Cue-independent forgetting by intentional suppression – Evidence for inhibition as the mechanism of intentional forgetting

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the target word. Then, they pressed the space key to get the correct answer and reported whether their answer was correct. The self-test phase lasted until subjects reached 91.67% (22 out of 24) accuracy for both A-T and B-T pairs so as to ensure that memory strength was strong for both series and for all of the subjects.

2.3.2. Interference/Inhibition training

Sixteen A-T word pairs were used for two divergent tasks: eight for interference and eight for inhibition training. Each cue word was first presented on the left side of the computer screen for 1 s. Then, the word turned red. In the interference condition, a substitute word appeared on the right side of the computer screen, and subjects were asked to memorize the new word pair (A-Distractor) in 4 s; in the suppression condition, no target word was shown, and the cue word remained on the screen for 8 s. Subjects were instructed to not think about the original target word, and two critical points were emphasized during the suppression condition. First, in order to achieve the inhibition effect, we asked subjects to initiate the suppression after they had an impulse to retrieve the target word. Second, subjects were required to not think about other distracting things. Both interference and inhibition trainings were repeated 12 times, with 192 trials in total. Compliance with instructions was checked after training, and all of the subjects reported that they had followed the above instructions correctly.

2.3.3. Testing

We tested subjects' memory for all of the word pairs learned during the first phase (A-?; B-?). Cue words from different conditions were intermixed and shown sequentially; subjects were asked to recall the corresponding target word by typing it on the computer keyboard, with no time limit. The order of testing for the trained- and independent-cue tests were counterbalanced across items and within subjects.

3. Results

We calculated the mean percentage of target words that were recalled during the final test. A 2 (test type: trained-cue vs. independent-cue) × 3 (treatments: interference, inhibition, control) repeated measures ANOVA was employed. Results (Fig. 2) showed that, the main effect of test type ($F(1,30) = 17.70$, $p < .001$, MES = 0.03, $\eta_p^2 = 0.37$) was significant, with stronger memory impairment for under trained- than independent-cue retrieval. The main effect of treatment ($F(2,60) = 10.52$, $p < .001$, MES = 0.03, $\eta_p^2 = 0.26$) was also significant. As expected, when compared to the control condition, both interference (MD = −0.95, $p = .012$) and inhibition (MD = −0.13, $p < 0.001$) caused target memory impairment.

The interaction effect of the two factors was also significant ($F(2,60) = 3.20$, $p = .048$, MES = 0.03, $\eta_p^2 = 0.10$). Simple effects analyses showed differences between the effects of interference and inhibition training. In the interference condition, memory impairment was only found under the trained-cue retrieval (A-T: interference < control, $t(30) = -3.43$, $p = .002$) but not under the independent-cue retrieval (B-T: interference < control, $t(30) = -0.52$, $p = .608$). In contrast, in the inhibition condition, memory impairment was found in both the trained-cue (A-T: inhibition < control, $t(30) = -4.90$, $p < .001$) and the independent-cue (B-T: inhibition < control, $t(30) = -2.79$, $p = .009$) tests. In addition, memory performance was not different between the two test types ($t(30) = -1.88$, $p = .071$) following inhibition training.

To further discriminate the effects of inhibition and interference, we calculated the percentage of forgotten items for the trained-cue test that generalized to the independent-cue test. If

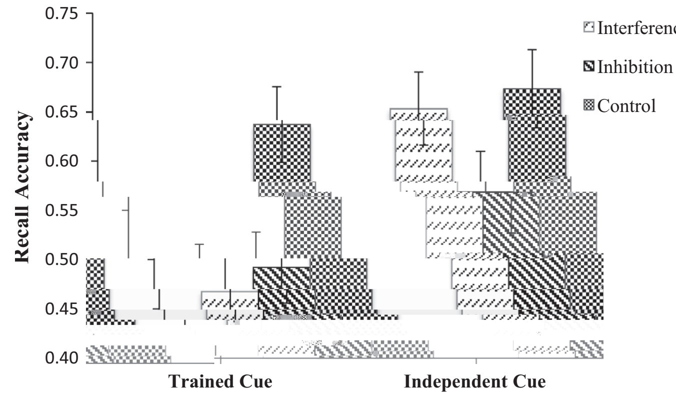

Fig. 2. Recall accuracy for each test type and each training condition. Error bars represent standard errors of the recall accuracy.

intentional suppression indeed works on the target memory itself, items that failed to be retrieved in the trained cue-target associations should also be forgotten in the independent cue-target associations. The generalization index was calculated by dividing the percentage of items that were forgotten in the trained-cue test from that in both the trained- and independent-cue tests. The percentage of generalization was different across the three conditions ($F(2,48) = 3.75$, $p = .03$, MES = 0.06, $\eta_p^2 = 0.14$). As expected, generalization was significantly higher in the inhibition condition than in the interference condition ($t(24) = -3.93$, $p < .001$), confirming the cue-independent nature of intentional inhibition.

4. Discussion

In this study, we used a double-cue paradigm to explore the underlying mechanism of intentional forgetting. Results show differences between the effect of intentional suppression and associative interference. Intentional suppression causes generalized memory impairment, as accessibility of the target memory is reduced for both the trained and the independent cues. In contrast, interference training only affects the directly trained cue-target association. As forgetting by intentional suppression is independent of the cue, it is in line with findings from Anderson and colleagues (Anderson, 2005; Anderson & Green, 2001; Anderson et al., 2004) which showed that intentional suppression impairs only the target memory.

Although the cue-independent forgetting has long been used to support the role of inhibitory control in intentional forgetting (e.g., Anderson & Green, 2001; Anderson et al., 2004; Benoit & Anderson, 2012), some have argued that it reflects interference mechanisms driven by covert cuing (Camp et al., 2009). However, as Weller et al. (2013) have reasoned, if the independent cue covertly retrieved the trained cue during test, it would also result in blocking on the cue-target association as well and further memory impairment. Yet their findings showed that deliberately recruiting covert cuing did not cause but masked the cue-independent forgetting, and therefore strongly opposed the covert-cuing explanation for independent-cue technique. While Weller et al.'s (2013) study was on retrieval-induced forgetting (RIF) effect, here we tested the covert-cuing explanation in relation to the TNT paradigm and intentional forgetting. By directly comparing the effects of interference and suppression training, different patterns of forgetting were revealed. Therefore, we rejected the role of covert-cuing in intentional forgetting. In this way, the covert-cuing explanation for independent-cue retrieval was excluded consistently by different experimental approaches.

Benoit and Anderson (2012) compared the effect of direct suppression with a procedure that trained subjects on thought substitutes. In contrast to the present findings, they found cue-independent forgetting effects in the thought substitution condition. However, this finding may be because of the difference between their manipulation and the one used in the current study. In Benoit and Anderson's (2012) study, participants first memorized a list of substitute associations, and during the training session, they retrieved the substitute words repeatedly to prevent the original memory from entering their mind. This type of manipulation is in line with the RIF procedure, where retrieving a related

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