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Are Independent Probes Truly Independent?

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The independent cue technique has been developed to test traditional interference theories against inhibition theories of forgetting. In the present study, the authors tested the critical criterion for the independence of independent cues: Studied cues not presented during test (and unrelated to test cues) should not contribute to the retrieval process. Participants first studied a subset of cues (e.g., *rope*) that were subsequently studied together with a target in a 2nd study phase (e.g., *rope–sailing*, *sunflower–yellow*). In the test phase, an extralist category cue (e.g., *sports*, *color*) was presented, and participants were instructed to recall an item from the study list that was a member of the category (e.g., *sailing*, *yellow*). The experiments showed that previous study of the paired-associate word (e.g., *rope*) enhanced category cued recall even though this word was not presented at test. This experimental demonstration of covert cuing has important implications for the effectiveness of the independent cue technique.

Keywords: independent probe technique, retrieval-induced forgetting, inhibition, interference, memory retrieval

An influential account of forgetting of information in memory is that forgetting is caused by interference processes at retrieval (e.g., McGeoch, 1942; Mensink & Raaijmakers, 1988; Müller & Pilzecker, 1900; Raaijmakers & Shiffrin, 1981; Roediger, 1974; Rundus, 1973). In this view, a memory item becomes less accessible over time by the addition of interfering memory traces. More recently, however, researchers have argued that forgetting is due to inhibition (Anderson, 2003; Anderson, Bjork, & Bjork, 1994; Anderson & Green, 2001; Anderson & Spellman, 1995; Bäuml, Zellner, & Vilimek, 2005; Levy & Anderson, 2002; for a more complete overview of different accounts of forgetting, see Anderson & Bjork, 1994). Inhibition theory states that people have executive control over the activation of items in memory and that they can actively inhibit the activation of certain memory traces when they compete with other traces for retrieval.

To differentiate between inhibition and interference theories of forgetting, Anderson and Spellman (1995) developed the independent cue technique. Independent cues are used in the test phase of the experiment to test memory for target items. Independent cues are cues that are unassociated with the competing item (i.e., cues that have not been studied with the competing item and that are pre-experimentally unrelated to the competing item). Interference and inhibition accounts make different predictions when an independent retrieval cue is used. Forgetting in interference accounts is cue dependent. For example, if participants study the pairs SOUPS–*chicken* and SOUPS–*tomato*, the existence of an association between SOUPS and *chicken* impairs retrieval of *tomato* to the cue SOUPS. The reason is that both *chicken* and *tomato* are associated to the same cue and compete for retrieval. In this account, retrieval of an item to a cue depends on the relative associative strength between the cue and the item in memory. Strengthening of a competing association decreases the relative associative strength between the cue and the target item and decreases the ease with which the target item can be retrieved from memory. According to standard interference accounts, however, strengthening of SOUPS–*chicken* should not affect retrieval of *tomato* to a different cue, such as RED. This is because the relative associative strength between RED and *tomato* is not affected by the association between SOUPS and *chicken*. In contrast, forgetting in the inhibition account is cue independent. That is, forgetting may be observed even when memory is tested with a cue (e.g., RED) that is not associated to the competing item (e.g., *chicken*). The reason is that the target item itself (e.g., *tomato*) is inhibited, and retrieval of the target item should be impaired regardless of the cue that is used to access memory (Anderson, 2003; Anderson & Bjork, 1994; Anderson & Spellman, 1995; Levy & Anderson, 2002).

The independent cue technique has been used in two types of paradigms: the retrieval-practice paradigm and the think/no-think paradigm. In the retrieval-practice paradigm, participants first study category-exemplar pairs, such as SOUPS–*chicken*, SOUPS–*turkey*, SOUPS–*tomato*, and SOUPS–*onion*. Then, in the retrieval-practice phase, participants retrieve a subset of the studied items in a category-cued word stem completion task (e.g., SOUPS–*ch*_____ and SOUPS–*tu*_____). Retrieval practice is assumed to result in competition between different items from the same category and causes inhibition of nonpracticed items from the category (e.g., *tomato* and *onion*). In the final test phase, memory is tested with an independent cue (e.g., VEGETABLES) that is not associated to the practiced items (e.g., *chicken* and *turkey*). Compared with control items from categories that did not receive retrieval practice, re-

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trieval practice leads to reduced recall of the nonpracticed items (*tomato* and *onion*) on a later cued memory test (e.g., Anderson & Bell, 2001; Anderson, Green, & McCulloch, 2000; Anderson et al., 2004; Anderson & Spellman, 1995; Aslan, Bäuml, & Pastötter, 2007; Saunders & MacLeod, 2006; but see Camp, Pecher, & Schmidt, 2007; Perfect et al., 2004; Williams & Zacks, 2001). These findings have been interpreted as strong evidence for the role of inhibition in forgetting.

A different, but related, paradigm that has provided evidence for inhibitory processes is the think/no-think paradigm. In this paradigm, participants are actively instructed to forget certain information that was previously studied. For example, participants study a number of unrelated cue-target pairs, such as *ordeal–roach*. Then, in a think/no-think task, they are presented with only the cue (*ordeal*) for a subset of the pairs and are instructed either to recall and think about the target (think condition) or to prevent the target from entering consciousness (no-think condition). Finally, in the test phase, all independent cues (e.g., INSECT–*r*_____) are presented, and participants are asked to respond with a studied target. Also, in this paradigm forgetting has been found when independent extralist cues are used (e.g., Anderson & Green, 2001; however, for failures to find cue-independent forgetting, see Bulevich, Roediger, Balota, & Butler, 2006; Wessel, Wetzels, Jelicic, & Merckelbach, 2005).

The finding of forgetting with the independent cue technique seems to provide solid evidence for inhibition theories of forgetting. However, the results of a few studies suggest, albeit indirectly, that the independent probe technique may not provide an independent test of memory. A potential problem of the independent probe technique is covert cuing (Anderson, 2003; Anderson et al., 2000). Covert cuing refers to the use of retrieval cues that were not provided at test. For example, in the retrieval-practice paradigm, it is possible that participants used the studied category (e.g., SOUPS) as a retrieval cue in the test phase of these studies, even though they were only cued with an independent cue (e.g., VEGETABLE). Half of the SOUPS items from the study phase were also VEGETABLE items, thereby possibly creating an association between the two categories. Moreover, attempting to recall studied items with an independent cue in the test phase may have proven difficult (Tulving & Thomson, 1973), and participants may have tried to use the category cue with which the items were originally studied as a more effective cue. Thus, it is possible that participants used the studied categories as cues in the test phase, because of the association between VEGETABLES and SOUPS and the higher effectiveness of SOUPS as retrieval cue. Moreover, the enhanced accessibility of SOUPS, because of its repeated presentation in the retrieval-practice phase, may also have increased the likelihood that it was used as a cue in the test phase. The same process may occur in the think/no-think paradigm. There, the cues from the study phase and the think/no-think task (e.g., *ordeal* for *roach*) may have been used as cues in the test phase, even when cued with an unstudied category (INSECT–*r*_____). The potential problem of covert cuing has been acknowledged by Anderson (2003), and he has emphasized the importance of adapting the experimental procedure to reduce this factor (Anderson, 2003; Anderson et al., 2000).

Some indication that participants use covert cuing strategies has been obtained by Anderson et al. (2000). On a post-experiment questionnaire, they asked participants to rate the degree to which they scanned back through the study categories to help them think of responses to the independent cues. Participants assigned an average rating of 2.68 on a 5-point scale. This suggests that study cues were used to retrieve studied items, even though only independent cues were presented in the test phase. Additional support for the covert cuing hypothesis was reported by Camp, Pecher, and Schmidt (2005). Camp et al. (Experiment 2) used an implicit memory task with independent extralist cues in the final memory test of the retrieval-practice paradigm. After the experiment, participants were asked whether they were aware of the relation between the test phase and the other phases of the experiment. Retrieval-induced forgetting was found for participants who were aware that their memory for studied items was tested, but no forgetting was found for participants who were unaware that their memory for studied items was tested. Camp et al. argued that aware participants may have used a retrieval strategy involving the activation of studied categories, which would be another demonstration of covert cuing.

Anderson et al.'s (2000) and Camp et al.'s (2005) studies suggest that covert cuing may play a role in the independent probe technique. However, this evidence comes from post-experiment questionnaires. Therefore, it is important to investigate more directly whether independent extralist cues are truly independent. The present experiments were set up to provide a more direct test of the independence of extralist cues. Because our primary concern was with the independence of extralist cues, we made an effort to keep the design as simple as possible (rather than to mimic the retrieval-practice paradigm as closely as possible). Therefore, we presented one word of a paired-associate pair in a different study task and investigated the effect of this extra study episode on final memory for the associate in a test using independent cues.

In Experiment 1, we used weakly related cue-target pairs, such as *rope– sailing*. In a first study phase, a subset of the cues was presented alone (e.g., *rope*), and participants were required to rate the cues on pleasantness and frequency. In a second study phase, participants studied the cue-target pairs (e.g., *rope–sailing*, *sunflower–yellow*). Finally, in the test phase, the effect of additional cue study was measured by testing memory for target items with extralist cues (e.g., *sport*, *color*). If extralist cues are truly independent, we would expect no effect of additional study of the cue on recall of the target. However, if the extralist cues are not truly independent, the cues that received additional study may be more available and used as additional cues in the test phase. In that case, we would expect a facilitation effect on recall of the target.

Experiment 1

Method

Participants. Forty students of the Erasmus University Rotterdam (Rotterdam, the Netherlands) participated for course credit. All participants were native speakers of Dutch.

Materials and design. We constructed 24 cue-target pairs, such as *rope–sailing* (note that all words were in Dutch; see Appendix A for the full list of cue-target pairs along with English translations). Cues and targets were weakly associated according to Dutch association norms (van Loon-Vervoorn & Bekkum, 1991). The mean cue-to-target association frequency was 0.023 (SD = 0.018), and the mean target-to-cue association frequency was 0.024 (SD = 0.016). Cues and targets within each pair were not related to any other cues or targets in the experiment. Each target was a member of a different taxonomic category (e.g., *sport–sailing*). The category names were used in the test phase of the experiment as independent extralist cues to test target recall. The mean position of the targets on a frequency-sorted list of their category was 7.0 (SD = 5.09) according to Dutch category production norms (Hudson, 1982). Apart from the target, no other item in the study list was a member of the category. The mean target-to-category association frequency according to the free association norms was 0.022 (SD = 0.028). Category-to-cue and cue-to-category association frequencies were very low (M = 0.001, SD = 0.003). Not all association strengths were available within each cue-target-category triple. In these cases, we selected items that we judged to be similar in association frequency to items for which these association frequencies were available.

Procedure. Participants were tested individually. The experiment consisted of two study phases and a test phase. In the first study phase, half of the cues (e.g., *rope*) were presented twice. In the first part of this phase, cues were presented for 2 s on the computer screen. After each presentation, participants were asked to give a pleasantness rating for each cue on a 5-point scale. In the second part of this phase, all cues were again presented for 2 s, but now participants were asked to give a frequency rating of the cue in the Dutch language on a 5-point scale. In both parts, cues were presented in random order. Two counterbalanced lists were constructed so that across participants each cue was presented equally often in each condition. Participants were not told that their memory for targets was going to be tested. In the second study phase, all 24 cue-target pairs were presented in a random order for 4 s on a computer screen (e.g., *rope–sailing*, *sunflower–yellow*). After each presentation, participants were asked to give a similarity rating for the pair on a 5-point scale.

In the test phase, using independent extralist cues, we tested recall for targets of which the cue had been studied in the first study phase (cue study items) and targets of which the cue had not been studied in the first study phase (control items). The 24 category names (e.g., *sport*, *color*) were presented individually, and participants were asked to type a word that they had seen in the first study phase that was a member of the presented category. Category cues were presented in random order, and the task was self-paced.

Results and Discussion

Recall percentages in the test phase can be found in Table 1. As can be seen, additional study of a cue (e.g., *rope*) led to significantly higher recall of its corresponding target (e.g., *sailing*), $t(39) = 3.52$, $p < .01$, $d = 0.56$. Thus, providing pleasantness and frequency ratings of a cue before the cue-target pair was studied facilitated recall of the target. This suggests that cues that received additional study were activated during the test phase to aid target recall. Because cues that received additional study were more accessible, recall of their corresponding targets was facilitated compared with targets of which the cue did not receive additional study. Thus, even when unrelated extralist independent cues are presented at test, studied cues may still be activated and affect retrieval. In other words, "independent" cues may not provide an independent test of memory. The present findings suggest that the critical criterion for the independence of the independent cue technique, namely that study cues that are not presented at test should not affect retrieval, is not met.

Table 1
Recall Percentages of Experiments 1–4

	Item type					
	Cue study items		Control items		Difference	
Experiment	*M*	*SEM*	*M*	*SEM*	*M*	*SEM*
Experiment 1	55.0	3.37	44.8	3.35	10.2	2.90
Experiment 2	39.7	3.03	30.8	2.50	8.9	3.01
Experiment 3						
Short list	87.5	1.89	89.8	2.08	−2.3	2.15
Long list	78.9	1.98	78.5	2.65	0.4	2.73
Experiment 4						
Original study cue	73.8	2.74	79.5	2.44	−5.7	1.73
Independent cue	50.9	2.20	44.9	2.23	6.0	2.83

Note. In Experiments 1 and 2, independent cues were used during testing. In Experiment 3, the original study cues were used. In Experiment 4, type of test probe (original study cue vs. independent cue) was used as a between-subjects condition.

Experiment 2

The results of Experiment 1 indicate that study cues were activated in the test phase. An important factor in this finding may have been that the recall task in Experiment 1 was self-paced. This gave participants ample opportunity to think back to earlier phases of the experiment. Thus, it could be that covert cuing effects are found only when participants have a lot of time to retrieve the target items from memory but not when the response time is limited (see Anderson, 2003). To investigate this, we did an additional experiment that was identical to Experiment 1 except that in the test phase participants were given a maximum response time of only 5 s for each category cue.

Method

Participants. Thirty students of the Erasmus University Rotterdam participated for course credit. All participants were native speakers of Dutch. None of the participants had participated in Experiment 1.

Materials, design, and procedure. The materials, design, and procedure of Experiment 2 were identical to Experiment 1, except that in the in the test phase, participants were given a maximum response time of only 5 s for each category cue.

Results and Discussion

The final recall results are presented in Table 1. Although the shorter response time reduced the general level of recall compared with Experiment 1, there was a significant difference in recall between cue study items and control items, $t(29) = 2.95$, $p < .01$, $d = 0.54$. This demonstrates that activation of the study cues occurs even with short response times in the test phase.

The results of Experiment 2 provide further evidence that study cues are activated at test, even when participants are only cued with independent cues and are given limited response time. Surprisingly, the facilitation effect in Experiment 2 was of the same magnitude as in Experiment 1. It was expected that limiting the response time would reduce covert cuing (see Anderson, 2003). This was not the case, indicating that limiting the response time in the test phase may not always reduce the amount of covert cuing.

Still, there is another alternative explanation for the results of Experiments 1 and 2. Study of the cues may have had its impact at the moment of cue-target study rather than at the moment of target retrieval. Study of a subset of the cues may have facilitated later encoding of the cue-target pairs in the second study phase relative to pairs for which the cue did not receive additional study. Thus, the results of Experiments 1 and 2 might be explained by stronger encoding of the cue-target pair at study instead of stronger retrieval cues at test because of cue strengthening. Some support for this hypothesis comes from studies on classical conditioning, showing that prior presentation of the conditioned stimulus leads to larger conditioned responses (Silver, 1973). In contrast, two recent studies show that processing of the cue prior to study of cue-target pairs does not enhance memory for the target on a subsequent cued recall test (Malmberg, 2008; Schwartz & Metcalfe, 1992). Thus, previous studies do not show strong evidence for facilitation of cue-target encoding because of prior study of the cue. These studies, however, differed on a number of dimensions from our experiments. In Experiment 3, we therefore tested the hypothesis that prior cue study results in better encoding of the cue-target pair using the same procedures and materials we had used in Experiments 1 and 2. To achieve this goal, we used the original cues from the study phase (e.g., *rope*) to test memory for targets (e.g., *sailing*) in the test phase instead of the independent cues used in Experiments 1 and 2 (e.g., *sport*). If prior study of the cue facilitated encoding of the cue-target pair, we expect to find a facilitation effect for cue study items. However, if prior study of the cue does not facilitate encoding of the cue-target pair, no facilitation effect is expected. Moreover, because the original study cues are now presented at test, covert cuing will not occur. Thus, a covert cuing account of our previous experiments would not predict a facilitation effect using study cues in the test phase.

Note that, in accordance with the encoding specificity principle (Tulving & Thomson, 1973), overall cued recall performance in Experiment 3 was expected to be better than that in Experiments 1 and 2. We therefore included a between-subjects condition in which we added additional filler pairs to the study list to increase the list length, thereby lowering final recall performance (Tulving & Pearlstone, 1966).

Experiment 3

Method

Participants. Eighty students of the Erasmus University Rotterdam who had not participated in any of the previous experiments participated for course credit. All participants were native speakers of Dutch.

Materials, design, and procedure. The materials, design, and procedure of Experiment 3 were identical to those of Experiment 2, except that the original study cues (e.g., *rope*) were used as cues to test memory for targets (e.g., *sailing*) in the test phase instead of independent cues (e.g., *sport*). List length was manipulated between subjects. For half of the participants, the list length was identical to that of Experiments 1 and 2. For half of the participants, we added 48 filler pairs to the study list (see Appendix B for the filler pairs along with English translations). Half of the cues from the filler pairs also received additional study in the first study phase. We constructed filler pairs that were unrelated to experimental cue-target pairs and that we judged to be similar in association frequency. Memory for the filler pairs was not tested.

Results and Discussion

Recall percentages in the test phase can be found in Table 1. There was no difference in recall between the targets for which the cue had received extra study and targets for which the cue did not receive extra study, $F(1, 78) < 1$. We used the effect size of Experiment 2 ($d = 0.54$) to calculate the power of Experiment 3 to detect an effect of the same magnitude as Experiment 2, given an alpha level of .05 and $N = 80$ (Faul, Erdfelder, Lang, & Buchner, 2007). The power was large, $1 - \beta = 0.97$. This is not surprising, given the large power of Experiment 2 ($1 - \beta = 0.92$) and the considerably larger sample size in Experiment 3 ($N = 80$ in Experiment 3 vs. $N = 30$ in Experiment 2). Thus, our procedure was quite adequate to detect a possible effect of additional cue study, but none was found. This indicates that previous study of the cue does not facilitate encoding of the cue-target pair. There was a main effect of list length, $F(1, 78) = 15.34$, $MSE = 255.33$, $p < .001$, $\eta_p^2 = .16$, which indicates that adding fillers to the study list significantly lowered recall. There was no interaction between the cue-study condition and the list length condition, $F(1, 78) < 1$. Thus, as expected, the mean recall percentages were rather high (87.5% for the cue study items and 89.8% for the control items) when no filler items were added to the study list, but these percentages were lowered significantly when filler items were added (78.9% for the cue study items and 78.5% for the control items).

These results indicate that previous study of the cue does not facilitate encoding of the cue-target pair in our paradigm. This finding is consistent with similar findings in the literature (Malmberg, 2008; Schwartz & Metcalfe, 1992). Taken together, the results of Experiments 1–3 indicate that study cues are used at test, even though participants are tested with independent cues.

This finding has serious consequences for studies that aim to differentiate between interference and inhibition as explanations of forgetting. To test the generalizability of our findings, we did a final experiment in which we varied a couple of conditions to reflect the range of conditions under which retrieval induced forgetting and forgetting in the think/no-think paradigm are obtained. First, a large number of studies using independent cues have used letter stems at test to make the cue specific for only one target (e.g., Anderson & Bell, 2001; Anderson & Green, 2001; Anderson et al., 2000, 2004; Aslan et al., 2007; Camp et al., 2007). We should note that the extralist independent cues that we used in Experiments 1 and 2 were also item specific, because only one studied target was a member of the presented category. Thus, a letter stem was not needed to make the cues item-specific in our experiments. Even so, to test whether the facilitation effect of cue study is still found when letter cues are presented at test, we added letter stems to our extralist independent cues in Experiment 4. Second, some studies have used a retention interval of 15–20 min between retrieval-practice and test in the retrieval-practice paradigm (e.g., Anderson & Bell, 2001; Anderson et al., 1994, 2000; Anderson & Spellman, 1995; Camp et al., 2005). In Experiments 1–3, we used a shorter retention interval of only 5 min between the second study phase and the test phase. We should note that other studies have found retrieval-induced forgetting using shorter retention intervals than 15–20 min (e.g., Aslan et al., 2007; Bäuml, 2002; Camp et al., 2007; Ciranni & Shimamura, 1999; MacLeod & Macrae, 2001; Racsmány & Conway, 2006; Racsmány, Conway, Garab, & Nagymate, 2008; Veling & van Knippenberg, 2004), and there is no a priori reason why the retention interval should be 15–20 min. However, it may be that covert cuing decreases over longer retention intervals. To test whether the covert cuing effect generalizes to longer retention intervals, we used a retention interval of 20 min between the second study phase and the test phase in Experiment 4. The addition of Experiment 4 also enabled us to manipulate the type of test probe within a single experiment. In Experiment 2, extralist independent cues were used, and a covert cuing effect was found. In Experiment 3, the original study cues were used at test, and this eliminated the facilitation effect. In Experiment 4, we used type of test probe (original study cues vs. extralist independent cues) as a between-subjects condition, which enabled us to randomly assign participants to the two test probe conditions. We expected an interaction between cue study and type of test probe, showing a facilitation effect in the independent cue condition but not in the original study cue condition.

Experiment 4

Method

Participants. One hundred and twelve students of the Erasmus University Rotterdam who had not participated in any of the previous experiments participated for course credit. All participants were native speakers of Dutch.

Materials, design, and procedure. The materials, design, and procedure of Experiment 4 were identical to those of Experiment 2, with the following exceptions. First, we manipulated the type of test probe between subjects. In the original study cue condition, participants were presented with the original study cues at test (e.g., *rope* for the target *sailing*). In the independent probe condition, participants were presented with the same extralist independent cues that were used in Experiment 2 (e.g., *sport* for the target *sailing*). Second, the first letter of the target was added to the test cue (e.g., *rope–s*___ in the original study cue condition, *sport–s*___ in the independent probe condition). Third, the interval between the second study phase and the test phase was extended from 5 min to 20 min. Finally, we added the same 48 filler pairs to the study list as we used in the long study list condition in Experiment 3 to lower final recall performance. This was done because, in accordance with the encoding specificity principle (Tulving & Thomson, 1973), we expected higher cued recall performance in the original study cue condition (see Experiment 3). Half of the cues from the filler pairs also received additional study in the first study phase.

Results and Discussion

Recall percentages in the test phase can be found in Table 1. There was no main effect of cue study, $F(1, 110) < 1$. However, there was a main effect of type of test probe, $F(1, 110) = 92.66$, $MSE = 498.53$, $p < .001$, $\eta_p^2 = .46$, indicating that participants recalled more items in the original cue condition than in the independent cue condition. The interaction between cue study and type of test probe was significant, $F(1, 110) = 12.25$, $MSE = 153.93$, $p < .01$, $\eta_p^2 = .10$, indicating that the effect of cue study was larger in the independent cue condition than in the original cue condition. Subsequent *t*-tests showed that in the independent cue condition, cue study items benefited significantly from extra study of the cue compared with control items, $t(55) = 2.10$, $p < .05$, $d = 0.36$. Surprisingly, in the original cue condition, cue study items were recalled more poorly than control items, $t(55) = 3.28$, $p < .01$, $d = 0.29$. This latter effect was unexpected because in Experiment 3 we obtained no difference between the cue study and control conditions when the original study cue was presented at test. Similarly, Malmberg (2008) and Schwartz and Metcalfe (1992) also found no difference between these conditions. One possible explanation of the present results is that cues that have received additional study during the study phase attract attention during final recall at expense of the letter cue. If indeed this happens, letter cues may not be used to the full extent in the retrieval process, and this may harm recall relative to a condition in which the letter cue is used more effectively during recall. In Experiment 3 of the present study, and in Malmberg's study and Schwartz and Metcalfe's study, no deficit may have been observed because letter cues were not presented during recall. Admittedly, this explanation is somewhat speculative. More important, however, was our finding that cue study again facilitated recall for independent cues. Thus, the facilitation effect that we found in Experiments 1 and 2 using extralist independent cues was also found in Experiment 4 using letter stems and a longer retention interval between the second study phase and the test phase.

General Discussion

Independent cues have been used in many studies to differentiate between interference and inhibition accounts of forgetting (e.g., Anderson & Green, 2001; Anderson et al., 2000; Anderson & Spellman, 1995). Because interference accounts do not predict forgetting for independent cues that have not been studied with the target, forgetting effects found when using independent cues have been attributed to inhibitory processes. However, the results of some studies have shown that participants report covert cuing strategies involving the activation of study cues, even though they are cued with independent items. Rather than relying on post-experiment questionnaires, the present experiments provided a more direct test of whether independent cues can provide an independent test of memory.

In Experiment 1, additional study of cues from previously studied cue-target pairs resulted in facilitation of the targets on a later test using extralist cues. This suggests that target recall depends on the accessibility of the study cue at test, even though independent cues are used that are expected to test the activation of the targets directly. In Experiment 2, it was shown that limiting retrieval time to 5 s does not eliminate the facilitation effect. The results of Experiment 3 demonstrate that the facilitation effect found in the previous experiments was not caused by better encoding of the cue-target pairs after study of the cue, because the effect was eliminated when we used the original study cues in the test phase. Finally, it was shown in Experiment 4 that the facilitation effect found with independent extralist cues in Experiments 1 and 2 generalizes to procedures that use letter stems (in addition to the cue word) at test and a longer retention interval between study phase and test.

The observed facilitation effect in Experiments 1, 2, and 4 indicates that covert cuing can provide a recall advantage for those items of which the cue received additional study. At first sight, it may seem that covert cuing in the retrieval-practice paradigm would lead to a final recall advantage, rather than a disadvantage, for nonpracticed items (e.g., SOUPS–*tomato* and SOUPS–*onion*) from practiced categories compared with control items. When in the final recall test memory for these nonpracticed items is tested with an extralist cue (e.g., VEGETABLES), the studied category (e.g., SOUPS) may be activated. The category cues of nonpracticed items from practiced categories may be more accessible than the category cues of control categories because of the retrieval-practice phase. Because category cues are more accessible for supposedly inhibited items than for control items, the inhibition effect might be masked (see Anderson, 2003). The results of Anderson et al. (2000) can be seen as support for the masking effect of covert cuing. In their study, participants who indicated higher levels of covert cuing showed numerically less forgetting. However, this difference was not statistically significant. Moreover, it was based on self-reports that may have been colored by performance on the recall task. Participants who showed forgetting (poor performers) could have denied the use of covert cuing strategies and participants that did not show forgetting (high performers) could have done the opposite (Perfect et al., 2004).

Also, it is unclear that a masking effect would indeed be predicted when covert cuing occurs. The current experiments did not employ an inhibition or interference paradigm, but focused on the effects of restudy of the cue. In the retrieval-practice paradigm, however, the study cue is not just restudied in the retrieval-practice phase, but it is used as a cue for a competitor. The strengthening of the association between the study cue and a competitor may lead to blocking of the target when the study cue is covertly cued in the test phase. Thus, it is quite possible that the use of covert cuing in the retrieval-practice paradigm would impair recall, rather than improve recall as we found in the present study. Some evidence for this hypothesis comes from Camp et al. (2005), who used an implicit memory test in the retrieval-practice paradigm. They showed that forgetting did not occur when participants were unaware that their memory for studied items was tested in an implicit memory test, but that forgetting did occur when participants *were* aware of this fact. Unaware participants were unlikely to use retrieval strategies involving the activation of studied categories, because they were not aware that they were generating previously studied items. Thus, blocking did not occur for unaware participants. Blocking could have occurred for participants who did notice the connection between the different phases of the experiment, even though the test instruction was implicit.[1] If covert cuing leads to blocking, this would indicate that the independent probe technique cannot adequately differentiate between interference and inhibitory accounts of forgetting.

It is clear that the consequences of covert cuing are still open to debate. Future research should investigate what the effect of covert cuing is on the degree of forgetting in the retrieval-practice paradigm and the think/no-think paradigm. Even so, the fact that covert cuing does occur poses a problem for the independence of independent cues, because the criterion for independence is that recall is not influenced by the original study cues.

We should mention that the retrieval-practice paradigm has also been used to study forgetting in other memory tasks. Forgetting has been found by researchers using tests of item recognition (Gómez-Ariza, Lechuga, Pelegrina, & Bajo, 2005; Hicks & Starns, 2004; Spitzer & Bäuml, 2007; Veling & van Knippenberg, 2004; but see Koutstaal, Schacter, Johnson, & Galluccio, 1999) and lexical decision (Veling & van Knippenberg, 2004), which is difficult to explain by interference processes. Whether noninhibitory explanations for these findings can be found is an issue that needs to be addressed by future studies. Our results do, however, imply that the use of the independent cue technique to differentiate between the contributions of interference and inhibition to forgetting in cued recall paradigms may be problematic. This is because covert cuing may not enhance but impair recall of the target in the retrieval-practice paradigm. The finding that independent cues are not always independent is, we believe, significant because in the last decade the independent cue technique has played a central role in discussions of the processes responsible for forgetting.

An additional question is whether our results generalize to other types of independent cues. Independent cues can be either intralist cues (e.g., Anderson & Bell, 2001; Anderson & Spellman, 1995) or extralist cues (e.g., Anderson et al., 2000; Camp et al., 2007; Johnson & Anderson, 2004; Levy, McVeigh, Marful, & Anderson, 2007), and they can cue one single item (e.g., Camp et al., 2007; Johnson & Anderson, 2004; Levy et al., 2007) or multiple items (e.g., Anderson et al., 2000; Camp et al., 2005). In the present study, we used item-specific extralist independent cues. We believe that when item-specific extralist cues are used, covert cuing is least likely to occur. First, when an independent cue is a cue for multiple items (e.g., VEGETABLE is a cue for *tomato* and *onion*), these items always belong to the same study category (e.g., SOUPS). Thus, already in the study phase, there is a relationship between the study category (SOUPS) and the independent cue (VEGETABLE). This promotes covert cuing at test compared with independent cues that test only one single item (see Camp et al., 2007; Perfect et al., 2004). Second, intralist cues are presented at study, whereas extralist cues are not. Presentation of intralist cues at study can also promote associations between the original cues and the intralist independent cues because they are presented in the same episode and context, which can lead to covert cuing at test. Moreover, intralist cues are a cue for multiple items (Anderson & Spellman, 1995), which also promotes covert cuing. In our experiments, we used extralist item-specific in-

[1] Although other studies using implicit memory tests in the retrieval-practice paradigm have demonstrated forgetting (e.g., Bajo, Gómez-Ariza, Fernandez, & Marful, 2006; Veling & van Knippenberg, 2004), these studies did not measure participant awareness. Therefore, it is possible that participants in these studies noted the connection between the test phase and the earlier phases of the experiment, and therefore, the test was not truly implicit (see also Butler, Williams, Zacks, & Maki, 2001).

dependent cues, which are least likely to promote covert cuing, and still we found a covert cuing effect. Therefore, although we did not test this directly, we believe our results generalize to other types of independent cues.

To summarize, our results indicate that independent cues are not always independent. Rather, participants may use retrieval cues that are not provided at test. Although the problem of covert cuing has been acknowledged in previous studies (Anderson, 2003; Anderson et al., 2000), the current experiments are the first to provide more direct evidence for the occurrence of covert cuing when so-called independent cues are used at test. Although the effects of covert cuing on the degree of forgetting should be investigated further, the criterion for independence, namely that test performance is not influenced by the original study cues, is not met. This may challenge the effectiveness of the independent probe technique in differentiating between interference and inhibitory accounts of forgetting.

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Appendix A

Stimulus Materials in Experiments 1–4

Dutch	English translation
Study cue–Target–Independent cue	
touw–zeilen–sport	rope–sailing–sport
zonnebloem–geel–kleur	sunflower–yellow–color
stoel–opa–familielid	chair–grandfather–relative
medaille–brons–metaal	medal–bronze–metal
pen–brief–wat je kan lezen	pen–letter–reading material
dierentuin–tijger–dier op vier poten	zoo–tiger–four-footed animal
zool–voet–menselijk lichaamsdeel	sole–foot–human body part
jam–kers–vrucht	jam–cherry–fruit
knal–pistool–strijdwapen	bang–pistol–weapon
poort–paleis–waar mensen in wonen	gate–palace–human dwelling
tralie–vijl–timmergereedschap	bar–file–carpenter's tool
haard–kolen–brandstof	fireplace–coal–fuel
ziekte–dokter–beroep	illness–doctor–occupation
geschiedenis–eeuw–tijdseenheid	history–century–unit of time
winter–jas–kledingstuk	winter–coat–article of clothing
concert–piano–muziekinstrument	concert–piano–musical instrument
fles–melk–alcoholvrije drank	bottle–milk–non-alcoholic beverage
station–bus–voertuig	station–bus–vehicle
kleuter–blokken–speelgoed	toddler–building blocks–toy
stronk–wortel–groente	stump–carrot–vegetable
moeras–mug–insect	swamp–mosquito–insect
bol–wol–textiel	ball–wool–kind of cloth
dessert–lepel–keukengerei	dessert–spoon–kitchen utensil
snavel–eend–vogel	beak–duck–bird

Note. Because of language differences, the English translations do not always exactly overlap in meaning with the Dutch words.

(*Appendixes continue*)

Appendix B

Filler Pairs in Experiment 3 and 4

Dutch	English translation
Study cue–Target	
slap–vies	weak–dirty
verhoor–boete	interrogation–fine
kei–steen	boulder–stone
lachen–blozen	laughing–blushing
kompas–slaapzak	compass–sleeping bag
stel–duo	couple–duo
eng–kil	scary–chilly
spijt–fraude	regret–fraud
ravijn–helling	ravine–slope
koptelefoon–stekker	headphone–plug
rad–wiek	wheel–sail
kegel–pion	cone–pawn
feest–slingers	party–streamer
vol–vat	full–barrel
drop–snoep	licorice–candy
korf–mand	basket–basket
plein–brug	square–bridge
lief–slim	sweet–smart
list–plan	trick–plan
brutaal–wreed	insolent–cruel
adder–gras	viper–grass
vijand–vriend	enemy–friend
bad–shampoo	bath–shampoo
altaar–eed	altar–oath
kalmte–rust	calmness–quiet
visioen–droom	vision–dream
spek–ham	bacon–ham
vrolijk–aardig	cheerful–nice
nieuws–serie	news–series
vallei–dal	valley–dale
ruzie–vrede	quarrel–peace
breedte–lengte	width–length
kieuw–vis	gill–fish
opdracht–avontuur	assignment–adventure
huilebalk–kwal	crybaby–jerk
vakantie–reizen	holiday–travelling
radio–knop	radio–button
dam–dijk	dam–dike
koffer–leeg	suitcase–empty
berg–heuvel	mountain–hill
respect–afkeer	respect–aversion
serieus–gemeen	serious–mean
kapot–slecht	broken–bad
hemel–ruimte	sky–space
fuik–dobber	fyke–float
vreemd–slordig	strange–careless
weegschaal–dun	scales–thin
gast–klant	guest–customer

Note. Because of language differences, the English translations do not always exactly overlap in meaning with the Dutch words.

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