The Effect of Target Detection on Memory Retrieval

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Abstract

Using the classic "study-test" paradigm, an interference task of target detection was set up during the test phase. By comparing whether target detection and distractor rejection would have different effects on memory retrieval, the relationship between retrieval interference and recognition memory was further explored. The results showed that, regardless of whether explicit (Experiment 1) or implicit (Experiment 2) detection responses were made to targets, recognition responses for old words under target detection were consistently better than under distractor rejection, indicating that explicit memory retrieval is also modulated by attentional resources. More importantly, however, difference analyses on the discrimination index (d) and decision criterion (C) revealed that target detection did not improve participants' recognition performance, but rather lowered their decision criterion, making participants more likely to respond "old" to words under target detection conditions. This response bias was independent of the motor response mode of target detection and was not modulated by the depth of encoding processing of the words. Thus, it can be seen that explicit memory retrieval is not entirely "automatic processing," but is still subject to modulation by attentional resources.

Full Text

Effects of Target Detection on Memory Retrieval

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Abstract

Using a classic "study-test" paradigm, the present research introduced a target detection interference task during the test phase to examine whether target detection and distractor rejection differentially affect memory retrieval, thereby further exploring the relationship between retrieval interference and recognition memory. The results revealed that, regardless of whether target detection required explicit (Experiment 1) or implicit (Experiment 2) responses, recognition performance for old words was superior under target detection compared to distractor rejection, indicating that explicit memory retrieval is also modulated by attentional resources. More importantly, analyses of discriminability index (d) and decision criterion (C) demonstrated that target detection did not enhance recognition sensitivity but rather lowered participants' decision criterion, making them more likely to respond "old" under target detection. This response bias was independent of the motor response mode employed in target detection and was not moderated by the depth of encoding processing. Thus, explicit memory retrieval is not entirely an automatic process and remains subject to attentional regulation.

Keywords: attentional boost effect; target detection; memory retrieval; dual task
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The influence of attention on memory has long been a central topic in cognitive psychology. Researchers typically employ a dual-task paradigm, requiring participants to perform a memory-irrelevant interference task while encoding or retrieving information, to investigate whether divided attention affects memory performance. Results consistently show that divided attention during encoding significantly impairs subsequent performance on free recall, cued recall, and recognition tests compared to full attention conditions. In contrast, divided attention during retrieval has little or no effect on memory performance (Anderson, Craik, & Naveh-Benjamin, 1998; Anderson et al., 2000; Baddeley, Lewis, Eldridge, & Thomson, 1984; Craik, Eftekhari, & Binns, 2018; Craik, Govoni, Naveh-Benjamin, & Anderson, 1996; Iidaka, Anderson, Kapur, Cabeza, & Craik, 2000; Naveh-Benjamin & Brubaker, 2019; Craik & Naveh-Benjamin, 2000; Naveh-Benjamin, Craik, Guez, & Kreuger, 2005; Meng & Guo, 2007, 2009; Meng, 2010). Consequently, researchers have proposed that encoding and retrieval processes differ qualitatively: encoding is a controlled process requiring attentional resources and is therefore vulnerable to interference, whereas retrieval is an automatic process. Given appropriate retrieval cues, learned elements are automatically activated without capacity limitations, making retrieval immune to divided attention effects.

However, recent studies using target detection tasks during encoding have revealed an intriguing phenomenon: divided attention during encoding does not necessarily impair subsequent memory. Swallow and Jiang (2010) first demonstrated this effect using a classic study-test paradigm. During encoding, participants performed a dual task: they encoded sequentially presented pictures at the center of the screen while simultaneously monitoring other stimuli co-occurring with the pictures (e.g., small squares in the picture center or auditory tones). Participants pressed a key when a target stimulus appeared (white square or high-pitched tone) but made no response to distractor stimuli (black square or low-pitched tone). The target-to-distractor ratio was 1:6, and a recognition test followed encoding. Results showed that pictures co-occurring with target stimuli were recognized significantly better than those paired with distractor stimuli. However, when participants were instructed to ignore the interference stimuli and focus solely on picture encoding, no differences emerged between conditions. Swallow et al. (2010) concluded that detecting target stimuli enhances memory for concurrently presented background information compared to rejecting distractors, terming this phenomenon the Attentional Boost Effect (ABE). This effect has been replicated across various background materials, including faces (Swallow & Jiang, 2012) and words (Mulligan, Spataro, & Picklesimer, 2014), and in different memory tests, such as short-term memory tasks (Makovski, Swallow, & Jiang, 2011) and implicit memory tests (Spataro, Mulligan, & Rossi-Arnaud, 2013). Intriguingly, memory performance under target detection can match or even exceed that of full attention conditions, while performance under distractor rejection is significantly worse than full attention, demonstrating a typical attentional interference effect (Spataro et al., 2013; Mulligan et al., 2014; Rossi-Arnaud et al., 2014). To explain this, Swallow and Jiang (2013) proposed the Dual-Task Interaction Model, suggesting that target detection triggers a temporal selective attention mechanism accompanied by locus coeruleus-norepinephrine (LC-NE) system activity, producing transient and broad perceptual enhancement (Aston-Jones & Cohen, 2005) that facilitates perceptual processing of background information co-occurring with targets. Thus, the relationship between attention and memory is multifaceted: divided attention during encoding can both impair and enhance memory trace formation.

Given established qualitative differences between encoding and retrieval processes, the present study focuses on whether target detection tasks during retrieval, similar to encoding, produce differential effects on retrieval. As noted, memory retrieval is considered an automatic process, and interference tasks during retrieval should not substantially affect explicit memory performance. Following this logic, even with target detection interference, retrieval should remain unaffected, showing no difference between target detection and distractor rejection. Makovski, Swallow, and Jiang (2011) addressed a related question using a change detection paradigm to investigate ABE in short-term memory. Participants made same/different judgments on sequentially presented memory arrays (3 or 5 colored squares) and test arrays while detecting letters appearing among the squares (target: T; distractors: H/X/L/V). They found that when the letter detection task occurred during memory encoding (i.e., during presentation of memory arrays), performance was better in the target condition than the distractor condition, demonstrating ABE. However, when the letter detection task occurred during test array presentation (i.e., during short-term memory retrieval), no ABE emerged; target and distractor conditions did not differ. They concluded that target detection only enhances encoding of concurrently presented background information, not retrieval. This result seemingly further confirms retrieval’ s “immunity” to interference.

Nevertheless, research on retrieval interference and explicit memory has also found that although retrieval interference does not or only minimally reduces memory performance, reaction times for the concurrent interference task are significantly prolonged. This prolongation decreases from free recall to cued recall to recognition. Researchers argue that explicit retrieval' s relative "immunity" to interference comes at the cost of greater interference task reaction time costs, suggesting that explicit retrieval does require attentional resources. Because retrieval is in some sense mandatory, this resource cost is transferred to the interference task (Craik et al., 1996). For example, manipulating dual-task instructions during retrieval—emphasizing either the memory task or the interference task—does not affect memory performance but does influence interference task responses: emphasizing the interference task speeds its responses, while emphasizing the memory task slows them (Craik et al., 1996; Anderson et al., 1998). Additionally, explicit memory' s "immunity" to retrieval interference varies depending on the nature of the secondary task. Fernandes et al. (2000, 2003) required participants to perform a recognition test concurrently with either a word judgment task (animal/non-animal) or a number judgment task (odd/even). They found that while number judgment did not affect recognition, word judgment impaired recognition performance. Fernandes et al. (2000, 2003) argued that this resulted from competition for shared attentional resources for lexical representations between the memory and interference tasks, thereby affecting memory performance. These studies demonstrate that memory retrieval is influenced by interference tasks' differential demands on attentional resources. Target detection is generally believed to require more attentional resources than distractor rejection (Swallow & Jiang, 2010, 2011, 2013) and relies more heavily on central executive system resources (Pashler, 1994). Therefore, if target detection is used as a retrieval interference task, target detection and distractor rejection should differentially affect recognition memory due to their different attentional demands.

Since Makovski et al. (2011) investigated target detection' s effect on short-term memory using meaningless colored squares, whereas previous retrieval interference research has typically used meaningful pictures or words to examine long-term memory, the present study adopted the classic study-test paradigm with two-character Chinese words as memory materials. During recognition, participants performed a target detection interference task to examine whether target detection and distractor rejection differentially affect memory retrieval for two-character words. Does target detection interference during retrieval affect memory extraction? Investigating this question will help us understand more directly whether explicit memory retrieval is influenced by attentional resources and provide a more comprehensive understanding of the relationship between retrieval processes and interference. Additionally, we manipulated encoding depth, requiring participants to perform deep (pleasantness judgment) or shallow (word color judgment) processing on words. Levels-of-processing theory posits that deeper processing yields better retrieval (Craik & Lockhart, 1972). Dual-process theory of recognition memory suggests that deep processing relies primarily on recollection, while shallow processing relies on familiarity, with recollection being more attention-demanding than familiarity. Therefore, divided attention should affect deeply processed information more than shallowly processed information (Jacoby, 1991). Since target detection consumes more attentional resources than distractor rejection (Swallow & Jiang, 2010, 2011, 2013), we also examined whether memory retrieval for differently encoded information shows differential sensitivity to target detection interference.

Experiment 1

2.1.1 Participants

Using G*Power 3.1 software with parameters set at f = 0.25 (medium effect size), = 0.05, and 1 − = 0.95, the required sample size was calculated to be 28. Considering potential attrition, we recruited 30 participants. All 30 participants were students from a normal university (13 male), aged 17–23 years (M = 20.4, SD = 1.5). All were right-handed with normal or corrected-to-normal vision, physically healthy, and without serious medical history. Participants received compensation after completing the experiment.

2.1.2 Materials and Apparatus

We selected 240 low-frequency two-character Chinese words from the *Modern Chinese Frequency Dictionary* (1986 edition), with frequencies ranging from 2.3 to 9.9 per million (M = 4.155 per million) and relatively neutral meanings. The 240 words were randomly divided into three groups of 80 words each, with no significant differences among groups in word frequency or stroke count [F(2,237) = 0.23, p = 0.80; F(2,237) = 2.21, p = 0.11]. Two groups served as study materials: one for shallow processing (color judgment; 40 red and 40 blue words) and one for deep processing (presented in black; pleasantness judgment). The remaining group served as new words and was mixed with the 80 deep-encoded old words and 80 shallow-encoded old words during the test phase. All words were presented at the center of the screen. During testing, half of the words in each group were paired with target stimuli (“+”) and half with distractor stimuli (“-”). These interference stimuli appeared 2 cm above the words. All test phase stimuli were presented in black, 60-point font.

The experimental program was developed using Presentation 0.71 software. The computer used was a DELL Dimension 8200 with a 15-inch CRT monitor (resolution: 800×600, refresh rate: 75Hz).

2.1.3 Procedure

Participants completed the experiment in a soundproof room, instructed to fixate on the center of the computer screen. The display background was black, with the stimulus presentation area in white. The experiment consisted of three phases: study, distractor, and test. Participants completed practice trials before the formal experiment; practice data were not analyzed.

(1) Study Phase: This included a shallow processing group (color judgment: press "F" for red, "J" for blue) and a deep processing group (pleasantness judgment: press "F" for pleasant, "J" for unpleasant). To balance order effects, the 80 deep-encoded and 80 shallow-encoded words were each randomly divided into five blocks of 16 words. The order of deep and shallow blocks was counterbalanced within participants using an ABBA sequence, which remained consistent across participants. Stimuli within each block were presented randomly. Each word was presented for 500 ms, with an interstimulus interval (ISI) of 1800±200 ms.

(2) Distractor Phase: The screen displayed "Please count backward from 300 by 2s for one minute." Participants followed this instruction for one minute, writing their answers on paper.

(3) Test Phase: This included both recognition and target detection tasks. For the recognition task, participants quickly judged whether each word had appeared during the study phase, pressing "F"for old words and "J"for new words. Simultaneously, they performed target detection on the interference stimulus appearing with each word: press the spacebar for target stimuli ("+") and ignore distractor stimuli ("-"). The interference stimulus appeared simultaneously with the word, disappearing after 100 ms while the word remained for an additional 700 ms. Participants were instructed to respond to both tasks as quickly and accurately as possible after stimulus onset. The ISI was 1800±200 ms. Words were presented in groups of 12, with 4–9 target stimuli ("+") per group. Response keys were counterbalanced across participants.

2.2 Results and Analysis

During the test phase, two participants were excluded due to excessively low accuracy on target detection. Subsequent statistical analyses were based on the remaining 28 participants' valid data. The average accuracy for target detection was 88%, indicating effective task performance.

We conducted separate 2 (attentional state: target detection vs. distractor rejection) × 3 (word type: deep-encoded old vs. shallow-encoded old vs. new) repeated-measures ANOVAs on recognition reaction times and accuracy (see Table 1).

For reaction times, the main effect of attentional state was marginally significant [$F(1,27) = 3.56$, $p = 0.07$, $p^2 = 0.12$, $0.06 < p^2 < 0.14$, indicating a medium effect size[1]]. The main effect of word type was significant [$F(2,54) = 10.05$, $p < 0.001$, $p^2 = 0.27 > 0.14$], and the interaction between attentional state and word type was significant [$F(2,54) = 24.69$, $p < 0.001$, $p^2 = 0.48 > 0.14$]. Simple effects analysis revealed that for both types of old words, recognition reaction times were significantly shorter under target detection than distractor rejection [deep-encoded old: $F(1,27) = 32.38$, $p < 0.001$, $p^2 = 0.55 > 0.14$; shallow-encoded old: $F(1,27) = 7.53$, $p = 0.011$, $p^2 = 0.22 > 0.14$]. However, for new words, reaction times were significantly longer under target detection [$F(1,27) = 9.32$, $p = 0.005$, $p^2 = 0.26 > 0.14$].

For accuracy, main effects of attentional state [$F(1,27) = 45.49$, $p < 0.001$, $p^2 = 0.63 > 0.14$] and word type [$F(2,54) = 17.81$, $p < 0.001$, $p^2 = 0.40 > 0.14$] were significant, as was their interaction [$F(2,54) = 45.72$, $p < 0.001$, $p^2 = 0.63 > 0.14$]. Simple effects analysis showed that for both old word types, recognition accuracy was significantly higher under target detection than distractor rejection [deep-encoded old: $F(1,27) = 39.29$, $p < 0.001$, $p^2 = 0.59 > 0.14$; shallow-encoded old: $F(1,27) = 62.92$, $p < 0.001$, $p^2 = 0.70 > 0.14$]. Conversely, for new words, accuracy was significantly lower under target detection [$F(1,27) = 36.49$, $p < 0.001$, $p^2 = 0.57 > 0.14$], indicating higher false alarm rates in the target detection condition.

In summary, for old word recognition, target detection produced faster and more accurate responses than distractor rejection, regardless of encoding depth. For new word recognition, the opposite pattern emerged: target detection yielded poorer performance. To more precisely understand the relationship between recognition retrieval and attentional state, we calculated discriminability index d and decision criterion C (see Table 2). Signal detection theory posits that d represents recognition sensitivity, unaffected by emotion, expectation, or motivation, and better reflects memory accuracy than accuracy rates or reaction times. Higher d values indicate greater sensitivity to old-new differences. Decision criterion C reflects changes in participants' response bias, and these two indices are independent, providing a more comprehensive understanding of how attentional settings affect recognition.

Separate 2 (attentional state: target detection vs. distractor rejection) × 2 (processing level: deep vs. shallow) repeated-measures ANOVAs were conducted on d and C. For d , only the main effect of processing level was significant [$F(1,27) = 59.78$, $p < 0.001$, $p^2 = 0.69 > 0.14$], with deep encoding producing higher d than shallow encoding. No main effect of attentional state [$F(1,27) = 0.72$, $p = 0.33$] or interaction [$F(1,27) = 0.11$, $p = 0.75$] was found. For C, main effects of attentional state [$F(1,27) = 56.18$, $p < 0.001$, $p^2 = 0.68 > 0.14$] and processing level [$F(1,27) = 59.78$, $p < 0.001$, $p^2 = 0.69 > 0.14$] were significant. Decision criteria were lower (more liberal) under target detection than distractor rejection and lower for deep-encoded than shallow-encoded words. No interaction was found [$F(1,27) = 0.11$, $p = 0.75$].

Thus, Experiment 1 demonstrated that target detection interference during retrieval did not enhance recognition sensitivity but primarily affected decision criteria, with target detection producing significantly more liberal criteria than distractor rejection. However, could this effect stem from the motor response to target stimuli, making participants more likely to respond "yes" to simultaneously presented words? Previous research suggests motor responses can influence subsequent behavioral decisions (Kaneko & Sakai, 2015; Pape, Noury,

& Siegel, 2017; Wolpert & Landy, 2012). To exclude this potential confound, Experiment 2 changed the response mode from explicit keypress to implicit counting.

Experiment 2

3.1 Method

Thirty different participants were recruited (16 male), aged 18-24 years ($M = 20.9$, $SD = 1.6$). All other conditions were identical to Experiment 1, except that during the test phase, participants were instructed to count the number of target stimuli ("+") appearing in each block of 12 words and report the answer aloud after each block, which the experimenter recorded.

3.2 Results and Analysis

During the test phase, one participant was excluded due to excessively low target detection accuracy, and another for failing to follow instructions. Statistical analyses were based on the remaining 28 participants' valid data. The average target detection accuracy was 89%, indicating effective task performance.

As in Experiment 1, separate 2 (attentional state) × 3 (word type) repeated-measures ANOVAs were conducted on recognition reaction times and accuracy (see Table 3). For reaction times, main effects of attentional state [$F(1,27) = 5.94$, $p = 0.022$, $p^2 = 0.18 > 0.14$] and word type [$F(2,54) = 4.88$, $p = 0.011$, $p^2 = 0.15 > 0.14$] were significant, as was their interaction [$F(2,54) = 14.38$, $p < 0.001$, $p^2 = 0.35 > 0.14$]. Simple effects analysis revealed that for both old word types, recognition reaction times were significantly shorter under target detection [deep-encoded old: $F(1,27) = 12.80$, $p = 0.001$, $p^2 = 0.32 > 0.14$; shallow-encoded old: $F(1,27) = 13.93$, $p = 0.001$, $p^2 = 0.34 > 0.14$]. For new words, reaction times were significantly longer under target detection [$F(1,27) = 6.18$, $p = 0.019$, $p^2 = 0.19 > 0.14$].

For accuracy, main effects of attentional state [$F(1,27) = 36.98$, $p < 0.001$, $p^2 = 0.58 > 0.14$] and word type [$F(2,54) = 37.32$, $p < 0.001$, $p^2 = 0.58 > 0.14$] were significant, as was their interaction [$F(2,54) = 32.50$, $p < 0.001$, $p^2 = 0.55 > 0.14$]. Simple effects analysis showed that for both old word types, recognition accuracy was significantly higher under target detection [deep-encoded old: $F(1,27) = 40.72$, $p < 0.001$, $p^2 = 0.60 > 0.14$; shallow-encoded old: $F(1,27) = 38.51$, $p < 0.001$, $p^2 = 0.59 > 0.14$]. For new words, accuracy was significantly lower under target detection [$F(1,27) = 21.16$, $p < 0.001$, $p^2 = 0.44 > 0.14$].

Discriminability index d and decision criterion C were calculated for Experiment 2 (see Table 2) and analyzed with separate 2 (attentional state) × 2 (processing level) repeated-measures ANOVAs. For d , only the main effect of processing level was significant [$F(1,27) = 90.65$, $p < 0.001$, $p^2 = 0.77 > 0.14$], with deep encoding producing higher d than shallow encoding. No main effect of attentional state [$F(1,27) = 1.86$, $p = 0.18$] or interaction [$F(1,27) = 0.03$, $p = 0.86$] was found. For C, main effects of attentional state [$F(1,27) = 40.76$, $p < 0.001$, $p^2 = 0.60 > 0.14$] and processing level [$F(1,27) = 90.65$, $p < 0.001$, $p^2 = 0.77 > 0.14$] were significant. Decision criteria were lower under target detection than distractor rejection and lower for deep-encoded than shallow-encoded words. No interaction was found [$F(1,27) = 0.03$, $p = 0.86$].

Consistent with Experiment 1, Experiment 2 using implicit counting responses also found no significant difference in d between target detection and distractor rejection, but significantly lower decision criteria under target detection. Thus, target detection's effect on recognition memory is independent of motor response mode and encoding depth.

General Discussion

Using a study-test paradigm with target detection interference during retrieval, this study compared the differential effects of target detection and distractor rejection on memory retrieval. Results showed that regardless of whether target detection required explicit (Experiment 1) or implicit (Experiment 2) responses, recognition performance and speed for old words were superior under target detection compared to distractor rejection, indicating that explicit memory retrieval is modulated by attentional resources. Further analyses of d and C revealed that target detection did not enhance recognition sensitivity but lowered decision criteria, making participants more likely to respond "old" under target detection. This response bias was independent of motor response mode and encoding depth. Thus, explicit memory retrieval is not entirely automatic and remains subject to attentional regulation.

4.1 Memory Retrieval Is Affected by Target Detection Interference and Is Not Fully Automatic

Previous research extensively examining retrieval interference and explicit memory has shown that retrieval interference does not or only minimally affects explicit memory performance (see also Meng, 2010). This led researchers to conclude that retrieval is an automatic process unaffected by attentional resources. However, other studies found that explicit memory retrieval varies with secondary task characteristics (Fernandes et al., 2000, 2003), suggesting retrieval is still affected by differential attentional demands. Yet most previous research compared divided-attention (dual-task) and full-attention (single-task) conditions, which cannot directly reveal how attentional allocation within dual-task situations affects explicit retrieval. The present study is the first to employ target detection as a retrieval interference task, comparing target detection and distractor rejection to examine whether explicit memory retrieval is modulated by attentional resources. Target detection is generally believed to consume more attentional resources than distractor rejection (Swallow & Jiang, 2010, 2011, 2013), and recognition tests also require attentional resources. According to limited resource theory, target detection should reduce attentional resources available to background information, producing worse recognition than distractor rejection. However, both experiments found that for old words, target detection produced faster and more accurate recognition than distractor rejection. We therefore propose that target detection settings affect not only background information encoding (as in ABE; see also Meng & Lin, 2018) but also memory retrieval processes. Thus, explicit memory retrieval is affected by differential attentional demands of interference tasks and is not fully automatic.

4.2 Target Detection's Effect on Memory Retrieval Primarily Involves More Liberal Decision Criteria

Further analyses revealed that target detection' s effect on retrieval primarily manifests as lower decision criteria rather than enhanced recognition sensitivity (d). Participants adopted more liberal response criteria under target detection than distractor rejection. Previous research has also found that attentional interference during memory testing produces more liberal criteria (Hicks & Marsh, 2000). The critical question is: why are criteria more liberal under target detection? The Dual-Task Interaction Model' s explanation for ABE during encoding may provide insight.

As noted, studies using target detection during encoding show that target responses enhance memory for concurrently presented background information, sometimes matching or exceeding full-attention performance. Swallow and Jiang (2013) proposed the Dual-Task Interaction Model to explain ABE. They argued that in dual-task paradigms, when task-relevant stimuli enter perceptual processing simultaneously, they compete for limited perceptual representation resources. The central executive system (CE) then performs attentional regulation based on task characteristics: deciding whether detection stimuli are targets while encoding study stimuli. The model proposes flexible allocation of perceptual resources such that when CE categorizes a detection stimulus as a target requiring response (e.g., keypress, counting, or maintenance in memory), it triggers a temporal selective attention mechanism accompanied by LC-NE release, producing transient activity enhancement (Aston-Jones & Cohen, 2005). This excitation projects diffusely to cortical sensory areas across modalities and spatial locations, enhancing perceptual processing of background information co-occurring with targets and producing ABE' s memory enhancement. fMRI data support this: when participants detected targets while encoding faces, scenes, or scrambled pictures, primary visual cortex activity increased for targets compared to distractors, regardless of modality (Swallow, Makovski, & Jiang, 2012).

We speculate that during retrieval, target detection triggers a similar temporal selective attention mechanism producing transient activity enhancement that facilitates perceptual processing of concurrent background stimuli. Kent and Lamberts (2006) proposed that recognition involves a perceptual stage (integrating stimulus features into perceptual representations) and a retrieval stage (matching perceptual representations to stored memory representations). We propose that enhanced perceptual processing of background stimuli under target detection prompts faster responses, explaining why old word responses were faster under target detection. Processing speed can serve as an objective index of fluency (Wurtz, Reber, & Zimmermann, 2008), and people typically experience fluent stimuli as more familiar or "old," leading to more "old" responses (Jacoby & Whitehouse, 1989; Kurilla & Westerman, 2008; Olds & Westerman, 2012; Westerman, Lloyd, & Miller, 2002; Whittlesea & Bruce, 2002). This explains why participants adopted more liberal criteria under target detection. For new words, the same perceptual processing advantage hindered correct rejection, producing poorer performance under target detection. These results support the Dual-Task Interaction Model' s claim that target detection produces transient perceptual enhancement (Swallow & Jiang, 2013) and provide retrieval-phase evidence for this view. Future research should further investigate the role of metacognitive knowledge about processing fluency and its interaction with attentional resources during retrieval.

4.3 Target Detection Affects Deep- and Shallow-Encoded Words Similarly

This study found that target detection interference during retrieval affected deep- and shallow-encoded words similarly. Deep-encoded words showed superior recognition performance, consistent with levels-of-processing theory (Craik & Lockhart, 1972). However, we found no interaction between attentional state and processing level, which seems inconsistent with some theoretical predictions. Dual-process theory suggests divided attention affects recollection-based retrieval (deep processing) more than familiarity-based retrieval (shallow processing; Jacoby, 1991), and target detection consumes more resources than distractor rejection (Swallow & Jiang, 2010, 2011, 2013). Therefore, target detection should affect deep-encoded words more. Yet we found consistent effects across encoding levels. Lozito and Mulligan (2006) reported similar findings. Using a study-test paradigm, they required deep (semantic) or shallow (phonological) encoding followed by recognition with a concurrent 1-back working memory interference task. They found that interference reduced old word recognition compared to no interference, concluding that "recognition is not automatic or mandatory" —consistent with our view that explicit retrieval is not fully automatic. Importantly, they also found no differential effect of retrieval interference on deep- versus shallow-encoded words. This suggests that encoding-level differences do not necessarily produce differential attentional demands during retrieval; stimuli encoded at different levels may show similar sensitivity to attentional resource fluctuations. Future research could combine EEG or fMRI with attention-sensitive neurophysiological indices (e.g., P300) to further investigate sensitivity to attentional changes during retrieval for differently encoded stimuli.

Limitations and Future Directions

First, this study used “+”and “-”as target detection stimuli. In Chinese contexts, “+” carries connotations of “affirmation” or “correctness,” potentially biasing participants toward “old” responses for words co-occurring with “+” . Future research should use different colors or shapes as target stimuli and increase attentional demands of the target detection task to examine potential differential effects on retrieval. Second, research has demonstrated distractor inhibition effects in target detection tasks (Meng, Lin, & Lin, 2018). Future studies should include a baseline condition where participants ignore the target detection task and perform only the recognition task to further clarify the distinct roles of target detection and distractor rejection in memory retrieval.

Conclusion

Explicit memory retrieval is affected by target detection interference during retrieval. This effect manifests not as enhanced recognition sensitivity (d) but as reduced decision criteria (C), making participants more likely to respond “old” under target detection. This response bias is independent of motor response mode and encoding depth. Thus, explicit memory retrieval is not fully automatic and remains subject to attentional regulation.

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[1] According to Cohen’ s (1992) criteria, p^2 values of 0.01, 0.06, and 0.14 correspond to small, medium, and large effect sizes, respectively.

Note: Figure translations are in progress. See original paper for figures.

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