MEMORY, 2002, *10* (5/6), 381–388

Directed remembering: Subliminal cues alter nonconscious memory strategies

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Much research on memory function has focused on changes in recognition performance brought about by differences in the processes engaged during encoding. In most of this work, participants either receive explicit instructions to remember particular items or they perform orienting (i.e., encoding) tasks that support different levels of memory performance. In daily life, however, the retention or dismissal of information often occurs without conscious intent, thereby suggesting an alternative, nonconscious route through which purposive remembering and forgetting can occur. Based on this line of reasoning, we speculated that recognition performance in a standard item-based forgetting paradigm may be moderated by subliminal cues that trigger the automatic activation of different mnemonic strategies. We report the results of two experiments that supported this prediction. In each experiment, the basic item-based forgetting effect was replicated, but via the subliminal presentation of "remember" and "forget" cues. In addition, cue-dependent differences in memory performance were traced to the operation of a covert rehearsal mechanism during encoding. We consider the implications of these findings for the nonconscious operation of memory processes in everyday life.

From cocktail parties to chemistry examinations to card games, failures of memory can have some troublesome consequences. An inability to remember the name of an acquaintance, the atomic weight of nitrogen, or the current trump suit may result in considerably more than mere frustration over the fragility of memory. Such lapses may promptly give rise to an embarrassing social interaction, an abysmal grade, or an irate bridge partner. It comes as little surprise, therefore, to learn that programmes promising to improve memory performance have existed since at least the Middle Ages (e.g., "memory theatres", see Schacter, 1996) and continue to the present

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This research was supported by a National Science Foundation graduate research fellowship to Jason P. Mitchell.

http://www.tandf.co.uk/journals/pp/09658211.html DOI:10.1080/09658210244000207

day in the form of self-help manuals and audio tapes (Greenwald, Spangenberg, Pratkanis, & Eskenazi, 1991; Higbee, 1977). Remembering, it would appear, is a skill worth having.

As it turns out, however, in charting the memorial operations that support effective daily functioning, remembering is only part of the story. Although interpersonal success clearly depends on the ability to retrieve information that is relevant to one's current goals and objectives, daily life also demands a mechanism through which unwanted, irrelevant, or inappropriate material can be screened out, ignored, or actively forgotten (see Anderson & Neely, 1996; Anderson & Spellman, 1995; Bjork, Bjork, & Anderson, 1998; Bjork, 1989; MacLeod, 1998). Just as an inability to encode information may prompt moments of embarrassment or confusion, indiscriminate or uncontrollable remembering can prove no less calamitous. Luria (1968) provided a now classic description of the mnemonist, S, whose nearly effortless memory for the most minute details of events severely hampered his everyday life. Similarly, Schacter (2001) relates the story of Donnie Moore, a baseball pitcher driven to despair and eventual suicide by the inescapable memory of a playoff game loss. Preventing the permanent etching of unwanted or inappropriate material in conscious memory is no less important than the ability to retain wanted and appropriate material, and both are basic requirements if the human mind is to function in an optimal manner (Freud, 1930/1989). Successful memory is defined by such selectivity: we must simultaneously remember that which should be remembered while forgetting (i.e., ignoring, discarding, or suppressing) that which should be forgotten.

So, how do we selectively remember and forget? Over the past three decades, one of the most useful answers to this question has been provided by the levels-of-processing (LOP) account, first introduced by Craik and Lockhart (1972) and subsequently expanded by Craik and Tulving (1975). Within the levels (or depth) of processing view, the mnemonic fate of information is determined by the amount of elaborative processing garnered by that material at encoding. All else being equal, information that attracts elaborative encoding operations tends to be better remembered than information afforded only relatively shallow, superficial processing. In work of this kind, elaborative processing is typically supported by encoding tasks in which participants are asked to integrate to-be-remembered items with existing semantic knowledge. This contrasts with shallow encoding tasks in which participants' attention is directed to perceptual features of the items (Craik & Tulving, 1975).

Admirably, the LOP account reflects our common experience of consciously choosing which information to discard or ignore and which information to commit to memory on a permanent basis. When attempting to retain a phone number for a temporary processing objective (e.g., ordering a pizza), we engage in rather shallow, rote rehearsal of the material (i.e., repeating the digits aloud). On the other hand, if the phone number is to be remembered into the future (e.g., the telephone number of one's new partner), we likely engage a different set of mnemonic strategies, perhaps considering how the number is similar to others we know or by thinking of the digits in some other system (such as golf scores or track & field times—see Schacter, 1996). Interestingly, however, everyday mnemonic operations rarely require such explicit intentions to remember or forget the past. Far more often, the processes underlying successful memory performance take place automatically and outside of consciousness. Although at times one may certainly make a conscious effort to remember or forget particular events or information, more often than not, these abilities do not require strategic deployment of encoding processes. For example, we may remember the details of a recent colloquium lecture we attended, despite the low probability that we consciously attempted to encode the information. At the same time, many such lectures have no doubt faded into obscurity in our minds—especially if the content was quite distant from our primary intellectual interests. Importantly, this information was likely discarded from memory in an effortless manner and did not require conscious inhibition of the material or the implementation of some counter-mnemonic; the unimportant material was simply forgotten. In both cases, we were likely to have been a quiet, attentive member of the audience, yet in one case information was easily remembered, whereas in the other it was readily forgotten.

What processes contribute to this automatic, nonconscious ability to remember or forget the past? The LOP account has proved useful for organising empirical observations that different memory performance is produced by encoding tasks that orient participants to different aspects of material. However, to what extent can this approach also incorporate the informal observation that such explicit orienting rarely occurs in everyday life, and yet successful, selective remembering nevertheless occurs? The present experiments provide evidence that LOP is indeed a useful framework for thinking about how memory processes are regulated (i) outside of conscious awareness, and (ii) without explicit manipulation of the processing orientation adopted by perceivers at encoding. In two experiments, we demonstrate that subliminally-rendered cues can successfully trigger shifts in the depth to which participants process stimulus items during an incidental encoding task.

These experiments dovetail with other recent investigations that suggest the power of subliminal cues to influence memory performance. In a recent investigation of implicit social cognition, Chartrand and Bargh (1996) demonstrated that the presentation of cues outside of conscious awareness can nevertheless prompt participants to adopt different mnemonic strategies. Indeed, subliminally-presented information was shown to influence not only participants' recall performance, but also the manner in which they represented material in memory. Participants read sentence fragments that described actions performed by a fictional person (e.g., "went skiing in Colorado", "had a party for some friends last week"). Prior to this phase of the experiment, however, a parafoveal priming technique (Bargh & Pietromonaco, 1982) was used to present some participants with subliminal cues that were related to impression-formation goals (e.g., *impression*, *judgement*, *personality*, *evaluate*). Critically, the subliminal presentation of these cues was sufficient to reproduce the pattern of memory performance that is observed when participants are given explicit impression-formation instructions, such as better memory for incongruent trait information (Hamilton, Katz, & Leirer, 1980). Thus, goal activation can seemingly be triggered automatically and can produce memorial effects identical to those elicited by conscious information-processing strategies (see also Bargh, 1997; Bargh & Chartrand, 1999; Bargh & Ferguson, 2000).

Extending work of this kind, we employed subliminal memory cues in a different experimental paradigm that has been shown to induce conscious changes in strategic encoding processes, namely, item-based directed forgetting (Basden & Basden, 1998; Bjork et al., 1998; Johnson, 1994; MacLeod, 1998). In the item-based method of directed forgetting, each stimulus is followed by a cue that signals whether the item should be remembered or forgotten. In this paradigm, participants adopt a rehearsal strategy (i.e., maintenance rehearsal) in which they minimally rehearse each item until the appearance of the cue (Basden & Basden, 1996). Then, depending on the nature of the cue (i.e., remember or forget), participants either initiate further processing of the item (for to-be-remembered items) or they suspend rehearsal altogether (for to-be-forgotten items). In other words, some items are processed more deeply or elaborately than others (Craik & Lockhart, 1972; Craik & Tulving, 1975), producing better recognition performance for items that were followed by "remember" (R) than by "forget" (F) cues (Basden & Basden, 1998; Johnson, 1994; MacLeod, 1998).[1]

In the two experiments reported here, we investigated whether the presentation of subliminal R and F cues would impact on people's subsequent memory performance. In a modified version of the item-based method of directed forgetting (Basden & Basden, 1998), participants were presented with a series of stimulus words (i.e., forenames) that were followed by subliminal R or F cues. Despite the subliminal nature of the cues, we anticipated that the standard differences in memory performance would emerge. That is, participants would show better recognition for items followed by R than F cues. As noted earlier, when previous research presented R and F cues supraliminally, differences in memory performance were directly linked to shifts in the encoding processes engaged by each type of cue. In the same way, we expected that subliminal cues to remember would likewise trigger deeper processing than subliminal cues to forget. Our second experiment tests this depth-of-processing prediction more directly.

Unlike previous research using the item-based directed forgetting method, participants in the present experiments were not forewarned about

[1] Of course, because the item-based method relies on differential rehearsal, memory differences between remember and forget items do not necessarily reflect intentional *forgetting, per se*. That is, within this paradigm, participants do not actively have to inhibit or suppress the retrieval of existing memories (Bjork, 1989; Johnson, 1994). Thus, directed *remembering* may be a better description of the effect that is elicited in work of this kind. Nevertheless, this approach is commonly used to investigate fundamental aspects of intentional forgetting, and we refer to the method as an item-based directed forgetting paradigm (Johnson, 1994; MacLeod, 1998).

an upcoming memory test. Because of the incidental nature of encoding in our experiments, participants were not likely motivated to explicitly commit the material to memory in the first place. Together with the subliminal presentation of the R and F cues, this incidental encoding task ensured that shifts in the depth to which stimuli were processed took place outside of conscious awareness.

EXPERIMENT 1

Experiment 1 examined whether subliminal cues to remember or forget material would impact memory performance. Participants incidentally encoded a series of forenames and, although no mention was made of a subsequent memory test, each item was followed by a subliminal R or F cue or a control cue that was unrelated to memory function. Following this incidental study phase, participants' memory for the items was assessed using a standard old/new recognition test.

Method

Participants and design. A total of 12 students at the University of Bristol participated in the experiment. The experiment had a single factor (cue type: remember or forget or control) repeated-measures design.

Procedure and stimulus materials. Stimulus presentation was controlled by an Apple Macintosh G3 computer. Participants sat in a darkened room with their head on a chin rest approximately 57 cm from the computer monitor. A pool of 120 common British forenames was assembled from Internet name compendia (e.g., www.babycentre.co.uk; www.namingbaby.co.uk) and divided into four lists of 30 names (15 female, 15 male). The average length and popularity of the forenames was equated across the lists. Counterbalancing ensured that each forename appeared equally often as a to-be-remembered (R), to-be-forgotten (F), control, or foil item. Stimuli were drawn in white on a black screen in Geneva 14-type font. In the first phase of the experiment, participants were introduced to a study on the effects of distraction on cognitive processing. No mention was made of an upcoming memory test. Each trial began with a forename presented in the centre of the screen for 1200 ms. Participants were instructed to read each forename aloud into a microphone when the item appeared on the screen. The forename was then masked by a random string of 11 letters for 66 ms (e.g., vckzfqnjwpr). Immediately following the mask, the word "remember" or "forget" or "extract" (i.e., control cue) was presented for 34 ms and then replaced by a different random letter string. The second mask remained for 250 ms, a blank screen was presented for 1700 ms, and then the next trial began. Previous pilot testing confirmed that, at an exposure duration of 34 ms, participants were unable to identify the items.[2] Participants were presented with 60 forenames, with the stimulus items accompanied by an equal number of R, F, and control cues. On completion of the study phase, participants were given a surprise old/new recognition test. Participants were presented with the 60 original forenames randomly interspersed with 60 foils. Forenames were presented sequentially and participants indicated whether each item was "old" or "new" by pressing one of two appropriately labelled keys. Each item remained on the screen until the participant responded and the next item followed after a 1000 ms interval. Following the recognition memory test, participants were debriefed, thanked for their assistance, and dismissed.

Results and discussion

The hypothesis in Experiment 1 was that recognition performance would be better for forenames followed by subliminal R than F cues. To test this

[2] To confirm that R and F cues were indeed presented subliminally, a separate group of 17 participants completed a set of 60 trials identical to those described, without any mention of the subliminal cues. Following these trials, participants were asked whether they "noticed anything unusual in the experiment". Subsequently, these participants were alerted to the subliminal cues and asked to guess five times what these cues might have been. No participant spontaneously indicated awareness of the subliminal words or successfully guessed the identity of the cues. Finally, participants were shown a new series of six trials with the experimental parameters and, after each, were asked to indicate the identity of the subliminal cue. On the vast majority of these trials (71/102), participants declined to guess; however, of the 31 guesses, the cue was correctly identified only once (in this case, the word "forget"). Accordingly, these results confirm that the experimental parameters successfully rendered the vast majority of cues subliminal, even after participants were expressly alerted to the presence of the subliminal stimuli, and that participants naïve to the subliminal cues were highly unlikely to have spontaneously perceived any of the cues.

prediction, corrected recognition scores were calculated separately for R, F, and control items by subtracting the proportion of false alarms (.117) from the proportion of hits. The top panel of Table 1 presents participants' mean corrected recognition performance. A single factor (cue type: remember or forget or control) repeated measures analysis of variance (ANOVA) revealed an effect of cue type on recognition performance, $F(2, 22) = 3.69$, $p < .04$. Post-hoc tests confirmed that recognition performance was better following the presentation of R cues than either F or control cues (both ps $< .05$). No difference in recognition performance was observed following the presentation of F and control cues. These effects, then, supported our experimental prediction. Although participants were unable to detect the subliminal cues, recognition performance was better for R- than F-cued items.

EXPERIMENT 2

The results of Experiment 1 confirmed that subliminal R and F cues can produce results comparable to other studies using an item-based directed forgetting paradigm. Elsewhere, researchers have traced item-based forgetting effects to the operation of different rehearsal strategies during the encoding phase of the task (Basden & Basden, 1996; Basden, Basden, & Gargano, 1993). Specifically, the provision of explicit R and F cues prompts participants to selectively rehearse the to-be-remembered items and to suspend processing of the to-be-forgotten words (see Basden & Basden, 1998; Wetzel & Hunt, 1977; Woodward & Bjork, 1971). As a result of these processing differences (Craik & Lockhart, 1972; Craik & Tulving, 1975), recognition performance is better for items that are followed by R than F cues.

Does this selective rehearsal strategy also account for the results observed in Experiment 1? The fact that recognition performance was equivalent for items followed by both F and control cues and superior for items followed by R cues is suggestive of the operation of such a process. Accordingly, our assumption is that subliminal R and F cues may indeed moderate the extent of item rehearsal, albeit unconsciously and unintentionally. In particular, the superior memory performance that is observed for R over F items following the presentation of subliminal cues may be due to the additional (but covert) rehearsal that R items receive during the study phase of the task.

To test this prediction, in our second experiment we added a secondary task (i.e., articulatory suppression) that was intended to prevent further rehearsal following the presentation of the subliminal cues (Bjork & Geiselman, 1978). Half the participants performed the identical incidental encoding task as Experiment 1. However, the remaining participants performed an additional articulatory suppression task (Baddeley, 1986) in which they were instructed to repeat aloud the colour of the backward masking stimulus. As such, to the extent that superior memory for to-be-remembered material is driven by a process of covert (but elaborative) rehearsal, we anticipated that recognition performance for R and F items would be equivalent under conditions of articulatory suppression.

TABLE 1
Recognition performance by cue type (Expts 1 & 2)

	Cue Type		
	Remember	*Forget*	*Control*
Experiment 1	.754 (17.4)	.668 (15.7)	.675 (15.8)
Experiment 2			
no suppression	.615 (45.0)	.539 (40.4)	–
articulatory suppression	.454 (41.8)	.465 (42.4)	–

Values indicate corrected recognition scores, calculated as the proportion of hits (ratio of "old" responses to the total number of previously seen items) minus the proportion of false alarms for each condition. Values in parentheses indicate the raw number of hits per condition. Participants studied 20 items per condition in Experiment 1 and 60 items per condition in Experiment 2.

Method

Participants and design. A total of 32 students at the University of Bristol were paid £3 ($4.50) for their participation in the experiment. The experiment had a 2 (cue type: remember or forget) × 2 (concurrent task: articulatory suppression or control) mixed design with repeated measures on the first factor.

Procedure and stimulus materials. Experiment 2 was basically a replication of the previous experiment, but with some important modifications. First, the number of stimulus items was increased to 120 forenames. Second, as performance following the presentation of control and F-cued items was equivalent, only R and F cues were used in the current experiment. Stimulus presentation was controlled by an Apple Macintosh G3 computer running PsyScope software (Cohen, MacWhinney, Flatt, & Provost, 1993). The sequence of events comprising each trial was similar to Experiment 1, except that the inter-trial interval was increased to 2000 ms. Participants were again introduced to an experiment on the effects of distraction on cognitive performance and were randomly assigned to one of two experimental conditions. Half the participants were assigned to the no-suppression condition, in which they performed the identical name-reading task as in Experiment 1. The remaining participants were assigned to the articulatory-suppression condition, and also performed the name-reading task. In addition, however, the articulatory-suppression participants also repeated aloud the name of the colour of the second letter mask until the next trial commenced (Baddeley, 1986). The second mask was drawn in one of three colours (blue, green, or red). Thus, upon the presentation of a forename, participants in both conditions read the name aloud. Following the appearance of the second mask, however, participants in the articulatory-suppression condition also repeated the colour of the second mask as many times as possible until the next forename appeared on the screen. The only other change to the study phase of Experiment 2 was the addition of nine buffer trials at the beginning of the experiment to ensure that participants understood how to perform the articulatory-suppression task. The items comprising these buffer trials did not appear in the subsequent recognition test. Immediately following the study phase, memory was assessed using a standard old/new recognition task. On completion of this task, participants were debriefed, paid, thanked for their assistance, and dismissed.

Results and discussion

Recognition memory was again indexed by computing the corrected recognition scores for both R and F items. The bottom portion of Table 1 presents the treatment means. We anticipated that if the superiority of R over F items was due to the operation of a covert rehearsal mechanism, then only in the no-suppression condition would we observe better recognition memory for R- over F-cued items. No difference in recognition performance was expected to emerge under conditions of articulatory suppression. To test these predictions, the corrected recognition scores were submitted to a 2 (cue type: remember or forget) × 2 (concurrent task: articulatory suppression or control) mixed model ANOVA with repeated measures on the first factor. A significant effect of cue type emerged in this analysis, $F(1, 30) = 6.47$, $p < .02$, indicating that recognition performance was better for R- than F-cued items. As expected, however, this effect was qualified by a significant cue type × concurrent task interaction, $F(1, 30) = 11.87$, $p < .002$. Additional analyses confirmed that, in the no-suppression condition (proportion of false alarms = .135), recognition performance was better for R- than F-cued items, $t(31) = 4.72$, $p < .0003$. Importantly, no such effect emerged under conditions of articulatory suppression (proportion of false alarms = .242), $t(31) < 1$, *ns*. Thus, as expected, the observed recognition advantage for R- over F-cued items appeared to be a consequence of additional covert rehearsal engendered by the subliminal cues to remember (Basden & Basden, 1998), a mnemonic strategy that was triggered without participants' awareness or conscious intent. When the requirement to perform a concurrent working-memory task (i.e., articulatory suppression) eliminated differences in elaborative rehearsal of R and F items, recognition performance was equivalent for both types of items.

GENERAL DISCUSSION

A characteristic feature of memory is that it operates silently and effortlessly without the necessity of conscious control. Only occasionally do we purposely direct ourselves to remember or forget particular things. The more commonplace scenario is that relevant material somehow enters and remains in memory without one's conscious intervention, while irrelevant, outdated, or redundant information is discarded and forgotten. But what is the mechanism that moderates the memorability of encountered material? The current research identifies one such candidate process. Critical to the memorial fate of information may be situational cues that are present when the material is encountered, cues that signal the relative importance or value of the information. Following the implicit registration of these cues (Bargh, 1997; Bargh & Chartrand, 1999; Chartrand & Bargh, 1996), covert rehearsal mechanisms then serve to determine whether the information is likely to be remembered or forgotten (Craik & Lockhart, 1972; Craik & Tulving, 1975). Such triggering situational cues are undoubtedly a ubiquitous feature of everyday life (Bjork et al., 1998). A professor's subtle prosodic emphasis of a point in class, the institutional affiliation of a speaker at a scientific meeting, or the source credibility of a witness in court may all serve as cues that trigger covert rehearsal processes—processes that enhance the memorability of encountered information. Ultimately, such cues help to gate the expenditure of limited processing resources by directing covert rehearsal operations to the encoding of information that is salient, important, or potentially goal-relevant to perceivers (Bargh, 1997).

Throughout this article we have referred to covert rehearsal, but in what sense can rehearsal be considered to be covert? Recent neuroimaging investigations of incidental memory encoding by Wagner et al. (1998) and Brewer, Zhao, Desmond, Glover, and Gabrieli (1998) may help to illuminate this issue. In each of these studies, event-related fMRI was used to index neural activity while participants performed an incidental encoding task, such as word classification (Wagner et al., 1998) or picture categorisation (Brewer, et al., 1998). Participants' memories were later assessed on a surprise recognition test and items were conditionalised on the basis of whether they were correctly recognised as old (i.e., hits) or incorrectly classified as new items (i.e., misses). Critically, items that attracted greater neural activity in left inferior frontal cortex and the medial temporal lobe during incidental encoding had the greatest likelihood of being correctly recognised at test. Interestingly, the left inferior frontal areas identified in these studies have been associated with different rehearsal processes (see Cabeza & Nyberg, 2000; Smith & Jonides, 1997).

In such incidental encoding tasks, why is it that some items attract greater covert rehearsal than others? Item familiarity, frequency, self-relevance, and natural fluctuations in attention are all factors that are believed to contribute to the observed variance in neural activity and covert rehearsal across items. To this list, we suspect it is possible to add another factor—namely, situational cues that signal the mnemonic value of encountered information to perceivers, such as the subliminal R and F cues that were employed in the current investigation. Although speculative, the differences in recognition performance observed in the present studies may be attributable to modulation of the neural activity in brain regions associated with elaborative rehearsal, specifically left inferior frontal regions. Furthermore, because articulatory suppression likely engages the same mechanisms that underlie phonological rehearsal (Baddeley, 1986), we suspect that the subliminal cueing effect observed in these experiments probably results from the additional phonological rehearsal received by R-cued items. These possibilities await future empirical attention.

CONCLUSIONS

Through selective remembering and forgetting, perceivers can retain important, relevant, and appropriate information while discarding material that is unwanted, irrelevant, or trivial. Supporting this process are a variety of mechanisms, some with their foundations in consciousness, others with their origins in the silent workings of the unconscious mind. That memory operations can be triggered automatically has obvious benefits to perceivers as they go about their daily business. Rather than deliberating over what needs to be remembered or forgotten, memory control can be devolved to covert rehearsal mechanisms that are triggered following the nonconscious registration of critical situational cues (Bargh, 1997; Bargh & Chartrand, 1999). As a result of this processing strategy, perceivers can deploy consciousness and its limited resources to a range of other problems, such as planning, troubleshooting, and behavioural self-regulation. As demonstrated herein, despite its purposive quality, directed forgetting and remembering can indeed be implemented unintentionally.

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