Erroneous and veridical recall are not two sides of the same coin: evidence from semantic distraction in free recall

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Erroneous and Veridical Recall Are Not Two Sides of the Same Coin: Evidence From Semantic Distraction in Free Recall

John E. Marsh[1,2], Robert W. Hughes[3], Patrik Sörqvist[2,4], C. Philip Beaman[5] & Dylan M. Jones[6]

[1]School of Psychology, University of Central Lancashire, Preston, Lancashire, UK.

[2]Department of Building, Energy, and Environmental Engineering, University of Gävle, Gävle, Sweden.

[3]Department of Psychology, Royal Holloway, University of London, Egham, UK.

[4]Linnaeus Centre HEAD, Swedish Institute for Disability Research, Linköping University, Linköping, Sweden.

[5]School of Psychology and Clinical Language Sciences, University of Reading.

[6]School of Psychology, Cardiff University, Cardiff, UK.

RUNNING HEAD: Erroneous and Veridical Recall

Correspondence: John E. Marsh, School of Psychology, Darwin Building, University of Central Lancashire, Preston, Lancashire, United Kingdom, PR1 2HE.

Phone (+44) 1772 893754, Fax (+44) 1772 892925

E-mail: JEMarsh@uclan.ac.uk

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Abstract

Two experiments examined the extent to which erroneous recall blocks veridical recall using, as a vehicle for study, the disruptive impact of distractors that are semantically similar to a list of words presented for free recall. Instructing participants to avoid erroneous recall of to-be-ignored spoken distractors attenuated their recall but this did not influence the disruptive effect of those distractors on veridical recall (Experiment 1). Using an externalised output-editing procedure—whereby participants recalled all items that came to mind and identified those that were erroneous—the usual between-sequence semantic similarity effect on erroneous and veridical recall was replicated but the relationship between the rate of erroneous and veridical recall was weak (Experiment 2). The results suggest that forgetting is not due to veridical recall being blocked by similar events.

Keywords: Erroneous Recall, Veridical Recall, Blocking, Semantic Distraction, Forewarning, Externalised Free Recall, Source Monitoring.

Many classical and contemporary theories of memory conceive of the process of retrieval as one of discriminating between targets and similar but task-irrelevant events, whether those irrelevant events were actually experienced or internally generated via their association with experienced events (Goh & Lu, 2012; Hunt, 2003; Nairne, 2006; Poirier, Nairne, Morin, Zimmermann, Koutmeridou, & Fowler, 2012; Roediger & McDermott, 1995; Smith, Ward, Tindell, Sifonis, & Wilkenfeld, 2000; Watkins & Watkins, 1975; Wickens, Born, & Allen, 1963). Thus, the ability to retrieve information on the whereabouts of a car parked earlier in the day, for example, is a direct function of the extent to which, at retrieval, memory for that event is distinguished from memories of other similar but goal-irrelevant events and hence ones that are likely to cause interference (e.g., where the car was parked the day before; see M. C. Anderson & Neely, 1996). One widely-invoked mechanism to explain such interference-at-retrieval is *associative blocking* whereby the perseverative erroneous recall of retrieval-cue-matching but ultimately inappropriate events impairs access to the target event (Kimball & Bjork, 2002; Raaijmakers & Jakab, 2012; Rundus, 1973; Spitzer & Bäuml, 2009). In the present article, we examine whether veridical recall is indeed determined by the tendency for (covert or overt) erroneous recall to block access to target representations by systematically overtaxing the discrimination-at-retrieval process: we present, during the encoding phase of a free recall task, distractor items drawn from the same semantic category as a list of (visually-presented) memoranda and ones that would therefore be expected to interfere at retrieval. A critical empirical feature of the setting for present purposes is that such distractors result not only in erroneous recall of the distractors (or ‘intrusions’) but also a reduction in veridical free recall (Beaman, 2004; Beaman, Hanczacowski, Hodgetts, Marsh, & Jones, 2013; Bell, Buchner, & Mund, 2008; Marsh, Hughes, & Jones, 2008; Neely & LeCompte, 1999; Sörqvist, Marsh, & Jahncke, 2010). This double-impact of between-sequence semantic similarity (B-SSS) is exploited here as a means of examining whether veridical recall is impaired as a function of blocking by similar-but-irrelevant events.

That the failure of recall—or forgetting—is due to the erroneous recall of retrieval-cue-matching but contextually-inappropriate events blocking access to target events has long been a key explanatory construct in memory theory (J. R. Anderson, 1983; Mensink & Raaijmakers, 1988; McGeoch, 1942; Rundus, 1973; for an extended discussion, see M. C. Anderson & Neely, 1996). To take just two classic examples of the application of the blocking construct, in a typical paired-associate learning procedure, unrelated pairs of words (e.g., *dog-rock*) are studied and then presented in a later memory test whereby the cue *dog* can elicit the relevant target response *rock*. If, in the interim between study and test, re-pairings are studied (e.g., *dog-sky*), such that two responses now share a retrieval cue (both *rock* and *sky* associated with the cue *dog*), this new learning interferes with memory for initial pairings (*dog-rock;* e.g., Postman, 1971). On the blocking account, this instance of retroactive interference results from the perseverative (covert or actual) erroneous recall of the competing response (i.e., *sky*) blocking retrieval of the target *rock* (e.g., Keppel, 1968; Postman, 1961; Postman & Underwood, 1973; Rundus, 1973). A second phenomenon for which a blocking account has been frequently be deployed is part-set cuing inhibition. Here, a list of words from each of several (e.g., semantic) categories is presented. If some of the exemplars from a studied category are provided as cues at test, recall of noncued exemplars of that category is impaired (relative to when no cues are given; Basden, Basden, & Galloway, 1977; Todres & Watkins, 1981). On the blocking account, cueing strengthens the association between the cued exemplars and the relevant category relative to the association between the category and the non-cued exemplars. This relative strength-advantage for cued exemplars results in those items intruding persistently, thereby blocking the retrieval of non-cued items (Rundus, 1973; see also Kimball & Bjork, 2002; Raaijmakers & Jakab, 2012; Rosen & Engle, 1997; Spitzer & Bäuml, 2009).

However, in all the foregoing cases, the inference that recall of the contextually-inappropriate item causes the failure to retrieve the target item is indirect and hence not empirically verifiable. For instance, in the paired associate learning paradigm, when a second-pair response intrudes, it cannot be determined with certainty that the intrusion was the cause of the failure to recall the first-pair response. Similarly, in part-set cuing inhibition, there is no direct evidence that cued items are indeed covertly recalled perseveratively or, even if they are, that this causes the impairment in the recall of non-cued items. In each case, the accessibility of the desired item(s) may be reduced for reasons other than erroneous recall of the competing item(s) (see M. C. Anderson & Neely, 1996). Indeed, the indirect nature of the evidence for associative blocking has meant that phenomena that have classically been attributed to blocking have been readily amenable to non-blocking type accounts (M. C. Anderson, 2003; M. C. Anderson & Neely, 1996; Huddleston & M. C. Anderson, 2012; Hulbert, Shivde, & M. C. Anderson, 2012). For example, part-set cueing inhibition has been explained without recourse to blocking by supposing that the provision of cues leads to the abandonment of a whole-list retrieval strategy in favor of a less effective part-list retrieval strategy (Basden & Basden, 1995; for an alternative non-blocking account, see Bäuml & Aslan, 2004). Similarly, retroactive interference in the paired-associate learning paradigm has been reascribed to a process in which competing items trigger a competitor-inhibition process which incurs an overhead cost for concurrent target recall as well as impaired subsequent retrieval of inhibited items (e.g., M. C. Anderson, 2003; M. C. Anderson & Neely, 1996; see also Postman, Stark, and Fraser's (1968) notion of response-set suppression).

What is required, therefore, to address the fundamental question of whether erroneous recall determines the probability of veridical recall is a setting in which the rates of erroneous and veridical recall are both directly observable and, in principle, free to vary orthogonally so that any relation that might exist between them can be observed. At first glance, the classic Deese/Roediger-McDermott (DRM) paradigm seems to meet this objective. In this paradigm, when a list of items (e.g., *bed, tired, snore…*) is presented, all associated with a critical, non-presented, word (e.g., *sleep*), participants tend to erroneously recall that critical lure (Deese, 1959; Roediger & McDermott, 1995). Thus, the rate at which the critical lure is erroneously recalled can be measured independently of the rate of recall for the target items and hence the relation between them is also, in principle, discernible. However, the DRM procedure is likely to be too blunt a tool for addressing our question because only the erroneous recall (or not) of just one critical lure is measured in this case. Indeed, this may account for why a variety of erroneous-veridical recall relations have been observed in this setting, with some studies showing dissociations between rates of erroneous and veridical recall—i.e., the absence of any relation—such as a reduction in erroneous recall in the absence of any change in the rate of veridical recall (Hanczakowski & Mazzoni, 2011; McCabe & Smith, 2006; Schacter et al., 1999) or veridical recall varying independently of erroneous recall (Schacter, Verfaellie, & Pradere, 1996; McEvoy & Nelson, 1998; Norman & Schacter, 1997). However, these results are inconclusive since other studies have shown a negative correlation between veridical and erroneous recall (e.g., McDermott, 1996), and still others have shown a positive correlation (e.g., Payne, Elie, Blackwell, & Neuschatz, 1996; Toglia, 1999).

In the present study, therefore, we use a distraction procedure in which multiple ‘lures’ can potentially be erroneously recalled during a free recall task so as to promote the chances of observing a relation between erroneous and veridical recall if one exists. In the typical semantic distraction study (e.g., Marsh et al., 2008), participants view a visually-presented list of items that are members of the same category (e.g., Furniture: *chair, desk, wardrobe*…) and are asked to recall them in any order when presented with a ‘recall’ prompt.

To-be-ignored spoken words (distractors)—that are either taken from the same semantic category as the targets (e.g., "table, sofa, bookshelf…") or from a different semantic category (e.g., Professions: "nurse, secretary, carpenter...")—are presented concurrently with the list of targets (or, in some studies, during a retention interval between the last target and a recall cue; e.g., Marsh et al., 2008). Despite explicit instructions to ignore the distractors and to avoid guessing at recall, B-SSS exerts two deleterious effects on performance. First, erroneous recall—or extra-list intrusions—are increased: words presented as semantically-similar distractors are erroneously recalled at a greater rate than spontaneous erroneous recall of those words (i.e., when those words are not presented as distractors; Beaman, 2004; Bell et al., 2008). Second, B-SSS impairs the recall of target items (i.e., reduced veridical recall). One interpretation of these two effects is that they reveal the action of associative blocking: it is the erroneous recall of the distractors that directly causes the disruptive effect of those distractors on veridical recall (Beaman et al., 2013; Hanczakowski et al., 2012). The starting point for this blocking account is the uncontroversial notion that in settings in which target-items are related to one another (e.g., by semantic category) the shared categorical information is used as a retrieval cue (Deese, 1959; Roediger & McDermott, 1995).[1] The B-SSS effects occur because in the semantically-related condition the distractors also match the cue. This distractor-cue match, coupled to the fallibility of the capacity to discriminate the environmental source of those items (e.g., auditorily- as opposed to visually-presented, e.g., Johnson, Hashtroudi, & Lindsay, 1993; Roediger, Balota, & Watson, 2001), leads to those items being retrieved as potential (but inappropriate) candidates for output. Such erroneous

[1] Whilst there was an initial suggestion that the false recalls generated from associatively structured lists and categorically structured lists are underpinned by two distinct monitoring mechanisms, one operable at study (for associatively structured lists) and one operable at test (for categorically-structured lists; Smith, Gerkens, Pierce, & Choi, 2002), false recall for both list structures is similarly modulated by factors such as modality of presentation (Pierce, Gallo, Weiss, & Schacter, 2005), blocking of items at study and instruction to generate associates (Dewhurst, Bould, Knott, & Thorley, 2009). This coheres with the notion that "associative illusions" in the DRM procedure constitute a reflection of semantic gist processing (e.g., Brainerd, Yang, Reyna, Howe, & Mills, 2008; see also Knott, Dewhurst, & Howe, 2012).

retrieval of distractor-items simultaneously blocks the retrieval of target items, thereby leading also to a decrease in veridical recall. Recent support for the blocking account comes from the finding that a single factor can beneficially affect both erroneous and veridical recall in this setting. For example, using a version of the semantic distraction paradigm in which both targets and distractors were spoken, Beaman et al. (2013, Experiment 1) found that promoting the capacity to discriminate perceptually between the targets and related distractors by presenting them in different voices—targets in a male voice and distractors in a female voice as opposed to all in the same voice—resulted both in fewer erroneous recalls and less impairment of veridical recall.

However, such co-variation of erroneous and veridical recall does not necessarily indicate that the B-SSS effects are underpinned by a single, blocking, mechanism. Other studies have shown dissociations between erroneous and veridical recall in this context: Erroneous recall is reduced markedly when the related distractors are presented during a retention interval between the last target and a recall cue but this has relatively little effect on veridical recall (Marsh et al., 2008; Sörqvist et al., 2010). Furthermore, older adults show a more pronounced B-SSS on erroneous recall compared to younger adults but not on veridical recall (Bell et al., 2008). Finally, there is no correlation—either positive or negative—between the extent to which an individual shows a B-SSS on erroneous recall and the extent to which that individual shows a B-SSS on veridical recall (Marsh et al., 2008).

Such dissociations between erroneous and veridical recall are more consistent with a two-mechanism account of the impact of B-SSS (e.g., Marsh et al., 2008) and hence, by extension, with the view that erroneous recall per se is not a major determinant of veridical recall. On this account, whereas the increase in erroneous recall is again attributed to use of a semantic-category cue at retrieval coupled with poor source-discrimination (as in the single-mechanism account), the impairment of veridical recall is thought to be causally unrelated to erroneous recall. Specifically, one prominent suggestion is that impaired veridical recall reflects competition from the distractors at the point of their presentation (hereafter: *immediate competition*) rather than the retrieval of those distractors as potential output candidates at test: Semantically-related distractors interfere with the semantic-based encoding and organization processes that are pressed into action to support the later retrieval of the target-items (Marsh et al., 2008, 2009). Some of the impairment of veridical recall may also be attributable to an overhead cost of inhibiting the distractors as they occur: By this view, the inhibition of a competitive (i.e., semantically-related) distractor spreads via a semantic network (e.g., Neumann & DeSchepper, 1992) to semantically related targets thereby reducing the probability of veridical recall (Marsh, Beaman, Hughes, & Jones, 2012; Marsh et al., 2008, 2009; Marsh, Sörqvist, Hodgetts, Beaman, & Jones, 2014). Support for this immediate competition view comes from a recent study by Marsh et al. (2012) using a negative priming procedure (e.g., Tipper, 1985): If the target items on trial n are the same as the semantically-related (and hence competitive) distractors on trial $n – 1$, veridical recall is poorer than when there is no relation between the distractors and targets across the two trials (see also Marsh et al., 2014). Based on the inhibitory account of negative priming (e.g., Tipper, 2001), this reduction in veridical recall reflects the fact that the target items had recently been inhibited due to their offering immediate competition as distractors on the previous trial.

In the present study, we address the question of whether erroneous recall determines the probability of veridical recall by seeking to determine definitively whether appealing to a single (e.g., blocking) mechanism is sufficient to explain the impact of B-SSS on both erroneous and veridical recall (Beaman et al., 2013; Hanczakowski et al., 2012) or whether, instead, some other mechanism must be invoked to explain the reduction in veridical recall (regardless of the specific nature of that second mechanism). To preview the logic of the present series, in Experiment 1 we introduce for the first time into the semantic distraction setting a technique used previously in the context of the DRM false memory paradigm (Deese, 1959; Roediger & McDermott, 1995): We warned participants about the tendency for erroneously recalling items presented as distractors. In line with a dual-mechanism account, we will show that whereas forewarning reduces the impact of B-SSS on erroneous recall, it leaves its impact on veridical recall unaffected. In Experiment 2, we go on to test a possibility that could potentially provide a reprieve for the blocking account: We examine whether the reliance on measuring *overt* erroneous recall in the standard free recall protocol used in Experiment 1—as well as all previous semantic distraction/free recall studies (e.g., Beaman, 2004; Beaman et al., 2013; Bell et al., 2008; Marsh et al., 2008; Sörqvist et al., 2010)—might obscure an actual relation between erroneous and veridical recall. Specifically, many instances of erroneous recall may be edited out just prior to overt output—and hence remain undetected in the standard procedure—and at a point at which they could have already exerted their negative impact on veridical recall. In Experiment 2, therefore, we will examine whether, in the usual free recall procedure, *covert* instances of erroneous recall in the face of B-SSS might underpin the impairment of veridical recall.

Experiment 1

Providing a forewarning about erroneous recall of the critical lure in the DRM procedure reduces such erroneous recall (Hicks & Marsh, 1999; Gallo, Roberts, & Seamon, 1997; Gallo, Roediger, & McDermott, 2001; McDermott & Roediger, 1998; Neuschatz, Lynn, Benoit, & Payne, 2003; Watson, Bunting, Poole, & Conway, 2005). Whilst this reduction does not affect veridical recall, as discussed above, it would be unsafe to infer from this dissociation that erroneous recall does not dictate veridical recall generally given the likely insensitivity of the single-lure design of the DRM task in relation to this issue. For example, the possibility of finding a statistically significant correlation between erroneous recall and veridical recall—negative or positive—is undermined by the low number of critical lures that can possibly be recalled in this paradigm. In Experiment 1, therefore, we introduced a forewarning manipulation in the context of the semantic distraction (‘multiple-lure’) setting, which is methodologically sounder that the DRM paradigm for investigating the particular research question of concern here. The blocking account would posit that any reduction in erroneous recall of the distractors by the provision of a forewarning should also exert a facilitative effect on veridical recall (Beaman et al., 2013; Hanczakowski et al., 2012). In contrast, according to a two-mechanism account (e.g., Marsh et al., 2008), the B-SSS effect on veridical recall should be independent of the degree to which the warning reduces erroneous recall, because these components are argued to be underpinned by two distinct mechanisms.

Method

Participants. Forty eight students at the University of Central Lancashire participated for £6 each. All were native English speakers and reported normal or corrected-to-normal vision and normal hearing. The participants were randomly divided into two 24-participant groups: Warning and No Warning.

Materials and Design. The experiment was run using E-Prime software. Each participant received 18 trials in which they were visually-presented with 15 to-be-remembered words (targets) all drawn from a single semantic category. Auditory distractors were presented synchronously with the targets. Distractors were either all drawn from the same category as the targets or all drawn from a different category.

Targets appeared centrally on the computer screen in black 72-point Times font on a white background at a rate of one every 1.5s (750ms on, 750ms inter-stimulus interval; ISI). Distractors were presented over stereo headphones at 65dB(A) and at a rate of one every 1.5s (750ms on, 750ms ISI). The distractors were digitally recorded in a male voice at an evenpitch and sampled with a 16-bit resolution at a sampling rate of 44.1 kHz using Sound Forge 5.

Fifteen words were chosen from each of 36 semantic categories taken from the Van Overschelde, Rawson and Dunlosky (2004) category norms. Items from odd-ranked positions in the category-norm lists were assigned to the target lists and items from even positions were distractors. The 36 selected categories were first arranged into pairs of unrelated categories (e.g., “Fruit-Carpenter’s Tools”). There was one experimental block of 18 trials: 9 related and 9 unrelated. On the related trials, the auditory distractors were taken from the same category as the targets. On unrelated trials, the distractors were taken from the semantically-unrelated category (e.g., “Fruit”) that was paired with the target category (“Carpenter’s Tools”).

The presentation order of exemplars within each to-be-remembered and distractor sequence was random but identical for each participant. Half received a semantically-related trial first followed by a semantically-unrelated trial (with trials alternating thereafter between related and unrelated). This order was reversed for the other half of the participants. Categories were assigned such that, across participants, there was an equal likelihood of each category appearing in the unrelated or related condition.

Procedure. Participants were tested individually in soundproof booths and were seated at a distance of approximately 60 cm from the PC monitor. Participants wore headphones throughout the experiment. Participants began by reading standardized instructions and were told specifically that they should ignore the distractor words, that they would not be asked anything about them during the experiment, and to focus on memorizing the visually presented items. The target words were presented one at a time on the computer screen. After all 15 targets had been presented the prompt “recall” appeared on the screen. Participants then had 60 s to recite, in any order, as many of the target words as they could remember. Participants’ oral responses were recorded via microphone input into Audacity software (SourceForge). Pressing the space-bar initiated presentation of the next list. One practice trial (in quiet) was given at the start of the experiment.

Participants in the *Warning* group were told that on some of the trials the distractor words would be semantically related to the to-be-recalled words and that these trials were designed to elicit erroneous recalls of the distractor words which were never presented visually and hence never task-relevant. Participants were encouraged to avoid outputting any distractor words. The instructions were made more concrete by the presentation of a trial in which an example category (written color-words) were presented as to-be-recalled and distractor words and the participants were told during test which items were the to-be-recalled were and which were the distractor words. Hence, if warned participants suspected that an available word had an auditory origin, it would be veridical to distinguish and withhold this word during free recall.

Results

Erroneous recall. A response that matched one of the fifteen items from the even positions in the Van Overschelde et al. (2004) norms (that were presented as distractors on related trials) was scored as an intrusion (i.e., erroneous recall). The same was also done for the unrelated condition (in which those items were not presented); this measure of the ‘spontaneous’ erroneous recall of these items when not actually presented provides the most appropriate baseline for assessing the extent to which erroneous recall is exacerbated by the actual presentation of the distractor items (see Beaman, 2004; Marsh et al., 2008). Figure 1 (Panel A) shows the mean number of intrusions for each condition. The rate of erroneous recall was clearly greater in the related compared to unrelated condition but this difference was attenuated dramatically in the Warning group.

A 2 (Warning) × 2 (Target-Distractor Relation) ANOVA of the intrusion data revealed a main effect of Target-Distractor Relation, $F(1, 46) = 50.25$, $MSE = 3.95$, $p < .001$,

η_p^2 = .52, a main effect of Warning, $F(1, 46) = 5.83$, $MSE = 12.60$, $p = .02$, η_p^2 = .113, and a significant interaction between these two factors, $F(1, 46) = 14.45$, $MSE = 3.95$, $p < .001$, η_p^2 = .24. A simple effects analysis (LSD) revealed that intrusions were more frequent in the related condition than in the unrelated condition for both the No Warning ($p = .025$; $CI_{.95}$ = .179, 2.49) and Warning ($p < .001$; $CI_{.95}$ = 3.26, 5.57) groups. More importantly, the Warning group produced significantly fewer intrusions in the related condition compared to the No Warning group ($p = .002$; $CI_{.95}$ = 1.27, 5.32), while there was no significant difference between the groups in the unrelated condition ($p = .73$, $CI_{.95}$ = -1.01, 1.43).

Veridical recall. Recall of the target items was scored according to a free recall criterion: Each target (i.e., visually-presented) item recalled was scored as veridical regardless of its position. As can be seen in Figure 1 (Panel B), the basic effect of B-SSS on veridical recall was replicated: target items were recalled less well in the related compared to unrelated condition. Most importantly, whereas forewarning strongly modulated the impact of semantic similarity on erroneous recall, this did not in turn affect veridical recall: Whilst there was a large and specific effect of forewarning on erroneous recall of related distractors, there was a small (and non-significant; see below) non-specific effect of forewarning on veridical recall (i.e., regardless of Target-Distractor relation).

A 2 (Warning: Warning versus No Warning) × 2 (Target-Distractor Relation: Related versus Unrelated) ANOVA of the target-recall data revealed a main effect of Target-Distractor Relation, $F(1, 46) = 54.90$, $MSE = 0.002$, $p < .001$, η_p^2 = .54, but no main effect of Warning, $F(1, 46) = .725$, $MSE = 0.009$, $p = .399$, η_p^2 = .02, and no interaction between these two factors, $F(1, 46) = .109$, $MSE = 0.002$, $p = .74$, η_p^2 = .002.

Relation between veridical and erroneous recall. There were also no significant correlations between the number of intrusions and the probability of veridical recall regardless of distractor-relatedness or Warning group, $r(22) = -.17$, $p = .42$, related condition, no warning; $r(22) = .127$, $p = .56$, unrelated condition, no warning; $r(22) = .13$, $p = .54$, related condition with warning; $r(22) = -.26$, $p = .22$, unrelated condition, no warning).

Discussion

Experiment 1 showed that a forewarning about the tendency to erroneously recall semantically-related auditory distractors during free recall reduces substantially the propensity for such erroneous recall. The result resonates with that found in the DRM task in which a critical lure is less likely to be falsely recalled when participants are forewarned that such erroneous recall tends to occur (e.g., Hicks & Marsh, 1999; McCabe & Smith, 2002; Watson et al., 2005). Of particular significance for the present purposes is the finding that while warning reduced erroneous recall it did not in turn affect veridical recall. Furthermore, regardless of condition, there was no correlation between the rate of erroneous recall and the accuracy of veridical recall. Thus, the results of Experiment 1 more clearly support a two-mechanism account (Marsh et al., 2008), which ascribes the effects of B-SSS on erroneous and veridical recall to distinct mechanisms, over a single-mechanism account in which the reduction in veridical recall is caused by distractors blocking the retrieval of target items (Hanczakowski et al., 2012; see also Beaman et al., 2013). The data also go against the possibility that veridical and erroneous recall are both direct consequences of a single response bias or threshold at output (cf. signal detection theory; e.g., Banks, 1970). More generally, the results of Experiment 1 are in line with the broader view that erroneous recall is not a key determinant of veridical recall (e.g., M. C. Anderson, 2003).

However, to conclude that the absence of a relation between the impact of B-SSS on erroneous and veridical recall as observed in Experiment 1 undermines the blocking account may be premature. First, there are known logical and statistical problems in drawing conclusions from an absence of evidence, even though a dual mechanism might seem the most plausible of the alternatives given the results obtained. Second, it remains possible that a blocking effect of erroneous recall on veridical recall does indeed account for the disruptive effect of B-SSS on veridical recall but, in the standard free recall procedure, this does not manifest empirically in the participants' recall protocols. Specifically, many instances of erroneous recall may remain unobserved because they are edited out by the participants prior to overt responding (Hunt, Smith, & Dunlap, 2012; Kahana et al., 2005). If so, this could result in an underestimation of erroneous recall and hence, potentially, explain the failure to observe the systematic relation between erroneous and veridical recall predicted by the blocking account. Experiment 2 was designed to examine this possibility.

Experiment 2

The key conclusion from Experiment 1—that the impact of B-SSS on erroneous recall is not related to its effect on veridical recall—seems to apply when erroneous recall is defined as overt output of distractor items. However, 'erroneous recall' could instead be defined less restrictively as items that enter consciousness and become available for output during test regardless of whether they are actually output. To date, articulations of the blocking account have tended to emphasize the fallibility of "front-end control" aspects of the retrieval process. Front-end control—an example of which is source-constrained retrieval (e.g., Jacoby, Shimizu, Velanova, & Rhodes, 2005)—operates by focussing retrieval such that it is mainly information from the desired source that comes to mind during test. This is achieved by reinstating the source context that specifically fits the way in which target information was encoded, and thereby potentially limits the accessibility of undesired information. In other words, the retrieval of targets is facilitated and potential intrusions are prevented from coming to mind during the test phase of the task. Hence, front-end control is often referred to as a pre-retrieval process. An example of the operation of front-end control in the present setting would be to constrain search to items whose visual properties (e.g., orthography) were utilised during the encoding episode thereby preventing irrelevant spoken items from coming to mind at test. Imperfect operation of such front-end control leads to the retrieval of distractor-items, thence to erroneous recall and finally to the blocking of access to target-items (resulting in poorer veridical recall; Beaman et al., 2013).

However, it is also commonly accepted that there are “back-end control” mechanisms such as the distinctiveness heuristic (Dodson & Schacter, 2002) or recollection rejection (Brainerd, Reyna, Wright, & Mojardin, 2003) that operate subsequent to (covert) retrieval but before output to assess the appropriateness of outputting a given item (e.g., Halamish, Goldsmith, & Jacoby, 2012). Once (covertly) retrieved, an item—or its associated features—is evaluated in terms of whether it can be differentiated as a target or an intrusion (e.g., an item presented as a distractor; Budson et al., 2005). An example of back-end control would be to covertly generate items presented as distractors but then edit the item after it has been retrieved on the basis of an assessment of the features associated with the item (e.g., modality information; recall of auditory information and/or failure to recall visual information).

Importantly, the possible existence of back-end control mechanisms means that whereas there may not be a relation between *overt* erroneous recall and veridical recall (cf. Experiment 1), a relation may indeed exist between erroneous and veridical recall if covert—and not just overt—instances of erroneous recall are taken into account. Such a relation would clearly provide a reprieve for the blocking account. Specifically, the account could posit that covert retrieval of items presented as distractors (or ‘covert erroneous recall’) blocks the retrieval of target items regardless of whether such *covert* erroneous recall translates into *overt* erroneous recall. In short, using only the rate of overt erroneous recall—as measured in Experiment 1 and all previous studies of the B-SSS effect—may obscure a true relation between erroneous recall (covert or overt) and veridical recall.

What is required for a fairer test of the blocking account, therefore, is a means of assessing the extent to which erroneous recall in the face of B-SSS is related to the level of veridical recall regardless of whether that erroneous recall is overt or covert. To do this, we used a modified externalised free recall editing technique (Bousfield & Rosner, 1970; Kahana et al., 2005; Roediger & Payne, 1985; Rosen & Engle, 1997; Unsworth & Brewer, 2010). Here, participants are encouraged to overtly produce any word that enters consciousness during test, be it a previously produced response or an intrusion, but they are instructed to press a button if they recognize the item as a repetition or intrusion (Kahana et al., 2005; Unsworth & Brewer, 2010). Participants are thus encouraged to use back-end control to monitor and edit the output of each item *after* the response has been output. In the present context, then, this technique should enable us to infer the extent to which, in the standard (i.e., non-externalized) free recall task, semantically-related distractors are subject to covert erroneous recall but edited out before output. In turn, this will allow us to assess whether the impact of B-SSS on veridical recall is indeed related to the rate of (covert or overt) erroneous recall as predicted by the blocking account.

Method

Participants. Twenty Cardiff University students participated for course credit. All were native English speakers and reported normal or corrected-to-normal vision and normal hearing.

Materials, design, & procedure. The remaining aspects of the method were the same as for Experiment 1 with the exception that participants were instructed to output any word that came to mind during the test phase and there was no warning manipulation. However, participants were also told that if a word that they had just output had not been a visually-presented to-be-recalled item they were to classify it as an intrusion by pressing a key on the desk in front of them immediately after outputting the word but prior to outputting any further items. Participants' oral responses were recorded via microphone input into *Sound Forge 5* software (Sonic Inc., Madison, WI; 2000).

Results and Discussion

The B-SSS effect on erroneous and veridical recall. Experiment 2 replicated the typical B-SSS effect on erroneous recall (Table 1): Erroneous recall was greater in the related condition than in the unrelated condition, $t(19) = 5.63$, $p < .001$, $CI_{.95} = 0.67, 1.46$, and this was the case regardless of whether those erroneously recalled items were correctly classified as intrusions (i.e., hits)[1], $t(19) = 3.12$, $p = .006$, $CI_{.95} = 0.19, 0.96$, or not classified as intrusions (i.e., misses), $t(19) = 3.51$, $p = .002$, $CI_{.95} = 0.11, 0.43$. The results also showed the typical B-SSS effect on veridical recall (Table 1). In a first step, all targets that were output (regardless of their subsequent classification) were scored as correct. Overall, recall was worse in the related condition compared with the unrelated condition, $t(19) = 2.45$, $p = .024$, $CI_{.95} = 0.07, 0.95$. Veridical recall was also impaired in the related condition when only targets that were correctly rejected as not being intrusions (i.e., correct rejections) were considered, $t(19) = 4.03$, $p < .001$, $CI_{.95} = 1.19, 0.38$. Table 1 also reports the rest of the data for the sake of completeness.

Relation between erroneous and veridical recall. If erroneous recall blocks veridical recall, there should be a negative correlation between erroneous recall—regardless of whether it was covert or overt—and veridical recall. That is, in the related condition, the more distractor items that come to mind the fewer the number of targets that should be produced. On the other hand, if erroneous recall and veridical recall are underpinned by functionally distinct mechanisms, we should find no correlation between them. As can be seen in Figure 2, there was no significant correlation between non-edited erroneous recall and veridical recall, $r(18) = .06$, $p = .802$. As this conclusion rests on acceptance of the null hypothesis, and the sample size was relatively small, we also report the

Bayes statistic for this result (http://pcl.missouri.edu/bayesfactor), because it can, unlike conventional statistics, quantify the support for the null hypothesis based on the obtained data. The JZS Bayes factor for the correlation between erroneous recall and veridical recall was 5.84. Values above unity are in favor of the null hypothesis, whereas values below unity are in favor of the alternative. A value of 5.84 is considered 'substantial evidence in favour of the null-hypothesis' (Jeffreys, 1961).

Experiment 2 replicated the typical B-SSS effect on erroneous and veridical recall. The findings provide evidence for the view that there is no relation between erroneous and veridical recall. There is no evidence in the results obtained here that the process of non-target items coming to mind blocks the retrieval of targets. Although we acknowledge that the sample size of Experiment 2 was relatively small, the Bayesian analysis, combined with the consistency with the results of Experiment 1, bolster our confidence in this conclusion. Taken together, our results suggest that the B-SSS effect on erroneous recall and that on veridical recall are underpinned by distinct mechanisms.

General Discussion

To summarize the results of the present study, we showed that the impairment in the ability to free-recall a list of words due to the presence of semantically-related distractors is independent of the propensity to erroneously recall those distractors: The effect of semantically-related distractors persists even when erroneous recall is drastically reduced by a forewarning about the propensity for such recall (Experiment 1) and there is no relation between erroneous and veridical recall even when participants are encouraged to output all items that come-to-mind prior to classifying them according to whether or not they were intrusions (Experiment 2). These results are at odds with the single-mechanism (blocking) account of the B-SSS effect as it posits that retrieval of target items is disrupted by semantically-related distractors because the erroneous recall of those distractors blocks access to target items (Beaman et al., 2013; Hanczakowski et al., 2012). On this account, the effect of related distractors on veridical recall should be attenuated when erroneous recall is constrained, and the rate of erroneous recall should be negatively associated with the rate of veridical recall. Instead, the results support a two-mechanism account (Marsh et al., 2008) in which the B-SSS effect on erroneous recall and on veridical recall occurs for different reasons. By extension, the present findings suggest more generally that forgetting is not driven to any appreciable extent by erroneous recall of similar but contextually-inappropriate events, contrary to several theories of memory (e.g., J. R. Anderson, 1983; Mensink & Raaijmakers, 1988; Raaijmakers & Shiffrin, 1981; Rundus, 1973).

Erroneous and Veridical Recall Dissociated

On both the single- and two-mechanism accounts, the erroneous recall component of the impact of B-SSS is attributed to the breakdown of source monitoring (Beaman, 2004; Bell et al., 2008; Marsh et al., 2008). Some of the distractor items—those not successfully inhibited during their presentation (see later discussion of the second mechanism in the two-mechanism account)—come to mind at test and undergo a monitoring process to determine whether or not they are appropriate for output. That a forewarning about the propensity for erroneous recall of distractors dramatically reduces such recall suggests that it can be prevented via back-end control. This resonates strongly with findings from the DRM procedure in which a warning about false recall of a single critical lure—a non-presented item strongly associated with target items—reduces recall of that lure (e.g., Hicks & Marsh, 1999; Watson et al., 2005). According to this source-monitoring view, non-target items can potentially be edited out through a strategy of examining, post retrieval, the details that differentiate the non-target item from target items (see Budson et al., 2005).

Typically, to examine the selection of targets from a “consideration set” of possibilities (Beaman, 2013), manipulations are implemented that impact on the discriminability of target and distractor items (e.g., Beaman et al., 2013). In the study reported here, output monitoring processes were manipulated by means of instruction alone, and the dimension along which targets could be discriminated from distractors (modality) remained unchanged. The finding that a mere instructional manipulation—forewarning—influences erroneous recall, suggests that in this case the observed reduction in erroneous recall is unlikely to be due to changes in front-end control. This is because this form of control operates by focussing retrieval such that it is mainly information from the desired source (e.g., visual properties such as orthography) that is used to prevent irrelevant spoken items from coming to mind during test (e.g., Jacoby et al., 2005). However, if front-end control was operating, then erroneous and veridical recall should be two sides of the same coin: factors that increase the effectiveness of front-end discrimination, like physical (non-semantic) discriminability of relevant and irrelevant information, should lead to both fewer instances of erroneous recall and improved veridical recall (Beaman et al., 2013). However, a note of caution must be added here since we cannot exclude the possibility that participants, having been given a sample trial in the forewarning condition, focused on the orthographic information at study during the experimental trials to aid discrimination of targets and distractors via front-end control. Although there was a tendency for forewarning to reduce veridical recall in Experiment 1, as might be expected if maintenance of the warning cue acted as a load (cf. Watson et al., 2005), this did not reach significance and further suggests that erroneous recall was reduced by back- not front-end control. Thus, one way to account for the finding that physical manipulations that involve increasing the discriminability of targets from distractors (via differences in voice or color) can affect both veridical and erroneous recall (Beaman et al., 2013) is to propose that the physical distinction facilitates the identification of the distractors as such at the point at which they occur thereby facilitating the inhibition of inappropriate information. The action of successful inhibition in this context, therefore, is to decrease erroneous recall of the distractors while increasing veridical recall of targets.

Regardless of whether or not instances of erroneous recall are successfully edited out via back-end control, the present findings suggest strongly that these do not determine the probability of veridical recall, contrary to predictions derived from the construct of associative blocking (Kimball & Bjork, 2002; Raaijmakers & Jakab, 2012; Rundus, 1973; Spitzer & Bäuml, 2009). The two-mechanism account proposes that veridical recall is impaired by distractors because they compete at the time of their presentation for the semantic-based processes supporting performance of the focal task (Marsh et al., 2008, 2009). To counteract this competition, related distractors are subject to an inhibitory process as they occur. Whilst the net result of such inhibition is the facilitation of selective attention of the target items, the process of inhibiting incurs some overhead cost due to the spreading of the inhibition from semantically-related distractors to features shared with target items thereby diminishing their accessibility at test (Marsh et al., 2008, 2009, 2012, 2014; see also Jones, Marsh, & Hughes, 2012). Whilst the present study was not designed to garner direct evidence for this competition-at-presentation/inhibition view, as noted in the Introduction, it enjoys support from the finding that the free recall of items that have recently been distractors is impaired (i.e., negative priming; Marsh et al., 2012). Recent evidence suggests further that the precise mechanism of disruption of veridical recall may differ depending on individual differences in working memory capacity (WMC): veridical recall of those low in WMC (and hence low distractor-inhibition ability; Conway et al., 2001; Conway, Tuholski, Shisler, & Engle, 1999) seems to be disrupted primarily by the distractor-competition itself whereas the veridical recall of those with high WMC is impaired—although to a lesser extent than those with low WMC—due to an overhead cost of inhibiting the competitors. Corroborating evidence for this analysis comes from the fact that those with high WMC show a greater negative priming effect than those with low WMC (Marsh et al., 2014). However, since in Experiment 2 the impact of B-SSS also manifested in an increased number of targets that were and incorrectly classified as intrusions, retrieval discriminability may also play some role in the B-SSS effect on veridical recall but not via a blocking mechanism.

A Role for Attentional Capture?

Evidence has been provided for a two-mechanism account of semantic auditory distraction, within which the exact processes operating in relation to the disruption of veridical recall remain open for debate. It is possible that some of the disruptive effect of semantically-related speech on free recall may be due to attentional capture whereby the distractors draw scarce attentional resources away from the encoding of the target items (cf. Cowan, 1995). There is again the possibility that attentional capture could affect veridical and erroneous recall in different ways. For example, erroneous recalls may be caused by attentional capture during study: Orientation of attention toward the distractors could result in the distractors being automatically encoded along with the target items. Moreover, if activation of the items *per se* (in the absence of the use of source-monitoring) is used to determine list membership, then this automatic encoding could feasibly result in the output of the distractors during test. Previous research (Conway et al., 2001) has demonstrated that salient semantic information captures attention. For example, in a shadowing task in which participants continuously repeat aloud a message presented to one ear while ignoring another message presented to the other ear, about a third of participants hear their own name in the to-be-ignored channel. Perhaps it is no coincidence, therefore, that participants with high WMC make fewer intrusions of related spoken distractors in the semantic distraction task (Beaman, 2004) and are less likely to make shadowing mistakes, or hear their name at the time it is presented, in the to-be-ignored channel in the context of dichotic listening (Conway et al., 2001). In essence, individuals with high WMC show stronger inhibition of information in a task-irrelevant auditory channel (Marsh et al., 2014; Sörqvist, Rönnberg, & Stenfelt, 2012).

However, not all spoken distractors are accurately edited even with a forewarning about erroneous recall. One possibility is that intrusions may be due (in part) to *attentional slippage* (the allocation of attention, perhaps without intention, to the irrelevant items) and *attentional leakage* (semantic processing of irrelevant material whilst attention is focused elsewhere; Lachter, Forster, & Ruthtuff, 2004; this may be synonymous with the view of immediate competition assuming that semantic processing of the distractors at the point of their presentation leads to their competition with targets). Attentional slippage may lead to an involuntary re-direction of attention towards the spoken item and then back to the visual targets. The consequence of attentional slippage, however, is presumably a greater analysis of the distractor, allowing for modality information to be encoded and thereafter used—if instructed to do so (e.g., via forewarning)—to edit the item post-retrieval. Processing of distractors via attentional leakage is known to occur (e.g., Scott, Rosen, Beaman, Davis & Wise, 2009), however, it may not involve further analysis of the irrelevant speech token and would therefore be unlikely to facilitate the editing process despite giving rise to erroneous recall. Even though attentional capture may underpin intrusion rates, it is unclear why attentional capture would leave veridical recall untouched, especially as sound that captures attention disrupts target recall in the context of serial short-term memory (e.g., Hughes, Vachon, & Jones, 2005, 2007; Hughes, Hurlstone, Marsh, Vachon, & Jones, 2013; Sörqvist, 2010). Because of this, we favor the view that a breakdown of source monitoring at recall rather than attentional capture at study underpins the erroneous recall component of the B-SSS effect.

A Functional View of Forgetting

More broadly, the present findings are in line with a functional approach to forgetting that emphasizes the role of conceptually-focused selective attention (M. C. Anderson, 2003; M. C. Anderson & Huddleston, 2012) and monitoring processes in establishing successful remembering (Marsh et al., 2008, 2012, 2014). This view eschews the idea that forgetting is attributable to passive factors such as decay, interference (e.g., overwriting), or context change. Rather, forgetting is not considered in terms of a negative outcome, but as a consequence of active inhibitory processes that serve important attentional functions. The notion of a conceptually-focused selective attention holds that selective retrieval requires similar processes to perceptually focused selective attention whereby one object has to be selected from an array of others that receive activation in parallel via perceptual input (Houghton & Tipper, 1994). For conceptually-focused selective attention, these objects may no longer be within the external world (such as images, facts or prior episodes). Here, attention is shifted across objects internally to allow attentional refocusing on the target object for mnemonic retrieval. When more than one object shares a retrieval cue such as the taxonomic cue "Fruit", many representations of "Fruit" will receive activation in parallel from the cue, only one of which may be the target for memory retrieval, the remainder non-targets (distractors/competitors). Selectively attending to the target entails isolation of the target representation from non-target representations. According to the conceptually-focused selective attention view, inhibition is the key process that is used to resolve this computational problem of selection. The inhibitory process resolves interference from non-targets by deactivating the mental representations of these competitors thus rendering them non-interfering and allowing the target memory to be retrieved (Anderson & Weaver, 2009). This cognitive control mechanism that responds to unwanted competition from related memories is functional in that it allows contextually appropriate responses—that are often weaker than the unselected alternatives—to be retrieved thereby overriding responses that are often prepotent. The result of this suppression, however, is that it carries a negative consequence for the later recall of the competing, non-target, memories should they then become the targets for selective retrieval (Anderson, 2003). That omissions of veridical recalls were unrelated to incidence of erroneous recall in the present study challenges passive theories of forgetting that are based on the constructs of decay or blocking (as we have focused on here). The present findings cohere better with the view that distractors compete with targets for retrieval and that the executive process of inhibition is required to prevent or reduce the competition (M. C. Anderson, 2003). Impairment in veridical recall therefore, is not related to the degree to which distractors are erroneously recalled at retrieval but rather to a cost of the immediate competition offered by those distractors during their presentation and the inhibitory process deployed to reduce that competition (Marsh et al., 2008, 2012, 2014).

In conclusion, the results reported here suggest that the B-SSS effect on veridical and erroneous recall is underpinned by two distinct mechanisms—one that is associated with disruption of veridical recall and one that is associated with production of erroneous recall—that are differentially sensitive to modulation by top-down knowledge about the tendency for erroneous recall. Forewarning seems to modulate the erroneous recall component through the process of back-end cognitive control, a monitoring process that does not influence veridical recall. Although processes relating to discrimination may also influence veridical recall, the disruption to veridical recall seems to be related to the direct competition between targets and distractors as they occur as well as an overspill of an inhibitory process (Marsh et al., 2008, 2012, 2014) rather than activation-blocking (Kimball & Bjork, 2002; Raaijmakers & Jakab, 2012; Rundus, 1973).

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Author note

John E. Marsh, University of Central Lancashire, Preston, UK, and the University of Gävle, Sweden. Robert W. Hughes, Department of Psychology, Royal Holloway, University of London, UK. Patrik Sörqvist, University of Gävle, Sweden and Linnaeus centre HEAD, Swedish Institute for Disability Research, Linköping University, Sweden. Philip Beaman, Centre for Cognition Research and School of Psychology and Clinical Language Sciences, University of Reading, Dylan M. Jones, School of Psychology, Cardiff University, UK. Dylan M. Jones is also adjunct Professor at the Department of Psychology at the University of Western Australia. The first two authors contributed equally to this work. The research was partially supported by an ESRC grant (RES-062-23-1752) awarded to C. Philip Beaman and Dylan M. Jones and on which the first author was a Research Associate and by a Swedish Research Council grant (2010-2012) awarded to Patrik Sörqvist. We thank Helen Hodgetts for help with data collection for Experiment 2 and Maciej Hanczakowski for useful comments on a previous draft. Correspondence can be addressed to John Marsh, Department of Psychology, University of Central Lancashire, Preston, UK. E-mail may be sent to jemarsh@uclan.ac.uk.

Footnote

1. Whilst it may seem more intuitive to think of the successful identification of an intrusion as an intrusion as a *correct rejection*, this would technically be incorrect. The ‘signal’ in this case (cf. signal detection theory) is an intrusion and hence to classify one as such is a *hit* and failure to classify it as such is a *miss.* To not classify a target-word as an intrusion is thus a *correct rejection* and to classify a target-word as an intrusion is a *false alarm*.

Figures and Table captions

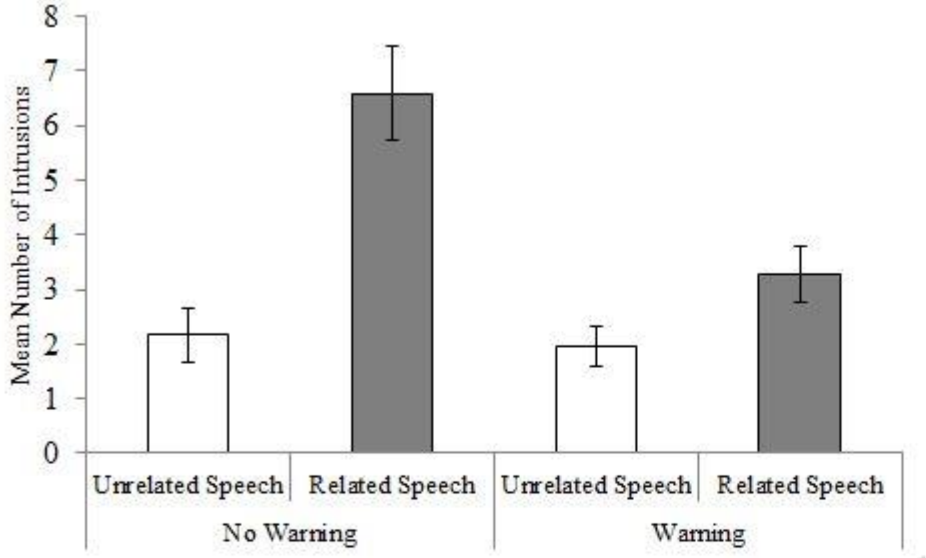
Figure 1. Panel A: Mean number of related-speech intrusions (for the unrelated and related speech trials in the no-warning and warning conditions) of Experiment 1. Panel B: Proportion of correct responses (i.e., for unrelated and related speech trials in the no-warning and warning conditions) of Experiment 1. Error bars represent the standard error of the mean.

Figure 2. The (absence of) a relation between non-edited veridical recall and erroneous recall in the related condition of Experiment 2.

Table 1. The table shows for the unrelated and related sound conditions of Experiment 2 the means (M) and standard errors (SE) for the number of times per list a distractor-item was output (overt erroneous recall) and also whether that item was classified as an intrusion (i.e., a hit), or not classified as an intrusion (i.e., a miss). The table also shows the number of times per list a target-item was output (veridical recall) and also whether it was not classified as an intrusion (i.e., a correct rejection) or classified as an intrusion (i.e., a false alarm).

Figure 1

A


Mean Number of Intrusions
8
7
6
5
4
3
2
1
0
Unrelated Speech
Related Speech
Unrelated Speech
Related Speech
No Warning
Warning

B

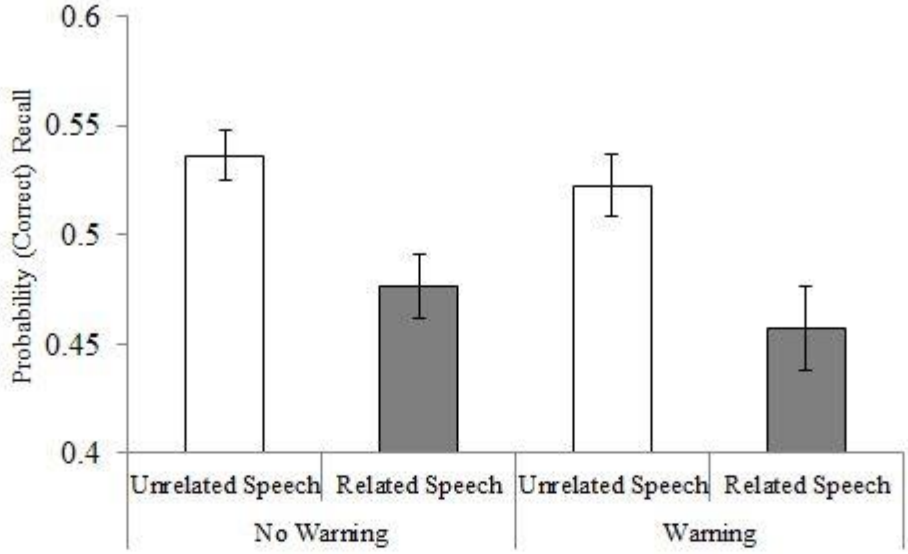

Probability (Correct) Recall
0.6
0.55
0.5
0.45
0.4
Unrelated Speech
Related Speech
Unrelated Speech
Related Speech
No Warning
Warning

Figure 2

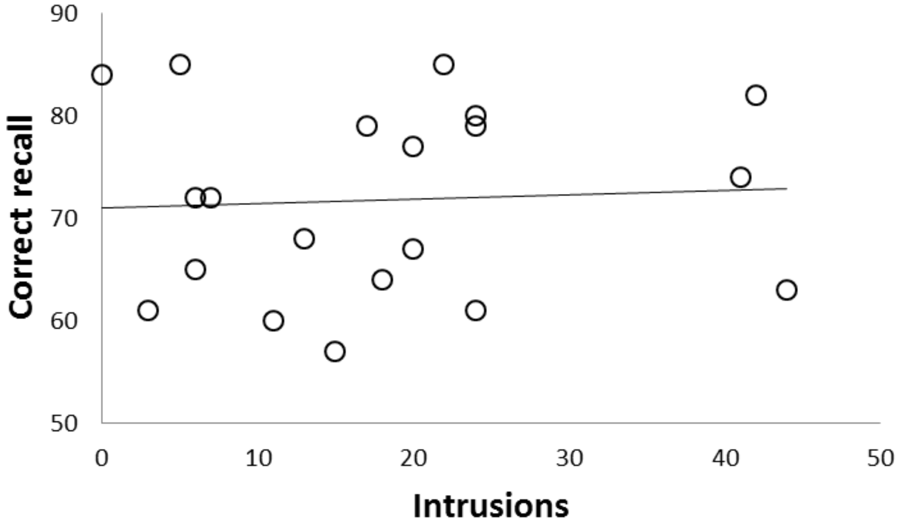


Table 1

	Condition			
	Unrelated		Related	
Dependent variable	*M*	*SE*	*M*	*SE*
Erroneous recall				
No. of distractors output regardless of their classification	0.95	0.19	2.01	0.32
Classified as an intrusion (Hits)	0.69	0.16	1.26	0.29
Not classified as an intrusion (Misses)	0.25	0.06	0.75	0.11
Veridical Recall				
No. of targets output regardless of their classification	8.48	0.21	7.97	0.23
Classified as not an intrusion (Correct rejections)	8.23	0.19	7.45	0.20
Classified as an intrusion (False alarms)	0.25	0.06	0.52	0.12