effects for Experiment 1A

	Secondary task				Flanker effects	
	Target recall		Distractor recall		Target	Distractor
Location	C	I	C	I	(I − C)	(I − C)
Recall						
RT	899	999	955	1,182	100**	226**
SE	25	27	39	47	7	18
ER	.03	.04	.03	.05		
No recall						
RT	901	1007	949	1,140	106**	191**
SE	26	28	38	39	6	13
ER	.03	.05	.03	.04		

Note. RT = reaction time; ER = error rate; C = congruent; I = incongruent.
* $p < .05$. ** $p < .01$.

For completeness, the main effect of memory task was significant, $F(1, 99) = 4.55$, $MSE = 242870.01$, $p < .035$, $\eta_p^2 = .04$, as was the main effect of location, $F(1, 99) = 4.08$, $MSE = 2616.84$, $p < .046$, $\eta_p^2 = .04$.

A corresponding analysis of error rates only showed a significant main effect of congruency, $F(1, 99) = 15.02$, $MSE = .002$, $p < .001$, $\eta_p^2 = .13$. Mean error rates for all conditions were less than .05. All error rates in the remaining experiments were similarly small, and analyses of error rates either showed significant effects of congruency, or no significant effects at all. For brevity, these analyses are not reported for the remaining experiments. Finally, subjects were accurate on the secondary memory task. Mean error rates were low overall for the target (.02) and distractor recall (.07) tasks.

Experiment 1B. The primary question of interest was whether congruency effects would be modulated by contextual cues in a mixed design, where target and distractor recall demands were associated with separate location contexts and presented randomly within the same blocks of trials. To address this question, mean RTs and error rates were submitted to repeated measures ANOVAs with congruency (congruent vs. incongruent) and memory task (target recall vs. distractor recall) as factors. Mean RTs and error rates are shown in Table 2.

The main effect of congruency was significant, $F(1, 48) = 73.10$, $MSE = 65005.52$, $p < .001$, $\eta_p^2 = .60$. However, the critical two-way interaction between congruency and memory task was not significant, $F(1, 48) = 2.46$, $MSE = 1325.95$, $p < .123$, $\eta_p^2 = .05$. This null result provides a first failure to show context-specific control over attention filtering demands induced by a secondary task. It is worth noting that flanker effects were very large in both target (303 ms) and distractor (320 ms) recall locations. This is consistent with the idea that attention settings for the distractor recall location were applied in a general fashion across location contexts.

All error rates were below .05 and their analysis is not reported. For the secondary task, error rates were slightly higher than 1A for the target (.12) and distractor (.14) recall tasks.

Experiment 1C. This experiment replicated 1B with a smaller response set of two letters. The same analysis as above was conducted. Mean RTs, *SE*s, error rates, and flanker effects for each condition are shown in Table 2.

Again, the main effect of congruency was significant, $F(1, 20) = 75.88$, $MSE = 10332.31$, $p < .001$, $\eta_p^2 = .79$. However, the critical interaction between congruency and memory task was not significant, $F < 1$. As with Experiment 1B, the flanker effects in the target (191 ms) and distractor recall (196 ms) locations were large. The analysis of error rates showed no significant effects, and all error rates were smaller than .03. For the secondary task, error rates were low for the target (.03) and distractor (.07) recall tasks.

Discussion

Experiment 1A validated a new method for modulating distractor interference by secondary task demands in a flanker task. Flanker effects were smaller in the target than distractor recall tasks, and these differences were generalised across the recall and no-recall trials.

Experiments 1B and 1C both failed to show context-specific modulation of distractor interference by secondary task demands. In both experiments, the target and distractor recall conditions were assigned to consistent locations presented randomly across trials. Evidence of contextual control would be found if flanker effects were smaller in the target than distractor recall locations. Instead, flanker effects were large in both locations. This is consistent with subjects using a single attentional strategy across both locations. Specifically, one that involved attending to the target and distractor letters for each item.

The null results of 1B and 1C are consistent with multiple interpretations. First, the (presumably) learned associations between location and secondary task demands could simply be ineffective for producing contextual control over flanker interference. Second, voluntarily control may override contextual control. For example, because subjects have to recall the distractors on half of the trials, they could have decided to attend to the distractors throughout the entire task. Third, other contextual cues may have dominated contextual control. For example, distractors in the primary task may have cued the attentional set required by the secondary distractor recall task. Last, the target and distractor recall tasks may not have induced distinct attentional sets; thus, location-based contextual control would not be observed because different locations were not triggering different attentional sets.

Table 2
Mean RTs, Error Rates, SEs, and Flanker Effects for Experiments 1B and 1C

	Secondary task context				Flanker effects		Context-specific scores
	Target recall		Distractor recall		Target	Distractor	
Set-size	C	I	C	I	(I − C)	(I − C)	$^{D}(I-C) - {}^{T}(I-C)$
4 (1B)							
RT	1,041	1,344	1,033	1,353	303**	320**	16
SE	31	56	30	58	36	37	10
ER	.03	.04	.03	.03			
2 (1C)							
RT	776	966	774	970	191**	196**	5
SE	25	34	24	33	14	15	5
ER	.02	.03	.02	.02			

Note. RT = reaction time; ER = error rate; C = congruent; I = incongruent; D = distractor; T = target.
* $p < .05$. ** $p < .01$.

Experiment 2A: Blocked Practice Phase

Experiments 2A, 2B, 2C, and 2D were designed to demonstrate contextual control over flanker effects. All four experiments failed in this regard (see Bayesian analyses of null-effects in the general discussion), but succeeded in replicating the basic pattern of results from Experiments 1A, 1B, and 1C. Each experiment progresses from 1C and incorporates manipulations from the proportion congruent literature assumed to bolster contextual control.

Experiment 2A included a blocked practice phase before the mixed phase. During practice, one block included trials presented in one location paired consistently with one of the memory recall tasks; the other block presented trials in the other location with the other memory recall task. Following practice the mixed phase was presented, and trials could appear randomly in either location. Critically, the pairing between location and memory recall task was consistent throughout.

The blocked practice phase was included for two reasons. First, context-specific control over flanker effects using colour rather than location as a cue have only been reported when subjects received blocked practice first (Lehle & Hübner, 2008). Therefore, using blocked practice here may strengthen associations between location cues and attention filtering demands induced by the secondary task, thereby increasing contextual control in the mixed phase. Second, the blocked practice phase provides a manipulation check. The null-results of Experiments 1B and 1C could be because of a failure of the secondary memory task to induce different attention filtering demands in a mixed design. Including the blocked practice phase gives confirmation that different attentional filtering demands were induced in the first place. All remaining experiments reported in this article include a blocked practice phase before the mixed phase.

Method

Participants. All subjects were recruited from AMT and were compensated $1.50 for participating. Sixty HITs were posted and 48 subjects completed all of the trials. Demographic information was collected and is reported in the Appendix.

Apparatus and stimuli. The apparatus and stimuli were identical to Experiment 1C.

Design. The design was similar to Experiment 1C except that subjects completed a blocked practice phase before the mixed phase. This involved separate 2×2 within-subject designs for each phase with congruency (congruent vs. incongruent) and memory task (target recall vs. distractor recall). The locations assigned to the target or distractor recall tasks were counterbalanced across subjects. The locations assigned to each recall task in the blocked practice phase were kept consistent in the mixed phase. Finally, whether the first practice block involved a target or distractor recall task was counterbalanced across subjects.

There were a total of 384 trials. The first practice block included 96 trials, with 50% congruent and incongruent items, all appearing in one location with a particular recall task following all trials. The second practice block was the same, except items appeared in the other location and were followed by the alternative recall task. The last two blocks included 96 trials each, with 50% congruent and incongruent items. Here, the flanker items appeared in an unpredictable fashion in either location (above or below fixation), and were always followed by the recall task associated with that location from the practice phase.

Procedure. The procedure was identical to Experiment 1C.

Results

Following the criterion established in Experiment 1, two subjects were eliminated for having mean proportion error rates greater than .2. The outlier procedure eliminated an average of 3% of RTs from correct trials. The resulting mean RTs and error rates from the blocked and mixed phases were submitted to repeated measures ANOVAs with congruency (congruent vs. incongruent) and memory task (target recall vs. distractor recall) as factors. Mean RTs, *SE*s, error rates, and flanker effects for the blocked and mixed phases are presented in Tables 3 and 4, respectively.

Blocked practice phase. The main effect of congruency was significant, $F(1, 45) = 215.94$, $MSE = 2519.88$, $p < .001$, $\eta_p^2 = .83$, and the main effect of memory task was significant, $F(1, 45) = 4.18$, $MSE = 8235.49$, $p < .047$, $\eta_p^2 = .08$. These main effects were qualified by a significant interaction between congruency and memory task, $F(1, 45) = 12.05$, $MSE = 1174.91$, $p < .001$, $\eta_p^2 = .21$. Flanker effects were larger in the distractor recall (126 ms) than target recall (91 ms) locations. The secondary memory task successfully induced different attentional filtering demands between blocks. Mean error rates were all less than .06. For the secondary task, error rates were low overall for the target (.03) and distractor (.04) recall tasks.

Mixed phase. Having established that the secondary memory task modulated flanker effects in the blocked practice phase, the primary question of interest was whether these influences could be contextually controlled. The critical two-way interaction between congruency and memory task that would show such a result was not significant, $F < 1$. Flanker effects were statistically equivalent for the distractor recall (163 ms) and target recall (165 ms) locations. The main effect of congruency was significant, $F(1, 45) = 222.44$, $MSE = 5581.21$, $p < .001$, $\eta_p^2 = .83$. Mean error rates were less than or equal to .05. For the secondary task, error rates were low overall for the target (.08) and distractor (.04) recall tasks.

Discussion

Experiment 2A included a blocked practice phase to strengthen associations between location contexts and attention filtering demands. This produced significant differences between flanker effects in the blocked phase, and provided a manipulation check confirming that different attention filtering demands were induced between each location context. However, no evidence for context-specific control was observed in the following mixed blocks. This is a third failure to show that modulations to the flanker effect by secondary task demands (that are confirmed to influence distractor interference in during practice) can be brought under contextual control.

Experiment 2B: Redundant Item-Specific Associations

Contextual control can depend on the distinctiveness of contextual cues (D'Angelo, Milliken, Jiménez, & Lupiáñez, 2013). Experiment 2B was designed to further strengthen contextual support

Table 3
Blocked Phase Mean RTs, Error Rates, SEs, and Flanker Effects for Experiments 2A, 2B, 2C, and 2D

Blocked phase experiment	Secondary task context				Flanker effects		Context-specific scores
	Target recall		Distractor recall		Target	Distractor	
	C	I	C	I	(I − C)	(I − C)	$^{D}(I - C) - {}^{T}(I - C)$
2A							
RT	631	723	641	768	91**	126**	35**
SE	16	21	18	23	9	9	10
ER	.04	.06	.03	.05			
2B							
RT	678	782	744	903	103**	159**	56**
SE	17	21	23	33	8	17	17
ER	.02	.06	.02	.06			
2C							
RT	710	799	761	918	90**	157**	67**
SE	29	35	30	38	16	17	18
ER	.04	.07	.02	.04			
2D							
RT	599	687	645	781	87**	136**	49**
SE	13	17	21	28	8	12	14
ER	.01	.05	.02	.06			

Note. RT = reaction time; ER = error rate; C = congruent; I = incongruent; D = distractor; T = target.
* $p < .05$. ** $p < .01$.

for the associations between location contexts and attention filtering demands. In all of the previous experiments, the flanker items contain cues (e.g., letter and response identities) that may be associated with attention filtering demands.

However, because all items appeared in all locations in the previous designs, each item was associated with both target and distractor recall demands, and could potentially interfere with the location cues that were uniquely associated with filtering demands.

To address the issue, in Experiment 2B item-specific associations were aligned with the location-specific associations. Flanker items were divided into two letter sets. For example, items composed of the letters D and F were always presented in one location, and items composed of H and J were always presented in the other location. Thus, cues from the items and the contexts were consistently associated with the target or distractor filtering demands.

Table 4
Mixed Phase Mean RTs, Error Rates, SEs, and Flanker Effects for Experiments 2A, 2B, 2C, and 2D

Mixed phase experiment	Secondary task context				Flanker effects		Context-specific scores
	Target recall		Distractor recall		Target	Distractor	
	C	I	C	I	(I − C)	(I − C)	$^{D}(I - C) - {}^{T}(I - C)$
2A							
RT	673	838	672	835	165**	163**	−2
SE	15	21	15	22	12	11	9
ER	.03	.05	.03	.05			
2B							
RT	870	1036	896	1,066	165**	170**	5
SE	30	39	34	52	17	25	17
ER	.04	.05	.04	.05			
2C							
RT	873	1,010	870	1,033	137**	163**	26
SE	37	43	37	43	16	13	20
ER	.04	.04	.02	.04			
2D							
RT	725	829	712	815	104**	103**	−1
SE	22	26	24	26	9	8	10
ER	.03	.04	.03	.05			

Note. RT = reaction time; ER = error rate; C = congruent; I = incongruent; D = distractor; T = target.
* $p < .05$. ** $p < .01$.

Method

Participants. All subjects were recruited from AMT and were compensated $1.50 for participating. Sixty HITs were posted and 54 subjects completed all of the trials. Demographic information was collected and is reported in the Appendix.

Apparatus and stimuli. The apparatus and stimuli were similar to Experiment 2A, with the exception that flanker stimuli were made up from the letter sets D and F, and H and J. Each letter set was associated to a specific location context, which was counterbalanced across subjects.

Design. The design was identical to Experiment 2A.

Procedure. The procedure was identical to Experiment 2A.

Results

No subjects were eliminated. The outlier procedure eliminated an average of 3% of RTs from correct trials. The resulting mean RTs and proportion error rates from the blocked and mixed phases were submitted to repeated measures ANOVAs with congruency (congruent vs. incongruent) and memory task (target recall vs. distractor recall) as factors. Mean RTs and Error rates for the blocked and mixed phases are presented in Table 3 and 4, respectively.

Blocked practice phase. The main effect of congruency was significant, $F(1, 53) = 166.14$, $MSE = 5608.77$, $p < .001$, $\eta_p^2 = .76$, and the main effect of memory task was significant, $F(1, 53) = 35.50$, $MSE = 13296.50$, $p < .001$, $\eta_p^2 = .40$. These main effects were qualified by a significant interaction between congruency and memory task, $F(1, 45) = 11.48$, $MSE = 3711.36$, $p < .001$, $\eta_p^2 = .18$. As expected, flanker effects were larger in the distractor recall (159 ms) than target recall (103 ms) locations. Mean error rates were less than or equal to .06. For the secondary task, error rates were low overall for the target (.07) and distractor (.10) recall tasks.

Mixed phase. The critical two-way interaction between congruency and memory task was not significant, $F < 1$. Flanker effects were statistically equivalent for the distractor recall (170 ms) and target recall (165 ms) locations. The main effect of congruency was significant, $F(1, 53) = 69.45$, $MSE = 21829.09$, $p < .001$, $\eta_p^2 = .57$. Mean error rates were less than or equal to .05. For the secondary task, error rates were low overall for the target (.08) and distractor (.06) recall tasks.

Discussion

In Experiment 2B contextual support was strengthened by aligning item-specific and context-specific associations with consistent attention filtering demands. Although the blocked practice phase shows that different attention filtering demands were induced, evidence for contextual control over these filtering demands was not obtained in the mixed phase.

Experiment 2C: Redundant Colour and Font Associations

Experiment 2C was designed to further strengthen contextual support. In the previous experiments flanker items appeared randomly in red or green (a manipulation held over from pilot work) in both locations, so the colour feature may have interfered with location-based contextual control. This confound was removed by consistently pairing colours, item-type, and location with the target and distractor recall demands. Additionally, different fonts were used in each location because context-specific proportion congruent effects in Stroop have been shown using font as a cue (Bugg, Jacoby, & Toth, 2008).

Flanker items were presented in Helvetica for one location and Times for the other. Thus, Experiment 2C used highly redundant contextual cues, with location, item-type, colour, and font all consistently associated with target or distractor recall demands. Finally, the letter and response set was modified slightly from the prior experiments. Flanker items for each set consisted of the letters A and S, and J and K, which are further away from each other on a QWERTY board and could enhance distinctions between the two sets.

Method

Participants. All subjects were recruited from AMT and were compensated $1.50 for participating. Sixty HITs were posted and 46 subjects completed all of the trials. Demographic information was collected and is reported in the Appendix.

Apparatus and stimuli. The apparatus and stimuli were similar to Experiment 2B, with the exception that flanker stimuli were presented in red or green, and in the fonts Helvetica or Times. Each of these features was assigned to a consistent location context throughout the experiment, and were fully counterbalanced. One set of flanker items was made up from the letters A and S, and the other from the letters J and K. These sets were counterbalanced across location and subjects.

Design. The design was identical to Experiment 2B.

Procedure. The procedure was identical to Experiment 2B.

Results

One subject was eliminated for having a mean proportion error rate above .2. The outlier procedure eliminated an average of 3% of RTs from correct trials. The resulting mean RTs and error rates from the blocked and mixed phases were submitted to repeated measures ANOVAs with congruency (congruent vs. incongruent) and memory task (target recall vs. distractor recall) as factors. Mean RTs and error rates for the blocked and mixed phases are presented in Table 3 and 4, respectively.

Blocked practice phase. The main effect of congruency was significant, $F(1, 44) = 73.95$, $MSE = 9231.45$, $p < .001$, $\eta_p^2 = .63$, and the main effect of memory task was significant, $F(1, 44) = 17.85$, $MSE = 18269.78$, $p < .001$, $\eta_p^2 = .29$. These main effects were qualified by a significant interaction between congruency and memory task, $F(1, 44) = 13.97$, $MSE = 3580.92$, $p < .001$, $\eta_p^2 = .24$. As expected, flanker effects were larger in the distractor recall (157 ms) than target recall (90 ms) locations. Mean error rates were less than or equal to .07. For the secondary task, error rates were low overall for the target (.03) and distractor (.05) recall tasks.

Mixed phase. The critical two-way interaction between congruency and memory task was not significant, $F(1, 44) = 1.72$, $MSE = 4343.69$, $p < .197$. Although flanker effects appeared to be moving in the right direction, they were statistically equivalent for the distractor recall (163 ms) and target recall (137 ms) locations.

The main effect of congruency was significant, $F(1, 44) = 190.93$, $MSE = 5299.44$, $p < .001$, $\eta_p^2 = .81$. Mean error rates were all less than or equal to .05. For the secondary task, error rates were low overall for the target (.04) and distractor (.02) recall tasks.

Discussion

In Experiment 2C contextual support was further strengthened by aligning item-specific and context-specific associations with unique attention filtering demands, and by additionally using colour and font features as redundant contextual cues. Although the blocked practice phase shows that different attention filtering demands were induced, evidence for contextual control over these filtering demands was again not obtained in the mixed phase.

Experiment 2D: Removing Secondary Task Demands

One explanation of the failure to find contextual control in the previous experiments is that the control processes used to meet secondary task demands in the mixed phase masked, overshadowed, or otherwise superseded location-based contextual control influences. To test this idea, Experiment 2D (which was otherwise the same as 2C) removed the secondary memory task during the mixed phase. If location-based contextual control was blocked by the presence of control processes for secondary task demands, then location-based contextual control may be present in Experiment 2D where secondary task demands are removed.

Method

Participants. All subjects were recruited from AMT and were compensated $1.50 for participating. Forty HITs were posted and 37 subjects completed all of the trials. Demographic information was collected and is reported in the Appendix.

Apparatus and stimuli. The apparatus and stimuli were identical to Experiment 2C

Design. The design was similar to Experiment 2C, with the exception that the secondary memory task was removed from all trials in the mixed phase.

Procedure. The procedure was identical to Experiment 2C.

Results

One subject was eliminated for having a mean error rate above .2. The outlier procedure eliminated an average of 3% of RTs from correct trials. The resulting mean RTs and error rates from the blocked and mixed phases were submitted to repeated measures ANOVAs with congruency (congruent vs. incongruent) and memory task (target recall vs. distractor recall) as factors. Mean RTs and error rates for the blocked and mixed phases are presented in Table 3 and 4, respectively.

Blocked practice phase. The main effect of congruency was significant, $F(1, 35) = 205.90$, $MSE = 2185.00$, $p < .001$, $\eta_p^2 = .85$, and the main effect of memory task was significant, $F(1, 35) = 23.87$, $MSE = 7483.45$, $p < .001$, $\eta_p^2 = .41$. These main effects were qualified by a significant interaction between congruency and memory task, $F(1, 35) = 11.72$, $MSE = 1831.84$, $p < .002$, $\eta_p^2 = .25$. As expected, flanker effects were larger in the distractor recall (136 ms) than target recall (87 ms) locations. Mean error rates were less than or equal to .06. For the secondary task, error rates were low overall for the target (.03) and distractor (.03) recall tasks.

Mixed phase. The critical two-way interaction between congruency and memory task was not significant, $F < 1$. Flanker effects were statistically equivalent for the distractor recall (103 ms) and target recall (104 ms) locations. The main effect of congruency was significant, $F(1, 35) = 232.19$, $MSE = 1658.59$, $p < .001$, $\eta_p^2 = .87$. Mean error rates were all less than or equal to .05.

Discussion. Experiment 2D tested the possibility that contextual control was masked by maintenance of filtering demands imposed by the secondary memory task in the mixed phase. This hypothesis was tested by removing the secondary memory task following all flanker trials in the mixed phase. Although the blocked practice phase shows that different attention filtering demands were induced, no evidence for contextual control was obtained in the mixed phase.

Experiments 3A, 3B, and 3C: Distractor Spacing

The previous experiments showed no location-based contextual control over the flanker effect in any of the mixed phases. Perhaps attentional filtering demands induced by a secondary task cannot be brought under contextual control. Or, the present task parameters may need to be modified to allow contextual influences to express themselves in performance.

For example, CSPC effects can depend on subtle task parameters. Crump, Gong, and Milliken (2006) showed location-based CSPC effects in a prime-probe version of the Stroop task where the word stimulus was presented as a central prime and removed before presentation of a colour patch probe. The authors noted that CSPC effects were not observed in pilot work using a more standard integrated colour-word task. One interpretation of that result was that a word stimulus appearing at the time of colour target onset interferes with location cues associated with different levels of proportion congruent. The distracting word stimulus itself may trigger the need for selective attention, and this trigger could override any adjustments to attention filtering provided by the location cues.

In flanker tasks, the spacing of target and distractors may have a similar influence on whether or not contextual control is observed. For example, increasing spacing reduces the size of the flanker effect (C. W. Eriksen & Murphy, 1987), presumably because subjects are better able to attend only to the target letter. Increasing distractor spacing should also enhance the relative difficulty of the secondary recall task.

Specifically, target recall would become even easier relative to distractor recall. The amplified differences in the treatment of distractors as a function of context-specific secondary recall task demands could encourage reliance on contextual control.

Experiments 3A, 3B, and 3C were a final attempt to show contextual control over filtering demands induced by the secondary task. In all prior experiments, targets were presented centrally, and distractors were presented five pixels to the left or right. In Experiments 3A and B (straight replication of 3A) distractors were presented 45 pixels to the left or right. In Experiment 3C distractors were placed 180 pixels to the left or right.

Method

Participants. All subjects were recruited from AMT and were compensated $1.50 for participating. For Experiment 3A, 50 HITs were posted and 43 subjects completed all trials. For Experiment 3B, 60 HITs were posted and 55 subjects completed all trials. For Experiment 3C, 50 HITs were posted and 45 subjects completed all trials. Demographic information was collected and is reported in the Appendix.

Apparatus and stimuli. The apparatus and stimuli were similar to Experiment 2C, with the exception that the spacing between targets and distractors was larger. Distractors were placed 45 pixels from targets in 3A and 3B, and 180 pixels from targets in 3C.

Design. The design was identical to Experiment 2C.

Procedure. The procedure was identical to Experiment 2C.

Results

Experiment 3A. All subjects were included in the analysis. The outlier procedure eliminated an average of 3% of RTs from correct trials. The resulting mean RTs and error rates from the blocked and mixed phases were submitted to repeated measures ANOVAs with congruency (congruent vs. incongruent) and memory task (target recall vs. distractor recall) as factors. Mean RTs, *SE*s, error rates and flanker effects for the blocked and mixed phases are presented in Table 5 and 6, respectively.

Blocked practice phase. The main effect of congruency was significant, $F(1, 42) = 104.44$, $MSE = 5247.11$, $p < .001$, $\eta_p^2 = .85$, and the main effect of memory task was significant, $F(1, 42) = 14.5$, $MSE = 20674.94$, $p < .001$, $\eta_p^2 = .26$. These main effects were qualified by a significant interaction between congruency and memory task, $F(1, 42) = 16.54$, $MSE = 14383.15$, $p < .001$, $\eta_p^2 = .28$. As expected, flanker effects were larger in the distractor recall (154 ms) than target recall (72 ms) locations. Mean error rates were less than or equal to .04. For the secondary task, error rates were low overall for the target (.03) and distractor (.05) recall tasks.

Mixed phase. Most important, the critical two-way interaction between congruency and memory task was significant, $F(1, 42) = 5.40$, $MSE = 2584.95$, $p < .025$, $p = .11$. Flanker effects were 36 ms larger in the distractor recall (144 ms) than target recall (108 ms) locations. The main effect of congruency was also significant, $F(1, 42) = 121.65$, $MSE = 5646.07$, $p < .001$, $\eta_p^2 = .74$. Mean error rates were all less than or equal to .04. For the secondary task, error rates were low overall for the target (.03) and distractor (.02) recall tasks.

The significant interaction shows for the first time that attention filtering demands induced by a secondary task can be brought under contextual control. Given that several preceding experiments failed to show this effect, and there might be some worry that the present results are spurious, Experiments 3B (a straight replication of 3A) and 3C were conducted to show that the results can be replicated. Each experiment showed the same pattern of results as above, and the critical Context × Congruency interaction was significant in the mixed phase for both experiments. For brevity, the ANOVAs are for 3B and 3C are not reported; however, the means are reported in Tables 5 and 6.

Discussion

Experiments 3A, 3B, and 3C show that attention filtering demands induced by a secondary task can be brought under contextual control. The major finding was that flanker effects in the mixed phase were modulated in a context-specific fashion, with larger flanker effects in contexts associated with distractor than target recall tasks.

Clearly, the presence or absence of contextual control can depend on subtle task parameters such as the spacing of targets and distractors. One possibility is that increasing distractor spacing further differentiated the attentional requirements for target and distractor processing between contexts, which then allowed contexts to serve as cues for attentional filtering in the primary task. More generally, the combination of positive and null-results hold constraints for understanding how voluntary and contextual control processes jointly coordinate the adjustment of attention filter-

Table 5
Blocked Phase Mean RTs, Error Rates, SEs, and Flanker Effects for Experiments 3A, 3B, and 3C

Blocked phase experiment	Secondary task context: Target recall C	Target recall I	Distractor recall C	Distractor recall I	Flanker effects: Target (I − C)	Distractor (I − C)	Context-specific scores $^D(I-C) - {}^T(I-C)$
3A							
RT	671	742	713	867	72**	154**	82**
SE	23	24	30	47	7	20	20
ER	.02	.04	.02	.04			
3B							
RT	670	734	697	802	64**	105**	41**
SE	19	20	20	22	6	8	9
ER	.02	.04	.02	.03			
3C							
RT	601	637	653	760	37**	107**	70**
SE	18	22	27	40	7	16	14
ER	.02	.03	.01	.03			

Note. RT = reaction time; ER = error rate; C = congruent; I = incongruent; D = distractor; T = target.
* $p < .05$. ** $p < .01$.

Table 6
Mixed Phase Mean RTs, Error Rates, SEs, and Flanker Effects for Experiments 3A, 3B, and 3C

Mixed phase experiment	Secondary task context				Flanker effects		Context-specific scores
	Target recall		Distractor recall		Target	Distractor	
	C	I	C	I	(I − C)	(I − C)	$^{D}(I - C) - {}^{T}(I - C)$
3A							
RT	795	904	785	929	108**	144**	36*
SE	24	29	27	39	12	16	16
ER	.02	.03	.02	.04			
3B							
RT	782	888	802	930	106**	128**	22*
SE	26	26	24	27	7	10	10
ER	.02	.04	.02	.03			
3C							
RT	777	860	752	866	84**	114**	30*
SE	37	37	32	39	11	12	14
ER	.03	.04	.03	.04			

Note. RT = reaction time; ER = error rate; C = congruent; I = incongruent; D = distractor; T = target.
* $p < .05$. ** $p < .01$.

ing demands, and these points are expanded upon in the general discussion.

General Discussion

A secondary memory recall task was validated as a method for modulating flanker effects. With the exception of Experiments 1B and 1C, which did not include a blocked phase, all experiments showed larger flanker effects in blocks containing a distractor versus a target recall task.

The more important question was whether context-specific modulations of the flanker effect would be observed in the mixed phase, where target and distractor recall tasks were paired consistently with the same contextual cues. Experiments 1B and 1C, which did not use a blocked practice phase, and Experiments 2A, 2B, 2C, and 2D, which did use blocked practice phases and also increased contextual support by adding redundant item-specific (2B), and colour and font (2C and 2D) cues, all failed to show context-specific modulation of flanker effects. However, when the spacing between targets and distractors was increased, Experiment 3 successfully demonstrated context-specific modulations of the flanker effect. These results show contextual control of selective attention operations that were directly manipulated by secondary task demands.

Statistical Evidence for the Absence or Presence of Contextual Control

All of the experiments indexed the presence of contextual control by a 2 × 2 interaction between context and congruency in the mixed phase. Experiments 1B, 1C, 2A, 2B, 2C, and 2D, all showed nonsignificant interactions; whereas, Experiments 3A, 3B, and 3C, all showed significant interactions. The *p* values indicate the likelihood that the observed results could be because of chance, but do not estimate the probabilities that the null or alternative hypotheses are more or less likely given the data.

The interpretation of null results can be clarified in a Bayesian framework. For example, Masson (2011) shows how the posterior probabilities of the null or alternative hypothesis being true can be approximated from conventional ANOVA analyses.

Following Masson's method, the probabilities that the null or alternative hypotheses are true were calculated for the 2 × 2 interaction indexing contextual control in each experiment (see Table 7). At the individual experiment level, Experiments 1 and 2 show weak (.5 to .75) to positive (.75 to .95) evidence favouring the null hypothesis; and, Experiments 3A, 3B, and 3C show weak (.5 to .75) evidence favouring the alternative.

However, when Experiments 1 and 2 are grouped together they show positive (.84) evidence in favour of the null; and Experiment 3 shows positive (.88) evidence in favour of the alternative. The Bayesian analysis supports the inference that contextual control failed to occur in Experiments 1 and 2, but did occur in Experiment 3. Moreover, it is worth pointing out that the same general materials, apparatus, design, and procedure were used across experiments, with specific variables varied in a parametric fashion across experiments. With this in mind, the presence of the critical interaction clearly depended on the distractor spacing manipulation. Therefore, the three positive replications in Experiment 3 show

Table 7
Mean Context-Specific Difference Scores With SEs and Bayesian Estimates for All Experiments

Experiment	Context-specific difference scores	*n*	pBIC(H0 ∣ D)	pBIC(H1 ∣ D)
1B	16 (10)	49	.673	.327
1C	5 (5)	21	.777	.223
2A	−2 (9)	46	.868	.132
2B	5 (17)	54	.877	.123
2C	26 (20)	45	.739	.261
2D	−1 (10)	36	.857	.143
All 1–2	8 (6)	251	.842	.158
3A	36 (16)	43	.327	.673
3B	22 (10)	55	.490	.510
3C	30 (14)	44	.432	.568
All 3	27 (9)	142	.119	.881

unambiguous evidence that flanker effects can be controlled by contextual cues associated with attention filtering demands introduced by a secondary task.

Task Parameters and Contextual Control

The present experiments show that attention filtering demands induced by a secondary task can be brought under contextual control, but only when several task constraints are met. For flanker tasks, these could include having subjects receive blocked practice to establish associations between contextual cues and attention filtering demands, enhancing contextual support by including multiple redundant cues such as location, item-specific, colour, and font, and ensuring that distractors are sufficiently spaced from targets. However, the progression of the present experiments prevents any strong conclusions about the necessity of all of these factors. Perhaps widening the spacing between distractors and targets, or extending the practice phase may be sufficient for producing contextual control in the experiments producing null-results. These parametric possibilities are left as a matter for future research.

Further Validation of Web-Based Methods

All of the present experiments were conducted online via Amazon Mechanical Turk. As a result, many factors that would normally be controlled in a laboratory setting were left to freely vary. For example, the size and spacing of flanker letters were described in terms of pixel values rather than visual angle because subjects' web browsers and screens could have rendered the materials differently, and subjects could have been sitting at different distances from the screen. More generally, each subject used a different computer with largely unknown settings, and completed the task on their own time in their own space. This is worth noting because it shows that the positive findings are robust across the kind of natural variation in task environment that could be present when subjects complete the experiment. The experiments were programmed using HTML and JavaScript which offers the capability of "millisecond" timing for stimulus-presentation and response collection; however, absolute accuracy in timing using these techniques may have an error of 20–50 ms (Neath, Earle, Hallett, & Surprenant, 2011). Nevertheless, because these measurement errors are near random, they are expected to average out across multiple observations (Ulrich & Giray, 1989).

Although there are clear limitations to the online methods used here, there are also many benefits, such as access to large samples of subjects from all walks of life, and the ability to conduct studies in a relatively inexpensive and time-efficient manner.

As mentioned earlier, the use of online methods for conducting behavioural research using multitrial designs that require precise timing has been validated in a number of recent studies that replicated several classic cognitive phenomena (Barnhoorn et al., 2014; Crump, McDonnell, & Gureckis, 2013; Schubert et al., 2013; Simcox & Fiez, 2014). The use of online methods holds great potential for building and sharing much larger datasets than would normally be possible using labouratory methods. More important, these data could be tapped in novel ways for testing and developing cognitive theory (Griffiths, 2015).

Explaining Contextual Control Effects

General memory account of contextual control. A global aim was to test a general memory account of contextual control over selective attention. On that view, contextual control is acquired from the history of context-specific control operations. Prior work from the proportion congruent literature showed evidence of contextual control, but was not clear on the nature of the control operations taking place within contexts during learning. The present experiments were designed to directly manipulate selective attention demands between different contexts, and then supply subjects with experiences in each to determine whether contextual cues would trigger associated selective attention operations. Experiments 3A, 3B, and 3C all showed evidence of contextual control over flanker effects as predicted; but, the preceding experiments did not.

The positive evidence for contextual control points to the generality of the phenomenon. Specifically, procedures borrowed from the proportion congruent literature were capable of showing contextual control even though the vehicle (i.e., secondary memory task vs. proportion congruent) for establishing different histories of context-specific control operations was changed. One important aspect of the extension is that the present evidence of contextual control cannot be explained by learning processes sensitive to item, or stimulus-response frequency. Many proportion congruent effects can be explained by a stimulus-response learning process (Schmidt & Besner, 2008), because item-frequency is often confounded with the proportion congruent manipulation. The present designs did not vary proportion congruent, and all items and responses appeared with equal frequency in all experiments. Thus, a frequency learning account cannot explain the present results.

The failures to observe contextual control suggest that presence or absence of contextual control can depend on the presence or absence of other forms of control. Although having a history of completing selective attention demands in a context specific manner may be a necessary prerequisite for contextual control, history alone is not a sufficient condition. These points, along with other accounts of contextual control phenomena are elaborated upon in the following sections.

Voluntary control. Selective attention operations may be controlled by higher level voluntary processes or lower-level stimulus-driven processes (Bugg, 2012; Bugg & Crump, 2012; Egner, 2008). The distinction between levels raises questions about whether a particular phenomenon reflects a voluntary or stimulus-driven process, and whether both levels jointly participate in the control of selective attention.

In item-specific and context-specific proportion congruent designs, it is possible that subjects become aware of the associations between particular stimuli and their attention filtering demands, and voluntarily switch between different attention sets at the time of target onset. As discussed in the introduction, this account does not explain prior CSPC effects where subjects were shown to be unaware of the CSPC manipulation (Crump et al., 2006, 2008). In the present experiments subjects were not asked if they were aware that secondary memory task demands were consistently paired with each location, and it is assumed that they were aware. Therefore, it is possible that subjects maintained two attentional control sets and rapidly deployed them upon target onset in a particular location. However, this view does not explain why location-

Table 8
Mixed Phase Mean Reaction Times, SEs, and Flanker Effects for Sequential Analyses of Experiment 3

Experiments 3A, 3B, and 3C	Secondary task context				Flanker scores		Context-specific scores
	Target recall		distractor recall		Target	distractor	
Context N−1	C	I	C	I	(I − C)	(I − C)	$^{D}(I{-}C) - {}^{T}(I{-}C)$
Same							
RT	734	819	740	860	85**	120**	35**
SE	14	15	14	16	7	6	7
Different							
RT	809	914	806	921	105**	115**	10
SE	17	18	18	20	8	7	9

Note. RT = reaction time; SE = standard error; C = congruent; I = incongruent; D = Distractor; T = Target.
* $p < .05$. ** $p < .01$.

contingent voluntary switching of strategies occurred in Experiments 3A, 3B, and 3C, but not in the previous experiments.

Another issue is whether voluntary sources of control can override contextual influences. Experiments 1 and 2 showed no context-specific modulations to flanker effects in the mixed blocks. In these cases flanker effects in all contexts were generally large, suggesting that subjects applied the attention filtering demands of the distractor recall task to processing of all flanker items, regardless of context. On this view, a voluntary process responsible for maintaining secondary task demands could have taken precedence as a source of control over selective attention operations. However, the findings of Experiment 2D addressed this possibility by showing that removal of secondary task demands in the mixed phase was not sufficient for demonstrating context-specific modulations to the flanker effect. Moreover, the fact that flanker effects were usually not modulated by context is consistent with the view that despite any best efforts, voluntary processes generally failed to apply different attentional sets in each context.

Priming of control. A general memory hypothesis of contextual control suggests that selective attention operations from the past can be retrieved to influence selective attention operations in the present. Borrowing again from the proportion congruent literature, contextual control could be driven primarily by recent past events. For example, according to the priming of control account (King et al., 2012) attention filter settings from the most recently completed trial can carry forward and "prime" attention filter settings in the present.

A sequential analysis of the combined results of Experiment 3 (A, B, and C) was conducted to determine whether context-specific modulation to the flanker effect depended on context repetition from trial to trial. A 2 (Trial N-1 Context: Same vs. Different) × 2 (Trial *N* Context: Target vs. Distractor Recall) × 2 (Congruency: Congruent vs. Incongruent) repeated measures ANOVA was conducted on the mean RTs from each subject in each condition. The means are displayed in Table 8.

The Context × Congruency interaction was significant, $F(1, 141) = 13.64$, $MSE = 2439.48$, $p < .001$, $\eta_p^2 = .09$; but was qualified by a significant three-way interaction between Trial N-1 Context, Context, and Congruency, $F(1, 141) = 5.09$, $MSE = 2123.79$, $p < .025$. The three way-interaction was interpreted by separate 2 × 2 repeated measures ANOVAs with Context and Congruency as factors for trials where trial n-1 context was the same or different.

When the trial n-1 context was the same as trial n, the Context × Congruency interaction was significant, $F(1, 141) = 24.81$, $MSE = 1652.36$, $p < .001$, $\eta_p^2 = .15$. Flanker effects were larger in the distractor (120 ms) than target (85 ms) recall locations.

However, when the trial n-1 context was different from trial n, the Context × Congruency interaction was not significant, $F(1, 141) = 1.06$, $MSE = 2910.92$, $p < .305$, $\eta_p^2 = .007$. The trend in the means was for larger flanker effects in the distractor (115 ms) than target (105 ms) recall locations.

The sequential analysis shows that context-specific modulation of the flanker effect was only obtained when contexts were repeated immediately on successive trials. An immediately preceding trial could bias current selective attention operations prospectively or retrospectively. A prospective influence refers to persisting attentional states that carry-forward from trial n-1 to trial n. A retrospective influence refers to recency biases at retrieval that increase the likelihood that settings from trial n-1 rather than more remote trials trigger adjustments on trial n. It is noteworthy that the sequential influences were not symmetrical. If a prospective influence simply involved applying trial n-1 settings to trial n, then the Context × Congruency interaction on trial n-1 different trials would have been reversed, with larger flanker effects in the trial *n* distractor location (preceded by target recall) than the trial *n* target location (preceded by distractor recall). Instead, the data are more consistent with a retrospective influence, whereby contextual cues gate whether or not recent attention filters adjust current performance. The fact that contextual control in this instance depended on the match between trial n-1 and trial *n* contextual cues does not rule out the general memory hypothesis, and a worthwhile project for future work is to further specify the conditions under which cue-driven retrieval processes reinstate attentional control settings from recent or remote past events.

Competing cues and contextual control. The general memory account suggests that any cue associated with past attentional control states could become a source of contextual control. As a result, contextual influences could depend on interactions or competitions between different cues, potentially associated with different attentional control states.[1] The notion that a stimulus compound, or conglomeration of cues, can trigger control operations has received ample support in studies of task-switching. Similar to the present work, a number of studies show that task-switching costs can be reduced when contextual cues (e.g., location) are associated with specific tasks (Mayr & Bryck, 2007), or the probability with which tasks-repeat (Crump & Logan, 2010; Leboe et al., 2008). As well, task-sets can be associated to particular

[1] Thanks to Mike Masson for pointing out this interpretation.

features of a stimulus compound (Allport & Wylie, 2000; Koch & Allport, 2006; D. W. Schneider & Logan, 2005; Waszak et al., 2003). Therefore, parts of a stimulus and its context can all serve as cues for reinstating prior control operations.

The presence of multiple competing cues for controlling selective attention could also explain the presence and absence of context-specific modulations to the flanker effect across Experiments 1. For example, in addition to location (and font, colour, etc.), the flanker stimuli themselves could cue associated attentional control sets. In particular, the target stimulus could become associated with the secondary task requirement for target recall, and the distractor stimuli could become associated with the secondary task requirement for distractor recall. As a result, early processing of distractors could generally cue a wide attentional set appropriate for later distractor recall. Furthermore, it is possible that distractor letters were a stronger cue for attentional control than their contextual counterparts. This would explain the absence of context-specific modulation of flanker effects in Experiments 1 and 2, and the generally large flanker effects that were observed there. A manipulation that reduced initial distractor processing, such as the manipulation of distractor-to-target distance in Experiment 3, would also reduce the potency of distractor-based cuing of attentional control, perhaps allowing contextual cues to exert a measurable influence.

Cuing specific filtering settings or a general need for selection? What is the form of attentional processing reinstated by context cues? One possibility is that context cues retrieve specific attention filter settings (Bundesen, 1990) tailored for the attention demands inherent to those contexts on past occasions. For example, the target recall task is assumed to narrow spatial attention filters toward the central location of the target, whereas the distractor recall task was assumed to widen spatial attention filters to encompass more information about the distractor letters.

Another possibility is that contextual cues trigger adjustments to attention in a more general fashion. For example, contexts may cue the overall need for selective attention. This view distinguishes between two attentional modes: a default mode, and a selective mode. The default mode refers to going-with-the-flow of the stimuli and task at hand. Here, stimuli are assumed to provide their own set of affordances and prepotent responses. The selective mode refers to situations where selective attention processes are required during online performance to filter irrelevant information and prepotent responses from controlling performance.

To interpret the positive results of Experiment 3A, 3B, and 3C, it is assumed that increasing the distance between targets and flankers made the default mode of processing a viable option for responding quickly and accurately in the task. Subjects would be less likely to initially attend to the distracting letters because they would fall outside of their default focus of spatial attention. On this view, contextual cues associated with the target recall task could simply have triggered the default mode, or an absence of the requirement to selectively attend. Similarly, contextual cues associated with the distractor recall task could have triggered the need to shift out of the default mode, thereby engaging a need for selective processing.

The idea that contextual control could trigger general aspects of attentional processing is again consistent with findings in the task-switching literature where contextual cuing of specific and general aspects of attentional control has been shown.

For example, location contexts associated with specific task-sets can reduce switch costs (Mayr & Bryck, 2007). As well, location contexts associated with a high or low proportion of task-switching (and not specific tasks) can also modulate switch costs (Crump & Logan, 2010; Leboe et al., 2008). The latter finding shows that contexts can trigger something more general about the requirement to maintain or switch a particular task-set. Whether the present evidence of contextual control involves cuing of specific attention sets or general attention requirements remains an open question.

Conclusions

Current research into cognitive control shows that control processes operate on a continuum spanning voluntary and cue-driven levels (Bugg, 2012; Bugg & Crump, 2012; Chun & Turk-Browne, 2007; Egner, 2008; Hutchinson & Turk-Browne, 2012). Evidence that control processes can be cue-driven, rather than purely voluntary in nature, has been gleaned from a wide variety of paradigms in attention and performance. These include the present work, the literature on proportion congruent effects, as well as numerous other domains. For example, visual search can be guided by contextual cues (Chun & Jiang, 1998); and low-level attention phenomena such as capture by feature singletons (Theeuwes, 1992) can be controlled by contextual cues (Cosman & Vecera, 2013). Several attention phenomena initially thought to operate on a transient short-term basis also operate on a memory-driven long term basis, including negative priming, inhibition of return (Tipper, Grison, & Kessler, 2003), priming of pop-out (Thomson & Milliken, 2013), response inhibition (Verbruggen & Logan, 2008), and task-switching costs (Waszak et al., 2003). Thus, the general notion that stimuli can be associated with and trigger their own attention filtering demands is broadly supported by evidence across paradigms.

Within attention the identification of multiple levels of control calls for more work on how different levels jointly participate in control operations. As well, the many lines of evidence for cue-driven control of attention could point to a class of related phenomena that operate according to similar general principles. Perhaps this class even shares fundamental relationships with cue-driven phenomena outside of attention. A broader project moving forward is to synthesize features of contextual control inside and outside of attention and evaluate the prospects of integrating phenomena-specific accounts into a general process theory.

Résumé

De multiples sources de données puisées dans la documentation sur l'attention et le rendement démontrent que le filtrage de l'attention peut être contrôlé par la mise en œuvre de processus volontaires conscients et de processus plus subtils axés sur des signaux (voir les études récentes suivantes : Bugg, 2012; Bugg & Crump, 2012; Egner, 2008). Les expériences ont été conçues dans le but de vérifier l'hypothèse générale selon laquelle le contrôle axé sur les signaux évolue grâce à des gestes antérieurs d'attention sélective propres au contexte. Plusieurs études avec distracteurs sur le Web ont été réalisées par l'intermédiaire du site Amazon Mechanical Turk. Les demandes de filtrage de l'attention étaient induites par une demande secondaire de rappel du dernier élément après chaque rappel d'essai de la dernière cible ou lettre de distraction. Le fait de bloquer les demandes de rappel faisait en sorte que la source de distraction produisait des effets plus importants que les conditions de rappel cibles. Le fait de mélanger les demandes de rappel et de les associer à des signaux stimuli (emplacement, couleur, lettre et police) se traduisait parfois par un contrôle rapide et contextuel de l'interférence indirecte, alors que d'autres fois ce n'était pas le cas. Les résultats démontrent que de subtils paramètres méthodologiques peuvent influer sur la possibilité d'observer ou non un contrôle contextuel. D'une manière plus générale, les résultats indiquent que le phénomène de contrôle contextuel peut être influencé par d'autres sources de contrôle, notamment des sources axées sur des signaux qui entrent en compétition pour le contrôle.

Mots-clés : attention sélective, apprentissage, mémoire, contrôle contextuel.

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Appendix

Subject Self-Report Demographics for Each Experiment Experiment

	1A	1B	1C	2A	2B	2C	2D	3A	3B	3C
Country										
USA	.35	.08	.10	.35	.33	.42	.94	.58	.98	.82
India	.50	.78	.71	.41	.46	.53	.03	.42	.00	.14
Other	.16	.14	.19	.24	.20	.04	.03	0	.02	.05
Gender										
Female	.42	.41	.33	.43	.44	.38	.42	.56	.59	.34
Male	.57	.57	.62	.52	.54	.60	.58	.44	.38	.66
Age										
Mean	35	33	37	32	32	35	33	35	40	33
Min	20	20	25	20	20	20	20	25	25	20
Max	65	65	70	60	55	70	50	70	65	60
Hand										
Both	.06	.08	.14	.11	.07	.13	0	.12	.07	.02
Left	.10	.04	.05	.04	.06	.09	.06	.05	.09	.20
Right	.83	.86	.76	.83	.87	.76	.94	.84	.83	.77
Vision										
Corrected	.47	.27	.33	.52	.33	.31	.61	.44	.62	.48
Normal	.51	.69	.57	.43	.61	.69	.31	.53	.36	.48
Other	.01	.02	.05	.04	.04	0	.08	.02	.02	.02
English										
First	.53	.41	.24	.48	.52	.71	.92	.70	.97	.89
Second	.45	.57	.71	.52	.44	.29	.08	.30	.02	.11
Other	.02	.02	.05	0	.04	0	0	0	0	.02

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