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Separating Habit and Recollection: Memory Slips, Process Dissociations, and Probability Matching

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Memory slips are errors in performance that result when an automatic basis for responding (e.g., habit) opposes the intention to perform a specific behavior. Prior research has focused on factors that influence the probability of a memory slip while neglecting factors that facilitate performance. Using L. L. Jacoby's (1991) process-dissociation procedure to examine performance in both a memory-slip and a facilitation condition, the authors separated the contribution of habit and recollection (intentional memory) in a cued-recall task. The authors found that manipulating the strength of habit affected its contribution to performance in a manner that produced probability matching, but recollection was unchanged. In contrast, manipulations of presentation rate and response time influenced recollection but did not affect habit. Such dissociations support a model of memory in which automatic and intentional influences make independent contributions to performance.

Suppose you are searching your home for the keys to your car. The typical place you keep your keys is on a table near the front door of your home. However, sometimes you leave your keys on the dresser in your bedroom, which is what happened on this occasion. What conditions make it likely that you will mistakenly begin the search for your keys at their typical location? One factor that is important is the past probability of leaving the keys in their typical place. The higher that probability, the stronger the habit of searching for them at that location will be and, consequently, the more likely one will be to commit an error when the keys are elsewhere. A second class of factors is potentially independent of those that influence the strength of a habit and has its effects by influencing the probability of recollecting where the keys were left. Inappropriately looking in the typical place for one's car keys might be more likely if one were rushed—a condition that makes recollection of having earlier left the keys in an atypical place less likely.

The error of searching for one's keys in the wrong location could be described as a failure in recollection in combination with proactive interference reflecting habit. In recent years, a great deal of evidence has accumulated to show dissociations between conscious recollection (explicit or declarative memory) and effects of learning that support the development of automatic responding or habit (implicit or nondeclarative memory; for a review, see Squire, Knowlton, & Musen, 1993). Dissociations between these two types of memory have been shown in the animal literature (e.g., Mishkin & Appenzeller, 1987; Squire, 1992) and with amnesic patients who show normal learning on some tasks despite being impaired in their ability to recollect particular events (e.g., Mayes, 1988; Squire, 1987). Adults with normally functioning memory also show dissociations between performance on explicit (direct) and implicit (indirect) tests of memory (for a review, see Roediger & McDermott, 1993). However, identifying processes with tasks, as is done by the explicit–implicit test distinction, overlooks an essential aspect of measuring conscious and automatic (habit) processes, which is that these processes seldom occur in isolation.

Memory slips are errors in performance that arise when habit and recollection operate in opposition, each leading to different outcomes. As in the example with the keys, memory slips occur when automatic influences of memory are not successfully opposed by recollection. In the following experiments, we separate the contribution of habit from that of recollection failure as determinants of memory slips. To do this, we show that it is also necessary to examine performance in situations where automatic influences of memory and recollection work in concert to produce the same response. In such a situation, habit serves as a basis for correct responding rather than as a source of error. As an example, finding keys in their typical location may not always rely on one's ability to recollect having placed them there but instead can reflect habit. For the in-concert case, separating the bases for responding amounts to correcting cued-recall performance for guessing. By our approach, the automatic influences (habit) that serve as a source of educated guessing for an in-concert test condition are the same as those that serve as a source of memory slips when automatic influences and recollection act in opposition. We combine results from in-concert and opposition conditions to separate the contributions of habit and recollection within the same task (cf. Jacoby, 1991; Jacoby, Toth, & Yonelinas, 1993).

The experiments reported here were carried out to produce

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dissociations between recollection and a habit that was created during the experimental session. The first phase of each of our experiments was a training session designed to create habits of specific strengths. During this initial phase, participants were exposed to pairs of associatively related words with the probabilities of particular pairings being varied. A stimulus word was paired with two related words such that a typical response (e.g., *knee–bend*) occurred more often than an atypical response (e.g., *knee–bone*). In Experiment 1, for example, 15 times out of 20 when the stimulus word *knee* was shown, it was paired with the response *bend*, whereas for the other 5 presentations of *knee*, it was paired with the response *bone*. Our intention was to build a habit, or automatic response, in a manner similar to that produced by placing one's keys in the same location on 75% of occasions and in a different location on the remaining 25% of occasions.

Once a habit was established, the second phase of the experiment created a situation similar to that of remembering where one's keys were left on a particular occasion. In the second phase of the experiment, short lists of paired words were presented for participants to remember. Within each list, some pairs were presented such that the right-hand member of the pair was the response that was made most habitual or typical by training in Phase 1 (e.g., *knee–bend*), whereas for other pairs, the right-hand member of the pair was the response that was atypical in Phase 1 (e.g., *knee–bone*).[1] After each study list, memory was tested by presenting participants with the left-hand member of each pair along with a fragment of the target word that could be completed with either the typical or the atypical response (e.g., *knee–b_n_*). Participants were asked to complete the fragment by recalling the response that was paired with the stimulus word in the short list they had just studied. For this test of memory, recollection of the target word was congruent (acted in concert) with habit when the word studied in the short list was the response that was made typical in Phase 1 but was incongruent (acted in opposition) with recollection when the studied word was the atypical response from Phase 1. For incongruent items, erroneously completing a fragment with the response that occurred most frequently in Phase 1 corresponded to a memory slip. In contrast, for congruent items, responding on the basis of habit established in Phase 1 would produce a correct response.

For congruent items, participants could give the correct answer at test either by recollecting (R) the item in the short study list presented in Phase 2 or by relying on habit (H) to produce the response that was made typical in Phase 1 when recollection failed ($1 - R$). Recollection of typical items was congruent with the habit participants had formed during training. The probability (*Prob*) of correctly giving a typical response in the congruent condition can be written as

$$Prob_{\text{typical}} = R + H(1 - R). \tag{1}$$

For incongruent items, habit served as a source of errors. Completing a fragment with a response that was made typical in Phase 1 but that did not appear in the study list that was presented in Phase 2 constituted a memory slip. To make this type of error, participants would have to fail to recollect the response they had just studied in the preceding list of word pairs and rely on their habit of giving the typical response. The probability of incorrectly giving a typical response to incongruent items can be written as

$$Prob_{\text{typical}} = H(1 - R). \tag{2}$$

By using these two equations, we can calculate estimates of recollection and habit. Subtracting the probability of a memory slip on incongruent trials from the probability of a correct response on congruent trials provides an estimate of recollection:

$$R = Congruent - Incongruent. \tag{3}$$

Given an estimate of recollection, an estimate of habit can be obtained by simple algebra, by dividing the probability of a memory slip in the incongruent condition by the estimated probability of not recollecting an item:

$$H = Incongruent/(1 - R). \tag{4}$$

The equations used to estimate the contributions of recollection and habit (automatic influences) are the same as those used in earlier experiments that have made use of Jacoby's (1991) process-dissociation procedure (e.g., Jacoby et al., 1993). For those earlier experiments, inclusion-test instructions were used to create a situation in which automatic influences and recollection acted in concert, corresponding to the situation for congruent items. For an inclusion test, participants were instructed to use a word stem as a cue for recall of a word studied earlier and, if unable to do so, were to complete the stem with the first word that came to mind. Exclusion-test instructions were used to create a situation for which automatic influences of memory and recollection acted in opposition, corresponding to the situation for incongruent items. For an exclusion test, participants were instructed to complete stems with words that were *not* studied earlier. The assumptions underlying the process-dissociation procedure are the same regardless of whether in-concert and opposition conditions are created by a manipulation of test instructions or by a manipulation of the congruence of items with prior training, as in the present experiments. In the General Discussion, we consider the relative advantages of these two means of implementing the process-dissociation procedure and discuss the importance of convergence in results for responding to critics of the procedure (e.g., Graf & Komatsu, 1994). We also consider the importance of dissociations between habit and recollection for broader issues that

[1] The probabilities created during training were maintained during Phase 2 of the experiment. For example, in the 75%–25% condition, typical items (e.g., *knee–bend*) were presented on six different occasions, and atypical items (e.g., *knee–bone*) appeared on two different occasions, thus maintaining the 75% (6/8) and 25% (2/8) probabilities that were created earlier in the experimental session. Therefore, participants were differentiating between memory for a particular episode (the specific study list) and the background probability of occurrence.

help us better understand action slips (e.g., Reason, 1979) and implicit learning (e.g., Reber, 1989).

A critical assumption underlying the process-dissociation procedure is that automatic and intentional processes serve as independent bases for responding. That is, recollection can occur with or without automatic responding and vice versa. If recollection and habit operate independently of each other, then it should be possible to show that some variables affect one memory process while leaving the other unchanged, as is the case when learning abilities are preserved by amnesics. Returning to our example with the keys, it should be possible to show that factors influencing the habit that comes from typically leaving one's keys in a particular location are different from those that are important for recollecting where the keys were left on a particular occasion. Factors traditionally identified with diminished intentional control have been shown to produce dissociations of this sort (for a review, see Jacoby, Jennings, & Hay, in press). For example, dividing attention reduces recollection but leaves automatic influences unchanged, as do the effects of aging (Jennings & Jacoby, 1993).

In Experiment 1, we manipulated the strength of a habit acquired through training in Phase 1. We expected this manipulation of habit strength to influence estimates of automatic influences but to leave recollection unchanged. In contrast, Experiments 2 and 3 examined the effects of speeded presentation of the study lists in Phase 2 and of speeded responding at test, respectively. We expected that such manipulations would influence recollection but leave automatic influences unaffected, demonstrating a dissociation opposite to that produced by the manipulation of habit. Such findings would provide support for the assumption that habit and recollection make independent contributions to performance.

Experiment 1

The first experiment manipulated the strength of habit acquired during the training session. In situations where habit is strong, it should be difficult to oppose its influence, and therefore, memory slips should occur more often. This view is similar to some of Hull's (1943) early learning work in which he proposed that as the number of repeated pairings between a stimulus and a response increases, so does the strength of that association or habit. To manipulate the strength of habit in Experiment 1, the probability of a particular response appearing with a stimulus word was varied in the initial training session (Phase 1). Two different probability conditions were used such that participants saw some typical items with a 75% probability and saw other typical items with 50% probability. (For the 50% condition, one set of items was arbitrarily designated as typical.) For example, in the 75% condition, the typical response *bend* appeared with the stimulus word *knee* on 75% of the trials (15 of 20 presentations), whereas the atypical response *bone* appeared only on 25% of the trials (5 of 20 presentations). The strength of the habit created during the training session was expected to be stronger for typical items in the 75% condition than in the 50% condition, because in the 50% condition typical items appeared on only 10 of the 20 training trials. We expected the different strength associated with typical items in the 75% and 50% conditions to produce differential estimates of habit, produced by performance in Phase 2. In contrast, recollection of an item as having been studied in Phase 2 was not expected to differ for items in the 75% and 50% conditions.

We further examined the extent to which the objective probability of presenting items during training was reflected by our estimates of habit. A great deal of experimental evidence has suggested that both animals and humans are very sensitive to the rate at which environmental events occur. Given a two-choice learning situation, participants tend to choose each of the alternatives with a rate that reflects the likelihood of their prior occurrence (e.g., Voss, Thompson, & Keegan, 1959) and thereby show probability matching (e.g., Estes, 1976). Similar demonstrations of probabilistic classification learning have been reported with amnesic patients (Knowlton, Squire, & Gluck, 1994). We expected our estimates of habit to reflect probability matching such that estimated habit in the 75% condition would be near .75. However, probability matching was not expected to be exact because any random responding produces regression toward a mean of .50 when there are only two alternatives.

As a source of converging evidence for our estimates of habit, we included items designed to measure guessing. These "guessing items" appeared within the test but were not presented in the study list for which memory was tested. Participants were to respond to these items with the first word that came to mind, and therefore, this measure served as an indirect test of memory. All guessing items were familiar to the participants, as they had been seen during the training session (Phase 1) in either the 50% or the 75% conditions; however, because these items were not presented in the Phase 2 study list, they could not be recollected. Participants' responses to guessing items were expected to provide a relatively pure measure of habit against which we could compare estimates of habit derived from congruent and incongruent test conditions. If estimated habit and measured guessing converged, it would provide support for the validity of estimates gained from the process-dissociation procedure.

Method

Participants and materials. Twenty introductory psychology students from McMaster University participated for course credit. All participants were tested individually. The stimuli were presented by means of a PC-compatible computer using Schneider's (1988) Micro-Experimental Laboratory software. Words were presented in the middle of the screen in lowercase letters. The character size of the stimuli was approximately 3 × 4 mm, and participants were seated approximately 70–75 cm from the screen.

A set of 18 stimulus words paired with two associatively related responses (e.g., *knee–bend, knee–bone*) was selected from the norms reported by Jacoby (1996). Words from these norms were chosen from a range of association frequencies with the majority occurring in the medium range. Both associatively related responses contained the same number of letters and could be used to complete the same word fragment (e.g., *knee–b_n_*). The two related responses were arbitrarily chosen to be presented as a typical or atypical response in a particular list. The list of 18 pairs was divided into two sets of 9 pairs each to construct training pairs for the 75% and 50% conditions. The preexperimental probability of completing fragments with the various responses was equated across sets of pairs used to construct conditions. Further, assignment of responses to conditions was counterbalanced across formats so that all words occurred equally often as the typical and atypical responses in both the 75% and the 50% conditions.

Design and procedure. In the training phase, word pairs were presented with the first word intact and the second word missing some of its letters (e.g., *knee–b_n_*). Participants were instructed to guess the word that would complete the fragment. They were told that the correct completion word would be semantically related to the intact word. The word and fragment remained on the screen for 2 s, during which time participants were to respond aloud by saying their predicted completion word. Next, the completion word we had chosen as correct was presented for 1 s. There were always two possible completions for each fragment (e.g., *bend* and *bone* for *knee–b_n_*), only one of which was presented as correct on any given trial. Participants were told that more than one response would appear with each stimulus word and were instructed to try to predict the response that would appear for each particular trial. They were informed that some completion words would appear more often than others. Two pairs of words that did not appear elsewhere in the experiment were used to illustrate the procedure, and then participants engaged in five successive blocks of training. The experimenter recorded all of the participants' responses.

The proportion of trials on which typical responses were presented in training (75% and 50%) was manipulated within subjects. The training session consisted of five blocks of 72 presentations. Each block contained 36 presentations of pairs representing the 75% condition and 36 presentations of pairs representing the 50% condition. Each of the 18 pairs (9 stimuli representing each of the two percentage conditions) was presented four times per block. For the 75% condition, the typical response was presented three times and the atypical response was presented one time in each block; for the 50% condition, typical and atypical responses were each presented twice in each block. The order of the items within each block was random with the restriction that the same stimulus could not be presented more than three times in a row.

Following training, participants received 18 successive study–test lists, divided into two blocks of 9 lists. Each study list contained eight of the word pairs that had been presented during training (e.g., *knee–bend*). Participants were instructed to silently read the word pairs and to remember them for the memory test that would follow the presentation of the study list. After each study list, participants received a cued-recall test of memory for the word pairs just studied. For that cued-recall test, stimulus words were presented with a fragmented version of the response with which they were paired in the study list (e.g., *knee–b_n_*)—the same cues presented during the training given in Phase 1. Participants were instructed to complete fragments by recalling aloud the response word from each pair in the list just studied. They were told that if they could not do so, they were to guess. Further, participants were warned that some pairs would be tested although they did not appear in the study list just presented. For those test items, participants were told to complete the fragment with the first word that came to mind. Word pairs were presented for test at a 3-s rate, during which time participants were to respond. Again, the experimenter recorded all responses.

Each study list contained eight word pairs and was presented at a rate of 1s/pair, with a 500-ms interpair interval. The study lists maintained the earlier proportion of typical and atypical items from training. For each study list of eight items, four items were presented from the 75% condition (three stimuli paired with their typical responses, one paired with its atypical response), and four items were presented from the 50% condition (two stimuli paired with their typical responses, two paired with atypical responses). Within each set of nine study lists, each typical item in the 75% condition was presented three times across different lists, whereas each atypical item was presented only once. For the 50% condition, each typical and atypical item was presented twice. Test cues were presented for all eight study items and for two additional items that were not presented in the preceding study list. For these two additional guessing items, one stimulus was always selected from each of the two probability conditions (75% and 50%). Within each set of nine tests, all stimulus words and their respective fragments appeared as guessing items once. The presentation order for all items in the study and test lists was randomly determined and remained fixed across subjects, with the constraint that no item was repeated within a list (see Figure 1).

Participants performed a short distractor task between study and test. A random number between 30 and 100 was presented on the computer screen immediately after each study list. Each number appeared for 1 s followed by a blank screen for 6.5 s. During that time, participants were required to count backward by threes aloud, as quickly as possible, starting with the number that appeared on the screen. It was emphasized that the backward counting should continue until a message appeared that instructed them to begin the test. The purpose of the distractor task was to prevent participants from holding study items in short-term memory by means of rehearsal. Following each test, the entire study–test procedure started again with a new study list until all 18 lists had been studied and tested. Different numbers were presented for the distractor task between each study–test trial. After completing nine study–test blocks, participants rested for a few minutes while the second set of nine study–test blocks was loaded into the computer.

The significance level for all statistical tests was set at $p < .01$. Tests revealing significant main effects are not reported when variables producing those main effects entered into significant interactions.

Results and Discussion

The purpose of the initial training phase was to create habits of different strengths. As expected, by the final block of training, the probability of a typical item being given as a response in the 75% condition was greater than that in the 50% condition (.64 vs. .50).

The data of interest came from Phase 2 of the experiment, in which participants attempted to remember specific study lists. Study lists included congruent trials, for which habit from training and recollection from the study list worked together to facilitate responding for the typical items. For incongruent trials, the habit of giving the typical completion opposed recollection of the atypical item from the study list. The probability of correctly giving a typical item as a response on congruent trials and incorrectly giving a typical item as a response on incongruent trials is shown in Table 1 for both the 75% and 50% conditions.

The probability of a typical response on congruent trials (correct responses) was significantly greater than the probability of a typical response on incongruent trials (incorrect responses), $F(1, 19) = 128.18$, $MSE = 0.030$. The proportion of training trials for typical responses also had a significant effect on responding, as participants showed a higher probability of giving a typical response in the 75% condition than in the 50% condition, $F(1, 19) = 17.85$, $MSE = 0.012$. The interaction of the two variables did not approach significance, $F(1, 19) < 1$.

A separate analysis of performance on incongruent trials showed that participants in the 75% condition gave typical responses significantly more often than did participants in the 50% condition, $F(1, 19) = 7.15$, $MSE = 0.011$, demonstrating that memory slips were more likely to occur when habit was stronger. A corresponding analysis of performance on congru-

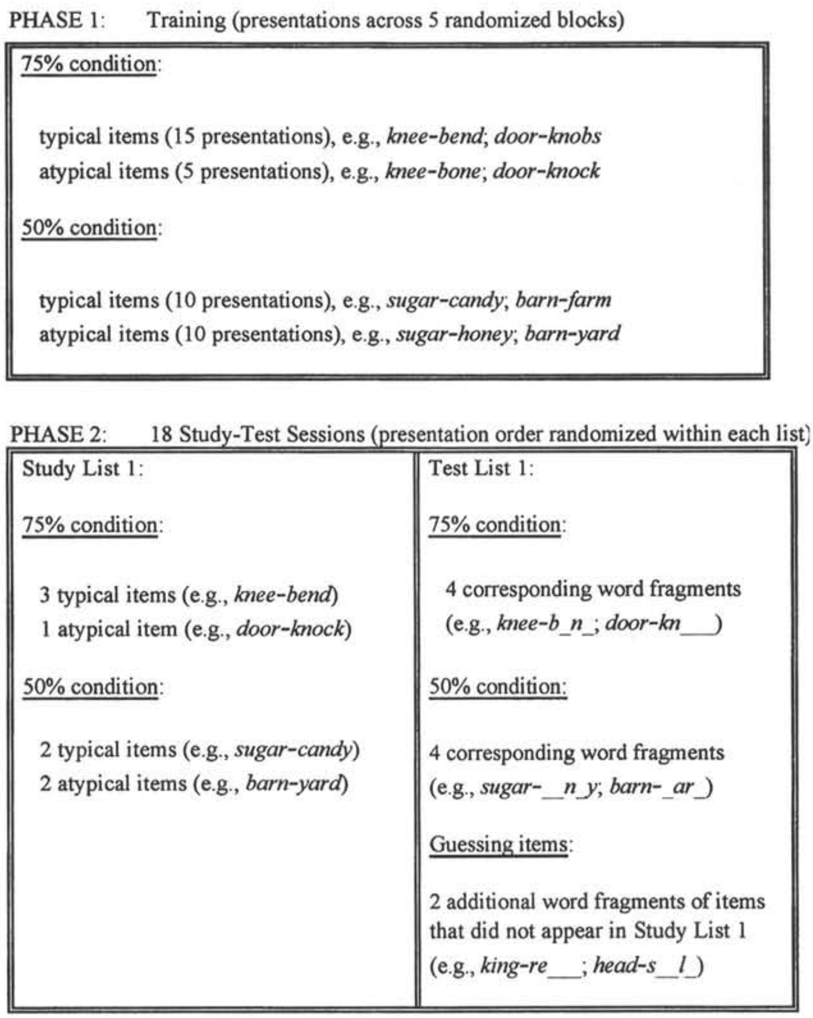

Figure 1. Overview of experimental design for Experiment 1.

ent trials showed that the probability of giving a typical response was significantly higher for the 75% condition than it was for the 50% condition, $F(1, 19) = 21.41$, $MSE = 0.006$. The stronger habit increased the probability of producing a typical response, thus increasing the probability of correct responding on congruent trials and the probability of a memory slip on incongruent trials.

Table 1
Probabilities of Responding With a Typical Item and Mean Estimates of Recollection and Automatic Influences as a Function of the Proportion of Typical Items Seen During Training in Experiment 1

Trial type and estimates	Proportion of typical items: 75%	50%
Trial type		
Congruent	.82	.71
Incongruent	.37	.28
Estimates		
Recollection	.45	.43
Habit	.67	.48
Guessing	.71	.53

Using the equations presented earlier, we estimated the probability of recollection as the difference between the probability of giving a typical response on the congruent and incongruent trials (Equation 3). As shown in Table 1, the probability of presenting typical items during training did not affect the probability of recollection, $F(1, 19) < 1$. This result did not reflect insensitivity of our measure, as the power to detect an effect on recollection estimates as large as that observed for habit was .99 (alpha = .05, Cohen's $d = 1.93$). (The power to detect an effect that was half the size of the effect on habit remained high at .93.) This result supports our prediction that recollection would not differ for the 75% typical items and the 50% typical items.

Although recollection was left invariant, manipulating the probability of seeing typical items during the training session was expected to affect estimates of habit. A process dissociation of this type would support the assumption that automatic and intentional influences of memory make independent contributions to performance by showing that the two types of influences can be manipulated independently. The equations described earlier were used to derive estimates of habit (see Table 1). Analysis of those estimates revealed that habit in the 75% condition was significantly greater than in the 50% condition, $F(1, 19) = 28.44$, $MSE = 0.014$, demonstrating that automatic influences of memory were indeed affected by the history of the items. As expected, the estimates of habit obtained for the 75% and the 50% conditions approximated the actual probability of the typical items being presented during training.

As a source of converging evidence for our estimates of habit, we examined performance on guessing items. We expected participants' guessing responses would reflect automatic influences of memory such that the probability of seeing a typical response in training would have a significant effect on guessing scores. Guessing scores were calculated as the total proportion of typical responses given at test for items that were not presented in the study list preceding their test (see Table 1). Guessing scores in the 75% condition were greater than those in the 50% condition $F(1, 19) = 16.85$, $MSE = 0.018$, and again probability matching was evident.

To compare the two measures of automatic influences, we performed a two-way analysis of variance (ANOVA) on the probability of typical responses seen in training (75% and 50%) and type of measure (habit and guessing). As expected, a significant difference between the 75% and 50% conditions emerged, with estimates in the 75% condition being greater than estimates in the 50% condition, $F(1, 19) = 27.44$, $MSE = 0.025$. The type of measure approached significance, with estimates of habit falling below guessing, $F(1, 19) = 5.51$, $MSE = 0.007$; however, this difference between estimates of habit and guessing did not replicate across Experiments 2 and 3. The interaction between the probability of typical items seen in Phase 1 and the type of automatic measure did not approach significance, $F(1, 19) < 1$.

Using the process-dissociation procedure devised by Jacoby (1991), we were able to separate the contributions of automatic and intentional memory processes within a single task. On the basis of estimates gained from this procedure, it was found that manipulating the typicality of responses by means of training influenced habit but had no effect on recollection. Strength of word-pair associations was manipulated by presenting typical items with a probability of either 75% or 50%. When habit was strong (75% condition), the likelihood of a memory slip being committed was higher than when habit was weak (50% condition). Although a strong habit was a source of error in the memory-slip case, it helped performance in the facilitation case; there was a greater probability of correctly remembering the typical items in the 75% than in the 50% condition. It is important to note that the estimates of habit computed with the process-dissociation equations and those gained from guessing items closely approximated the actual proportions used for presenting items during the training session (75% and 50%). The importance of this probability matching is further considered in the General Discussion.

The finding that manipulating the strength of habit influenced the estimated contribution of habit but left recollection invariant provides support for the independence assumption underlying the process-dissociation procedure. Manipulations used in the following experiments were expected to produce process dissociations of a form that would be opposite that produced by the manipulation of habit, thereby providing further evidence of the functional independence of habit and recollection. Manipulations in later experiments were expected to influence recollection but to leave the estimated contribution of habit unchanged.

Experiment 2

The purpose of Experiment 2 was to examine differential effects of the presentation rate of the study lists shown in Phase 2. This manipulation varied the amount of study time allowed for items whose presentation was to be recollected. Returning to our example with the keys, the manipulation is akin to varying the amount of time one spent rehearsing where one's keys were left on a particular occasion. It was expected that a fast presentation rate at study would have a detrimental effect on recollection but would not influence the contribution of habit. The lack of effect on habit was expected because habit should reflect prior learning from Phase 1 and, consequently, should be relatively unaffected by presentation rate in a particular short list. Additionally, Experiment 2 allowed us to further investigate the influence of prior presentations on later memory performance by using a level of habit strength different from those used in Experiment 1. A habit strength of 67% was created during the training session by presenting typical responses on 67% of the occasions and atypical items on the remaining 33% of occasions in Phase 1.

Method

Participants and materials. The participants were 16 undergraduates in a first-year psychology course at McMaster University who participated for course credit. The materials and details of list construction were the same as in Experiment 1.

Design and procedure. The procedure was the same as in Experiment 1 with the following exceptions: During the initial training phase, participants were presented with typical items on 67% of the occasions. Training consisted of three blocks of 108 presentations each. Within each block, each stimulus was presented six times: four times with its typical response and two times with its atypical response. In Phase 2, the presentation rate of the study lists was manipulated such that all participants received nine study lists at a slow rate (1,000 ms/item) and nine study lists at a fast rate (300 ms/item). A random ordering of fast and slow lists was constructed and then divided into two blocks of nine lists such that five at a given rate and four at the other rate appeared in each set of nine study–test blocks. The position of the fast and slow lists within the ordering was counterbalanced across subjects.

The study lists maintained the earlier proportion of typical and atypical responses from training. Each list contained nine word pairs, six of which had responses made typical by training and three of which had responses made atypical by training. Each of the 18 typical items was presented three times across the nine study lists for each rate. Each of the 18 atypical items was presented once, with an additional 9 of the possible 18 atypical items chosen randomly for a second presentation. The selection of these 9 items was counterbalanced across subjects so that all atypical items were tested equally often in the fast and slow conditions. The order of the items was randomly determined and remained fixed throughout the experiment. All other details of the procedure were the same as in Experiment 1, as were analyses of results.

Results and Discussion

During the training session, our intention was to create a habit strength of 67% by presenting typical items as responses on 67% of the trials. In line with our expectations, the probability of responding with a typical item in the final block of training was .63.

The mean probability of responding with a typical item on congruent and incongruent trials was investigated for fast and slow presentation rates, and a significant interaction emerged, $F(1, 15) = 32.75$, $MSE = 0.005$ (see Table 2). Analysis of congruent trials revealed only that when items were presented at a fast rather than a slow rate, participants were less likely to correctly give a typical response, $F(1, 15) = 13.78$, $MSE = 0.001$. For the incongruent trials, participants were more likely to mistakenly give a typical item as a response when items were presented at a fast rate, $F(1, 15) = 16.41$, $MSE = 0.012$. That is, participants had fewer correct responses in the facilitation condition and committed more memory slips in the opposition condition when only a short amount of time was allowed for study.

An analysis of estimates of recollection (Table 2) showed that recollection was much higher when items were presented at a slow rate as compared with a faster rate, $F(1, 15) = 32.75$, $MSE = 0.010$.

An analysis of estimates of habit (Table 2) showed that manipulating presentation rate had no effect on the automatic influences of memory, $F(1, 15) = 1.30$, $MSE = 0.005$. This null effect was not due to insensitivity of our measure, as the power to detect an effect of presentation rate on habit estimates as large as that observed for recollection was .99 (alpha = .05, Cohen's $d = 3.13$). (The power to detect an effect that was half the size of the effect on recollection was also .99.) Again, the estimates closely matched the actual probability of having seen a typical item during the training session (67%). These results show that recollection was affected by an experimental manipulation that left habit invariant, further supporting a dual-process model of memory in which components make independent contributions to performance. The dissociation shown by these results is opposite the one found in Experiment 1, thus demonstrating that both automatic and intentional influences of memory can be selectively manipulated.

Guessing scores were again used to provide converging evidence for the estimates of habit (Table 2). As expected, the analysis of habit estimates and guessing scores did not reveal significant effects. The difference between guessing and estimates of habit was not significant, $F(1, 15) = 3.03$, $MSE = 0.009$, $p < .10$. The effect of presentation rate and the interaction of type of measure with presentation rate also were not significant ($Fs < 1$). For both measures of automatic influences, probability matching was again evident.

The results of Experiment 2 show that manipulations of presentation rate at study affected recollection but left habit unchanged. These results provide further evidence for the assumption of independence between intentional and automatic memory, as put forth by Jacoby's (1991) dual-process model of memory. In addition, there were no differences between estimates of habit and guessing, suggesting that automatic influences from the training session were reflected similarly in both types of measures and that both measures again approximated the proportion of typical items seen during training (67%).

Table 2
Probabilities of Responding With a Typical Item and Mean Estimates of Recollection and Automatic Influences as a Function of Presentation Rate in Experiment 2

Trial type and estimates	Presentation rate: Slow	Fast
Trial type		
Congruent	.79	.74
Incongruent	.32	.48
Estimates		
Recollection	.47	.27
Habit	.62	.65
Guessing	.68	.66

Experiment 3

A third experiment was carried out to extend the findings of Experiment 2. In daily life, people are often faced with situations where they have to make decisions quickly, and it is in these rushed situations that they seem most susceptible to memory slips. Returning to the example with the keys, it is likely that one would mistakenly begin the search for the keys at their typical location when hurried to find the keys. The effects of speeded responding were investigated in Experiment 3 by imposing a deadline for responding at the time of test. We expected the contribution of conscious recollection to be reduced when only a short amount of time was allowed for responding but did not expect deadlining to affect the contribution of habit. Typical responses were again presented on 67% of the trials in the training session to create a habit strength of that magnitude. Once again, we expected the probability of seeing a typical item in the training session to be reflected in estimates of habit.

Method

Participants and materials. Twenty-four undergraduates enrolled in an introductory psychology course at McMaster University participated for course credit. The materials, word lists, randomized orders, and counterbalancing conditions from Experiment 2 were used in Experiment 3.

Design and procedure. The training and study–test blocks were identical to those in Experiment 2 with the following exceptions: All study lists were presented at a rate of 1,000 ms per word pair, with a 500-ms interpair interval. The amount of time allowed for responding to test items was manipulated between lists and varied within subjects. For half of the tests, a long deadline was imposed on participants' responding (3,000 ms), and on the other half, a short deadline was imposed (1,000 ms). The computer triggered a beep when the time for responding elapsed, and then the next test item appeared on the screen.

After the presentation of each study list, participants were informed whether the upcoming tests would have a long or a short deadline and were instructed to respond before the computer beeped. They were told that any response given after the beep would not be counted. In reality, responses were scored without reference to whether they met the deadline for purposes of analyses. With word pairs that did not appear elsewhere in the experiment, eight practice trials (four short and four long deadlines) were provided to allow participants to become familiar with the response deadlines.

Results and Discussion

The purpose of the training session was to create a habit strength of 67%. In line with our expectations, the mean probability of giving a typical item as a response in the final block of training was .57.

The mean probability of responding with a typical item on congruent and incongruent trials was examined for short- and long-deadline conditions, and a significant interaction was found, $F(1, 23) = 17.03$, $MSE = 0.008$ (see Table 3). Further analyses showed that the probability of correctly giving a typical item as a response on congruent trials was greater in the long-deadline condition, $F(1, 23) = 10.07$, $MSE = 0.005$. In contrast, the probability of incorrectly giving a typical response on incongruent trials (the likelihood of committing a memory slip) was greater in the short-deadline condition, $F(1, 23) = 10.66$, $MSE = 0.008$. These results supported the prediction that memory slips would be more prevalent when participants were pressed for time.

An analysis of recollection estimates (Table 3) revealed that recollection was higher when participants were allowed more time to respond at test (long deadline) than when they were forced to respond quickly, $F(1, 23) = 17.03$, $MSE = 0.016$. The effect of response deadline on recollection estimates was similar to the effect of varying presentation rate observed in Experiment 2.

An analysis of estimates of habit (Table 3) confirmed that there was no difference between the short- and long-deadline conditions, $F(1, 23) < 1$. This null effect was not due to insensitivity of our measure, as power analyses revealed that the power to detect an effect of deadline on habit estimates as large as that observed for recollection was .99 (alpha = .05, Cohen's $d = 1.72$). (To be conservative, the power to detect an effect that was half the size of the effect on recollection was .86.) Once again, probability matching was apparent, as the estimates of habit approximated the earlier proportion of typical items presented during the training session (.62 vs. .67, respectively).

As a source of converging evidence for our estimates of habit, we again computed guessing scores (Table 3). Guessing scores were not significantly affected by deadlines at test, $F(1, 23) = 2.53$, $MSE = 0.009$. An analysis of habit estimates and guessing scores did not reveal a significant difference between the two measures, $F(1, 23) = 2.07$, $MSE = 0.009$. Furthermore, that analysis showed that neither response deadline, $F(1, 23) = 2.81$, $MSE = 0.004$, $p = .103$, nor the interaction of response deadline with type of measure, $F(1, 23) < 1$, produced a significant effect.

The results of Experiment 3 showed that memory slips were more likely when participants were forced to respond quickly than when they were allowed to respond at a more leisurely pace. In addition to the increase in errors on incongruent trials, requiring fast responding resulted in fewer correct responses on congruent trials. That is, the deadline manipulation had a significant effect on recollection such that a short deadline significantly lowered conscious recollection as compared with a longer deadline. However, the deadline manipulation did not affect estimates of automatic influences. Estimates for habit and guessing again approximated the proportion of typical responses presented during the training session, showing probability matching.

Table 3
Probabilities of Responding With a Typical Item and Mean Estimates of Recollection and Automatic Influences as a Function of Response Deadline in Experiment 3

Trial type and estimates	Response deadline: Long	Short
Trial type		
Congruent	.77	.71
Incongruent	.37	.45
Estimates		
Recollection	.41	.26
Habit	.62	.61
Guessing	.66	.62

General Discussion

Results from our experiments with the process-dissociation procedure showed that some factors influence the contribution of habit but do not affect recollection. Varying an item's prior history (i.e., habit strength) influenced the automatic component but left the contribution of recollection unchanged (Experiment 1). In contrast, estimates of habit were not affected by manipulating the amount of time to study an item (Experiment 2) or by manipulating the amount of time given to respond at test (Experiment 3). However, recollection was significantly influenced by both of these factors. Such functional dissociations support a dual-process model of memory in which consciously controlled and automatic processes make *independent* contributions to memory performance (Jacoby, 1991). Later, we argue that effects of habit can be treated as a special form of response bias that reflects a type or use of memory that is independent from that reflected by recollection.

Our findings of dissociations between habit and recollection have implications for a variety of issues. First, we describe the convergence of results from the experiments reported here with results from other procedures used to separate the contributions of automatic and consciously controlled processes. We argue that our procedure of creating in-concert and opposition conditions by manipulating congruency with prior training holds advantages over other means of implementing the process-dissociation procedure. In doing so, we respond to criticisms that have been aimed at the process-dissociation approach. Next, we describe automatic influences of memory as producing a form of response bias and suggest that this response bias and recollection reflect different functions or types of memory (Jacoby et al., 1993). We further suggest that the dissociation between recollection and habit, described as a form of response bias, provides a better understanding of action slips (e.g., Reason, 1979) and redirects investigations of proactive interference. Finally, probability matching is described as a form of implicit learning (e.g., Reber, 1989), and we discuss advantages of separating the contributions of implicit learning from other intentional processes contributing to performance on a task, rather than identifying implicit learning with a particular type of task.

Convergence With Results Using the Inclusion–Exclusion Procedure

For most of the experiments using the process-dissociation procedure, in-concert and opposition conditions have been created by manipulating instructions given at the time of test (e.g., Jacoby et al., 1993). Participants are told to report remembered items for an inclusion test (in-concert condition) but to withhold remembered items for an exclusion test (opposition condition). In contrast, when conditions are created by manipulating congruency with prior learning, participants are always instructed to give remembered items as responses. Using this new version of the process-dissociation procedure, we were able to separate the contribution of habit from recollection for specific events. Kelley and Jacoby (1993) used a variant of the procedure that is similar to the one used in the experiments reported here and showed that general knowledge and recollection can make functionally independent contributions to performance on a cued-recall test of memory. Similarly, Yonelinas and Jacoby (1995) used a manipulation of congruency to examine automatic and controlled processes within a Sternberg memory search task.

The two ways of implementing the process-dissociation procedure produce parallel results. Using the inclusion–exclusion procedure, we have manipulated factors that are traditionally treated as important for conscious control and have found process dissociations. For example, divided attention at study reduces recollection but leaves automatic influences invariant, as do the effects of aging (for a review, see Jacoby, Jennings, et al., in press; Jennings & Jacoby, 1993). Using response deadlines to require fast responding also reduces recollection without changing the contribution of automatic processes (Toth, 1996; Yonelinas & Jacoby, 1994). In the experiments reported here, we found similar results by manipulating congruency with prior training. We showed that reducing the amount of time for study (Experiment 2) or requiring fast responding (Experiment 3) reduces recollection but leaves the contribution of habit unchanged.

Both versions of the process-dissociation procedure are similar in their support of the independence assumption, which is the most controversial assumption underlying the procedure (e.g., Curran & Hintzman, 1995). However, there is substantial support for the independence assumption (e.g., Cowan & Stadler, 1996; Jacoby, Yonelinas, & Jennings, in press). One source of support comes from the convergence of estimates of automatic influences with performance on indirect tests of memory. Although indirect tests cannot be relied on to provide a process-pure measure of automatic influences, close agreement between performance on an indirect test and estimates of automatic influences from the inclusion–exclusion procedure can be expected in some cases. This correspondence should be closest when conditions are such that performance on the indirect test is unlikely to be contaminated by the effects of recollection, such as under conditions of divided attention or when quick responding is required (Jacoby, Yonelinas, et al., in press). Results of the present experiments showed similar convergence between estimates of habit and performance on guessing items, which served as an indirect test of memory. Furthermore, both measures of automatic influences showed probability matching.

Creating conditions by manipulating congruency holds some advantages over creating conditions by manipulating instructions. Here, we demonstrated that it is possible to vary automatic influences while leaving recollection unchanged (Experiment 1), whereas only the opposite form of memory dissociation has yet been shown using the inclusion–exclusion procedure. Some critics have argued that inclusion–exclusion instructions are too complicated for participants to comprehend (e.g., Graf & Komatsu, 1994). We believe that such criticisms are unfounded and have discussed evidence to show that participants did follow instructions in our inclusion–exclusion experiments (see Toth, Reingold, & Jacoby, 1994). Regardless, creating conditions by manipulating congruency makes it unnecessary to vary instructions across in-concert and opposition conditions and thus eliminates the possibility that such difficulties will arise. Floor and ceiling effects have also produced some problems for interpreting results from inclusion–exclusion experiments (e.g., Jacoby, Begg, Toth, & Shrout, in press). In contrast, creating conditions by manipulating congruency makes it easier to avoid floor and ceiling effects because the background probability of a response is created within the experimental session and, therefore, is under greater experimental control. Finally, differences in willingness to respond for inclusion versus exclusion tests can make it necessary to adopt a means of correcting for differences in response bias when obtaining estimates of recollection and automatic influences of memory (Buchner, Erdfelder, & Vaterrodt-Plunnecke, 1995; Jacoby et al., 1993; Yonelinas & Jacoby, in press). In contrast, the *forced-choice procedure* used in the experiments reported here makes it unnecessary to correct for differences in willingness to respond.

An assumption underlying the process-dissociation procedure is that automatic influences are the same for in-concert and opposition conditions. There is reason to question whether this assumption was satisfied by the procedure used for the experiments reported here. It is possible that the magnitude of habit was slightly greater for congruent trials than for incongruent trials, as typical items had an additional presentation in the study list for congruent trials only. (Atypical responses were presented in the study list for incongruent trials.) The additional presentation at study may have boosted the habit present for congruent tests above that present for incongruent tests.[2]

[2] If habit differs for congruent (H_{con}) and incongruent (H_{incon}) items, then the derived estimate for habit (H) would equal: $H_{incon}/1 - (H_{con} - H_{incon})$. As can be seen from this equation, the derived estimate of habit will be a function of H_{con} and H_{incon} and will not be influenced by recollection. Therefore, invariance in the automatic component (H) will still be found as long as habit and recollection are independent.

However, there are several reasons to suggest that any difference in habit across congruent and incongruent trials was minimal. Typical items were presented in training on 12–15 separate occasions, with an additional 6 presentations during testing in Phase 2, thus making it likely that habit was already at a level where one additional presentation had a negligible impact. (Similarly, any differences in preexperimental strength of associations in the word pairs were likely overwhelmed by the effects of training and were thereby made unimportant.) This seems especially likely given that our estimates of habit closely reflected the actual probabilities of items being presented in training—our findings of probability matching. Furthermore, guessing items, which were not presented for study (similar to typical items in the incongruent condition), produced a probability of responding that was very close to and even slightly higher than our estimates of habit. This convergence suggests that any difference between congruent and incongruent trials was unimportant for estimating the contribution of habit.

Response Bias

Convergence with Ratcliff and McKoon (1995). Ratcliff and McKoon (1995) investigated effects of memory in an object-decision task that was earlier used by Schacter and his colleagues (e.g., Schacter & Cooper, 1993) as a source of evidence that performance on implicit (indirect) and explicit (direct) tests of memory rely on separate memory systems. Schacter and his colleagues reported that prior presentation of a possible object speeds its later acceptance as possible, whereas prior presentation of an impossible object has no effect. This difference was taken as strong evidence for a perceptual representation system that is separate from episodic memory. However, using conditions designed to eliminate recollection, Ratcliff and McKoon showed equivalent effects of prior presentation on possible and impossible objects. They concluded that prior presentation of an object produces a bias to respond *possible,* which is opposed for impossible objects by recollection. A balance in the opposition between recollection and the bias to respond *possible* was said to produce the approximately null effect for impossible objects found in experiments by Schacter and his colleagues. Further, Ratcliff and McKoon interpreted their results as reflecting different processes operating in a single memory-processing system rather than separate memory systems.

We agree that automatic influences of memory can be expressed as bias (Jacoby et al., 1993). Our findings of process dissociations can be interpreted as showing that automatic influences of memory, including habit, can produce a response bias that is separate from recollection. However, that bias is very different from the list-wide or situation-wide differences in willingness to respond that the term *response bias* usually describes. We found that the effects of habit were specific to studied items. Item-specific bias can be treated as evidence of automatic processes (habit) that are independent of consciously controlled processes (recollection).

Automatic influences of memory viewed as response bias (guessing). The goal of separating the contributions of recollection and automatic processes is the same as that of correcting memory performance for response bias, except that it is acknowledged that recollection and response bias produced by automatic processes reflect different functions or types of memory (Jacoby et al., 1993). Bias has traditionally been treated as uninteresting—a target for elimination or correction. However, as later discussed, bias relies on a form of memory reflected by probability matching and could as well be called *categorization* (e.g., Gluck & Bower, 1988). We hold that a test of episodic memory always involves categorization processes that classify types of items across situations and are responsible for guessing (bias) and that such a test also involves consciously controlled processes that are responsible for recollection.

For measuring recollection, the problems produced by differences in habit are the same as those encountered by models of memory that are meant to separate *memory* from guessing. The different ways of creating in-concert and opposition conditions for use of the process-dissociation procedure are akin to using different means of obtaining hits and false alarms to test a model of response bias. The success of a model designed to take differences in response bias (guessing) into account when measuring memory is evidenced by the invariance in its estimates of memory across levels of manipulations meant to selectively influence bias. The measure of "true" memory is expected to remain invariant across conditions that differ in the extent to which they encourage guessing. Similarly, for the process-dissociation approach, an adequate treatment of habit must show estimates of recollection to be invariant across manipulations that selectively influence the contribution of habit and vice versa—process dissociations such as those reported here.

Memory Slips

An action slip is an error in performance that results when an automatic basis for responding (e.g., habit) dominates the intention to perform a specific behavior. These errors arise in situations that place habit and current intentions in opposition, each leading to different outcomes. Similarly, a memory slip can be viewed as a type of action slip that emerges when habit dominates recollection for a specific event. Among the first to write about action slips were William James (1890) and later Freud (1922) who analyzed behavior slips, including "slips of the tongue." Freud argued that these errors reflect unconscious desires and thoughts because such utterances conflict with what people consciously intend to say. More recently, investigators have attempted to categorize action slips into various types to develop theories of action and to explore the cognitive mechanisms that underlie them (e.g., Norman, 1981; Reason, 1979). However, very little has been done to examine action or memory slips by directly manipulating the likelihood of their occurrence in experimental situations. In the research presented here, we not only manipulated memory slips but also teased apart the roles played by automatic and intentional responding in their production.

Rather than focus only on errors as was done previously, we combined results from in-concert (hits) and opposition (false alarms) conditions to separate the contributions of habit and recollection. Just as one would not investigate recognition memory by examining only false alarms, we argue that the effects of habit should not be investigated by examining only memory slips. The same argument can be made for proactive interference. In fact, the effects of training in Phase 1 on the probability of producing a memory slip could be described as reflecting proactive interference. Proactive interference has traditionally been treated as a topic for investigation that is separate from that of learning—the two topics are seldom addressed in the same experiment. From our perspective, that traditional approach is no more defensible than would be treating false alarms and hits as separate topics for investigation, never including the two in the same experiment. We advocate investigating *proactive bias* by using both hits and false alarms, rather than investigating proactive interference by relying on false alarms alone.

Implicit Learning and Implicit Memory

Investigations of implicit learning examine effects of extensive training, whereas investigations of implicit memory examine effects of a single prior presentation of an item (Roediger & McDermott, 1993). Similarly, the experiments reported here separated the contributions of habit (multiple presentations) from recollection, whereas other applications of the process-dissociation approach have separated automatic influences produced by a single prior presentation of an item from recollection. The convergence of results across procedures suggests continuity between automatic influences produced by a single prior presentation of an item and those produced by habit.

Another process-dissociation study that relied on multiple presentations of an item to investigate automatic influences found results similar to those reported here. Yonelinas and Jacoby (1995) used the process-dissociation procedure to examine automatic and controlled processes within a Sternberg memory search task. As in the present experiments, opposition and in-concert conditions were created by manipulating congruence with prior experience. Results of their experiments revealed process dissociations such that memory-set size influenced recollection (controlled memory search) but left automatic influences (automaticity) invariant. They too found evidence of probability matching produced by the automatic component and argued that the observed probability matching qualified as implicit learning.

Probability Matching as Implicit Learning

There exists a large amount of literature on probability matching dating back to the 1930s. As an analogue of classical conditioning, early studies used a binary task that asked participants to predict which of two lights would be illuminated on each of a series of trials (e.g., Humphreys, 1939). Other probability-learning paradigms have used paired-associate learning tasks in which two response words are probabilistically paired with one stimulus word. Participants are asked to predict the response that would be paired with each presentation of a stimulus and, in doing so, typically produce each response with a rate that matches its probability of occurrence (e.g., Voss et al., 1959). The task used in Phase 1 of our experiments and the results of our experiments are representative of this paradigm. Probability matching is a particularly striking phenomenon because it is not the optimal solution to the task when participants are trying to maximize the accuracy of their predictions. The best strategy would be to predict that the more frequent event would be presented on every trial, but humans and animals are extremely resistant to abandoning probability matching.

Knowlton et al. (1994) described probability learning as a task that relies primarily on the form of memory preserved by amnesics. They found that amnesics show evidence of probability learning but perform more poorly than people with normally functioning memory. Reber (e.g., 1989) has argued that probability matching reflects implicit learning of an event sequence that is acquired independently of a conscious effort to learn and without intentional strategies. A similar argument has been made for the learning of artificial grammars (see Reber, 1993, for a review). However, an important question arises: To what extent is responding in an implicit learning task consciously controlled, and to what extent is it unconscious and automatic? The claim that participants are unaware of regularities in events across trials in implicit learning experiments is controversial (see Shanks & St. John, 1994, as well as accompanying commentaries). Knowlton et al. (1994) suggested that the reason for poorer probability learning among people with amnesia is that they lack the ability to recollect (declarative memory), a type of memory used by people with normal memory to supplement the more automatic, unconscious form of memory (procedural memory) that is fully relied on by those with amnesia for probability learning tasks.

The controversy that currently surrounds implicit learning is the same as that which earlier surrounded accounts of probability learning. Estes (1964) suggested that it is a mistake to try to decide whether active cognitive processes or more passive associative processes are responsible for probability learning because both types of processes play a role. Rather than equate different forms of memory with different tasks as others have done, we separate the contributions of automatic and consciously controlled processes in performance of a task (see Jacoby et al., 1993, for further comments regarding the *process-pure assumption* that underlies the use of implicit–explicit tests). In Phase 2 of our experiments, probability learning was not the focus, yet the form of memory responsible for probability matching was observed. Our procedure allowed us to separate the contributions of habit and recollection and to thereby examine effects of habit uncontaminated by recollection. In doing so, we found that only the automatic component (habit) reflected the probability of responses from training. The differential habit strength of typical responses did not influence recollection, nor did factors that influenced recollection affect the contribution of habit.

A critic might object to the claim that habit served as an unintentional, unaware basis for responding in our experiments by arguing that participants were aware of the presentation probability of responses and intentionally used that knowledge, thereby inflating the estimates of automatic influences. If conscious guessing sometimes occurs, it might be expected to be a relatively slow basis for responding. If so, then requiring fast responding in Experiment 3 should have reduced the contribution of habit relative to the longer deadline condition in which conscious guessing could occur. The lack of change in the contribution of habit across the manipulation of response deadline makes it likely that habit served as an unaware, unintentional basis for responding. In contrast to the results for habit, manipulating response deadline had a large influence on recollection. By separating the contribution of processes within a task, we investigated implicit learning and recollection as they operate in the same context. Perhaps much of the controversy that has surrounded implicit learning could be avoided by separating processes within a task rather than identifying processes with separate tasks.

Does Independence Between Habit and Recollection Always Hold?

Do automatic influences of memory produce only bias, an effect that is the same for congruent and incongruent test items? It seems almost certain that the typicality of an event sometimes influences recollection as well as bias. Novel events may sometimes be particularly memorable, producing good recollection and large automatic influences of memory. However, the two effects might still be independent of one another. The possibility that the independence assumption is sometimes violated makes it even more important to seek process dissociations so as to specify boundary conditions for independence.

Problems produced by a violation of independence between habit and recollection are shared with other models that attempt to take differences in response bias into account when measuring recollection. Our independence assumption is similar to an assumption that underlies models used to correct memory performance for guessing. Such correction procedures (e.g., true memory = hits − false alarms) are as open to concerns about violations of independence as is the process-dissociation procedure (cf. Curran & Hintzman, 1995). The multinomial model proposed by Buchner et al. (1995) includes an assumption that automatic influences of memory for old items are independent of guessing performance on new items. Yonelinas and Jacoby (in press) responded to Buchner et al. by objecting to their assumption of independence and describing advantages of using a model based on signal-detection theory to describe automatic influences of memory. As an attempt to reject the multinomial model, we could have attempted to show that guessing and automatic influences of memory are correlated at the Item × Participant level. One can make a seemingly convincing argument that such a correlation exists. However, because of Simpson's paradox (Hintzman, 1980), we do not trust correlational data as a means of disproving or proving independence. Of course, signal-detection theory also includes an assumption of independence (Snodgrass & Corwin, 1988). Rather than trying to prove or disprove independence, we prefer to test the pragmatic utility of an independence assumption across different situations and paradigms.

Concluding Comments

Memory slips emerge in situations for which habit and current intention act in opposition. However, habit is not always a source of error; automatic responding and current intention sometimes work together to produce the same outcome. Unlike previous work on memory slips that has focused on opposition conditions, we show it is necessary to also investigate facilitation conditions. By combining performance from in-concert and opposition conditions, we found that habit and recollection were differentially affected by various experimental manipulations, thus supporting the assumption that the two bases of responding can operate independently of each other. These results converge with earlier results gained using the inclusion–exclusion variant of the process-dissociation procedure.

Rather than investigating proactive interference, we think it better to examine *proactive bias* by using in-concert and opposition conditions to separate effects on automatic processes in the form of proactive bias from effects on recollection. Similarly, we think implicit learning is better studied by separating the contributions of habit and recollection within a task, rather than by identifying the different types of processes with different tasks. This change in research strategy might also prove useful for specifying anatomical bases for the different forms of memory (cf. Knowlton et al., 1994).

The goal of separating the contribution of processes within a task seems particularly important given that in most natural situations, both automatic and consciously controlled processes are simultaneously in play. In the experiments presented here, we were able to separate out these memory processes as they occurred together by manipulating congruency with prior learning. We believe that this extension of Jacoby's (1991) process-dissociation procedure offers a useful method for investigating automatic and consciously controlled influences on memory, and furthermore, it serves well to answer some of the criticisms aimed at earlier versions of the inclusion–exclusion procedure.

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