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What is the mechanism for fluency in successive recognition?

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Abstract

There are a number of reasons to believe that processing fluency may affect successive recognition judgements, but evidence about the mechanism for these effects is currently lacking. This study used a successive task design to examine whether subjective ease might underlie effects of fluency on recognition. At study subjects performed lexical decisions; in a subsequent test with studied and new items, subjects performed lexical decisions followed immediately by recognition or ease judgments. In a previous study we used the process dissociation procedure to show that recognition in a similar task was largely based upon fluency. In the present study, successive recognition judgments interfered with lexical decision performance to a greater degree than did ease judgments, suggesting that the recognition judgment was not automatic and involved processes additional to the judgment of ease. The data suggest that the fluency involved in successive recognition is more complex than a subjective judgment of ease of processing. One possible mechanism for fluency in recognition may be based upon reductions in the orientation of attention that accompany item repetition. © 1998 Elsevier Science B.V. All rights reserved.

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1. Introduction

Current theories of recognition memory hold that recognition judgments rely upon two bases known as *familiarity* and *recollection* (Mandler, 1980; Jacoby, 1991). Familiarity is a subjective nonrecollective experience of "oldness", whereas recollection involves the retrieval of a specific episode from memory. A method for separating the independent contributions of recollection and familiarity in recognition memory has recently been developed and tested by Jacoby and his colleagues (Jacoby, 1991; Jacoby et al., 1993). Known as the *process dissociation procedure*, this technique relies upon placing recollection and familiarity in opposition.

In the process dissociation procedure, subjects study at least two sets of items (e.g., visual and auditory presentation), and are then placed in one of two test conditions. In an *inclusion* condition, subjects are told to say "Old" to any item that they remember having encountered on either study list. In this condition, recollection and familiarity both work to produce the same response. In an *exclusion* condition, subjects are told to say "Old" only to items that they encountered on one of the study lists (e.g., only to visually presented items). They are told to say "New" to items that they remember having seen on the other (excluded) list. In this condition, recollection and familiarity are placed in opposition for items on the excluded list; recollection leads to a new response for items on the excluded list, but familiarity leads to an old response for these items. A method has been presented that allows the estimation of the probability of saying "Old" on the basis of familiarity versus on the basis of recollection, and a number of studies have shown that these estimates can be functionally dissociated (e.g., Jacoby et al., 1993; however, see Mulligan and Hirshman, 1997 for a critical view of this procedure).

One possible source of familiarity in recognition comes from attributions of *fluency*. Fluency refers to the ease with which a task is performed, and can be reflected in the speed or accuracy of processing as well as in a subjective experience of ease. One source of fluency is previous experience with a specific stimulus, which can result in facilitation of performance on that stimulus on a later test (Jacoby and Dallas, 1981). This memory-related fluency can be attributed by the participant to previous experience on a recognition test. To the extent that items previously encountered are found to be more quickly or easily processed than new items, a significant contribution to recognition could occur simply on the basis of subjective ease or fluency. That is, by calling easier items old and harder items new, the subject could perform better than chance on a test of recognition memory without any participation of explicit memory retrieval.

The relation between fluency and recognition has been investigated in studies of "perceptual fluency", in which subjects identify an item under difficult perceptual conditions and then perform an immediate successive recognition judgment on the identified stimulus. In such studies, previously studied items are generally identified more quickly than new items (Jacoby, 1983). Johnston et al. (1985) found that subjects were more likely to call an item old if it was identified quickly, regardless of whether it was actually old. Johnston et al. (1991) showed that this effect depended critically upon the use of a successive recognition test that immediately follows the identification trial, and was not dependent upon item characteristics. Whittlesea (1993) showed that manipulations of the fluency of conceptual processing affected recognition judgments to a much larger degree than did manipulations of perceptual processing, and that manipulations of fluency also affected other tests such as pleasantness, relatedness, and recency. Thus, there is evidence that both perceptual and conceptual fluency may affect performance on a number of tests, at least when the test closely follows the processing event.

In a recent study, we (Poldrack and Logan, 1997) examined whether the fluency that influences recognition in a successive recognition task is based upon response speed. Lists of words and pseudowords were first studied in naming or lexical decision tasks. At test, repeated and new items were presented for lexical decision. On a proportion of trials recognition probes were presented together with either inclusion or exclusion instructions, as used in the process dissociation procedure (Jacoby, 1991). Computations of the process dissociation estimates suggested that recognition performance was largely based upon fluency. To determine whether speed could have supported recognition in the task, we calculated a measure of discriminability between the response time distributions for old and new items, called dRT. If recognition responses were based upon response speed, then recognition discriminability would be no better than dRT. However, in every case, dRT was much smaller than the observed recognition discriminability, suggesting that recognition could not be relying solely upon speed. Construction of operating characteristics from response time distributions confirmed the dRT analysis. We concluded that response speed was not a viable mechanism for the effects of fluency in successive recognition tests.

1.1. Automaticity and fluency

Jacoby (1991) has recently argued that the effects of fluency on recognition are automatic, whereas the effects of recollection on recognition are controlled. Evidence for this argument comes from the finding that estimates of recollection in the process dissociation procedure are affected by a secondary task, whereas estimates of fluency remain constant across single-task and dual-task conditions (Jacoby, 1991). This suggests that the performance of a recognition judgment, if based upon fluency, should display a hallmark feature of automaticity: It should not interfere with the performance of a concurrent task (e.g., Logan, 1979).

The experiment presented here examined the question of whether recognition judgments are as automatic as judgments of subjective ease, and thus whether fluency-based recognition could involve judgments of ease. While ease judgments have not been investigated in the context of recognition memory, we expected that they would be relatively automatic, though the processing associated with the decision phase could result in some interference with concurrent tasks. To examine recognition we used a lexical decision task with a successive recognition test, in which recognition is largely based upon fluency according to the process dissociation procedure (Poldrack and Logan, 1997). Thus, to the degree that recognition judgments interfere with the ongoing task to a greater degree than do ease judgments, we would conclude that "fluency"-based recognition requires effortful processing beyond that involved in the judgment of subjective ease. We chose the ease judgment task as a comparison to recognition because it seems to capture intuitively the notion of subjective fluency, namely that it is based directly on the perceived ability with which an individual trial was performed.

In the present study, we used a successive task technique in which lexical decision trials were followed immediately by recognition judgments or by ease judgments (i.e., judgments of how easy the previous lexical decision was). These secondary judgments will be referred to as *probe* trials. Although the tasks were performed successively, there is good reason to believe that concurrent processing occurred; Poldrack and Logan (1994) found that, compared to single-task performance, lexical decisions were significantly slowed by a successive recognition task. This suggests that, although the two tasks were not performed simultaneously, there was significant interference between the tasks.

2. Method

2.1. Subjects

Forty-eight University of Illinois undergraduates participated in the experiment as part of a class requirement. All subjects were native English speakers. Subjects were randomly assigned to response conditions and to experimental groups (ease judgment or recognition judgment) before the experiment.

2.2. Materials

Words were selected randomly for each subject from a pool of 339 common words or matched nonwords, and assigned randomly to conditions. For each subject, a set of 64 study stimuli (32 words and 32 nonwords) was chosen. In addition, the study list included an additional 10 primacy and 20 recency buffer items. An additional 192 items were chosen randomly for use as new items in the test blocks. The words were nouns selected from the Kucera and Francis (1967) word frequency norms, with a mean frequency of 75.27 per million and a range of 8–787 per million. All nonwords were produced by changing one or two letters from the matched word, and all were pronounceable (see Logan, 1990 for more details on the stimulus set).

2.3. Procedure

Stimuli were displayed in white lowercase text on a black background at the center of an Amdek 722 monitor, and stimulus presentation and response collection were controlled by IBM AT microcomputers. Subjects were instructed that they would see words and nonwords, and would make lexical decision and recognition or ease responses to these stimuli. During the study block, lexical decision responses were made using two fingers on one hand; during the test block, these same fingers were used to make lexical decision responses, and two fingers on the other hand were used to make recognition or ease responses. Responses were made using the *x*, *z*, period (.), and slash (/) keys, which were assigned to responses factorially across subjects. The experiment consisted of one session lasting approximately 35–40 min.

The session began with 64 study trials, on which the subject only performed lexical decision. The 64 target study items (32 words and 32 nonwords) were surrounded by 10 primacy and 20 recency buffer items (half of which were words and half nonwords), which were not repeated thereafter. Following the study trials, subjects performed three blocks of lexical decision test trials. Each block consisted of the entire set of 64 studied items and different set of 64 new items. On each trial, a probe was presented immediately after the lexical decision response. Subjects in the recognition condition were presented with the recognition probe "Old or New?", and were instructed to respond old on recognition probes if they remembered having studied the item during the study block. Subjects in the ease judgment condition were presented with the ease probe "Easy or Hard?", and were instructed to respond "Easy" or "Hard" depending upon the difficulty of the lexical decision trial immediately preceding the ease judgment.

On each trial, a 500 ms signal (+) was followed by the presentation of the word or nonword. The stimulus remained on the screen until the subject made the lexical decision response. On the following recognition or ease judgment trial, the stimulus remained on the screen and the probe was presented (depending upon the condition). Subjects were instructed that speed and accuracy were both important for the lexical decision. On occasions when the subject made a lexical decision error, an error message ("ERROR") was displayed on the screen for 1000 ms between the lexical decision trial and the judgment trial. No feedback was given on judgment probes.

3. Results

The significance level for all statistical tests was alpha = 0.05. When repeated measures analysis of variance (ANOVA) was used, the significance level was adjusted according to the Box correction for nonsphericity (Hays, 1988). Response times (RTs) greater than 3500 ms were excluded from the RT analysis, excluding a total of 0.54% of all trials; excluded trials were not counted as errors for the purposes of accuracy analyses.

3.1. Response times for lexical decision

3.1.1. Study

Study response times are shown in the top row of each half of Table 1. These data were analyzed using a 2 (item type: word versus nonword) × 2 (group: recognition versus ease) repeated measures ANOVA with group as a between-subjects factor. There was a significant effect of item type, $F(1,46) = 84.51$, $\mathrm{MSE} = 4489$; lexical decision times for words were faster than those for nonwords. There were no other significant effects (p's > 0.05).

Table 1
Study and test response time for lexical decision by subject group, item type, study type, and test block, with accuracy in parentheses

	Old words	New words	Old nonwords	New nonwords
Recognition group				
Study	621 (0.966)		774 (0.914)	
Block 1	1047 (0.980)	1122 (0.966)	1237 (0.962)	1158 (0.956)
Block 2	990 (0.977)	1066 (0.957)	1133 (0.964)	1105 (0.974)
Block 3	939 (0.965)	1063 (0.918)	1118 (0.956)	1090 (0.952)
Ease group				
Study	696 (0.945)		794 (0.941)	
Block 1	728 (0.975)	755 (0.953)	937 (0.911)	946 (0.949)
Block 2	666 (0.966)	741 (0.927)	827 (0.897)	834 (0.936)
Block 3	654 (0.982)	747 (0.915)	818 (0.906)	824 (0.936)

3.1.2. Test

Test response time forms the rest of Table 1. These data were analyzed using a 2 (item type: word versus nonword) × 2 (study type: repeated versus new) × 3 (test block) × 2 (group: recognition versus ease) repeated measures ANOVA with group as a between-subjects factor. There was a significant effect of group, $F(1,46) = 36.10$, $\mathrm{MSE} = 357158$, showing that subjects in the recognition group were slower than subjects in the ease judgment group. The main effect of block was significant, $F(2,92) = 19.04$, $\mathrm{MSE} = 20761$. A test for linear trend was significant ($p < 0.001$), reflecting a decrease in RT across test blocks. There was a test block x item type interaction, $F(2,92) = 5.51$, $\mathrm{MSE} = 6221$, reflecting the fact that nonwords gained more speed than words between blocks 1 and 2, but both exhibited the same speedup between blocks 2 and 3. There was also a significant test block x study type interaction, $F(2,92) = 4.01$, $\mathrm{MSE} = 4971$; responses to repeated items became progressively faster to a greater degree than responses to new items. There was a significant main effect of item type, $F(1,46) = 73.94$, $\mathrm{MSE} = 30826$; lexical decision times were faster for words than for nonwords. There was a significant main effect of study type, $F(1,46) = 12.36$, $\mathrm{MSE} = 10423$; repeated items were faster in the lexical decision task than new items. This effect was accompanied by a significant item type x study type interaction, $F(1,46) = 54.57$, $\mathrm{MSE} = 6237$. Planned comparisons showed that repeated words were faster than new words ($p < 0.001$), whereas repeated nonwords were marginally slower than new nonwords ($p < 0.07$). However, a significant group x item type x study type interaction showed that this pattern held for the recognition condition but not the ease condition, $F(1,46) = 9.09$, $\mathrm{MSE} = 6237$. No other effects or interactions were significant (p's > 0.05).

Test lexical decision times for new items in block 1 were compared to study lexical decision times to determine whether the introduction of the successive recognition or ease tasks interfered with lexical decision performance. New items in test block 1 and study items were compared separately for words and nonwords using paired t-tests. There was no significant difference between study and test in the ease group for words (59 ms difference, $p > 0.1$), but there was a significant difference for nonwords

(152 ms difference, $p < 0.01$). Test responses for the recognition group were slower than study responses, and this was true for both words and nonwords (501 and 384 ms differences respectively p's < 0.0001). Study-test difference scores were computed and compared for the recognition and ease groups. The recognition group exhibited a significantly larger increase in response times from study to test for words, $t(46) = 7.78$, and for nonwords, $t(46) = 3.60$. This shows that the successive recognition task interfered with the lexical decision task to a greater degree than did the successive ease task.

3.2. Accuracy for lexical decision

3.2.1. Study

Study accuracy for the lexical decision task is shown in parentheses in the top row of each section in Table 1. These data were analyzed using a 2 (item type: word versus nonword) × 2 (group: recognition versus ease) repeated measures ANOVA with group as a between-subjects factor. There was a significant main effect of item type, $F(1,46) = 6.24$, $\mathrm{MSE} = 0.003$; lexical decisions for words were more accurate than those for nonwords. The interaction between item type and group was also significant, $F(1,46) = 4.62$, $\mathrm{MSE} = 0.003$; words and nonwords were equally accurate for ease judgments, but words were more accurate than nonwords for lexical decision. The main effect of group was not significant ($p > 0.8$).

3.2.2. Test

Test accuracy for lexical decision is shown in parentheses in Table 1. These data were analyzed using a 2 (item type: word versus nonword) × 2 (study type: repeated versus new) × 3 (test block) × 2 (group: recognition versus ease) repeated measures ANOVA with group as a between-subjects factor. The main effect of item type was significant, $F(1,46) = 9.68$, $\mathrm{MSE} = 0.003$, reflecting greater accuracy for words than for nonwords. This effect was accompanied by an item type x group interaction, $F(1,46) = 9.68$, $\mathrm{MSE} = 0.003$; words were more accurate than nonwords for subjects in the ease condition, but not those in the recognition condition. There was a main effect of study type, $F(1,46) = 8.20$, $\mathrm{MSE} = 0.001$, reflecting greater accuracy for old items than for new items. The study type x item type interaction was significant, $F(1,46) = 52.17$, $\mathrm{MSE} = 0.002$, reflecting the fact that old words were more accurate than new words, but old nonwords were less accurate than new nonwords. This pattern was more strongly pronounced for the ease group compared to the recognition group, as shown by a significant study type x item type x group interaction, $F(1,46) = 12.40$, $\mathrm{MSE} = 0.002$. The main effect of block was significant, $F(1,46) = 4.00$, $\mathrm{MSE} = 0.003$, reflecting decreasing accuracy across subsequent blocks (linear trend, $p < 0.01$). In addition, the study type x block x item type interaction was significant, $F(1,46) = 3.372$, $\mathrm{MSE} = 0.001$; this result reflected an increase in the difference between old and new items across blocks for words but no such increase for nonwords. No other effects or interactions were significant.

Test accuracy in block 1 was compared to study accuracy, to further determine whether the introduction of the successive recognition task interfered with lexical decision performance. New items in test block 1 and study items were compared using paired *t*-tests. There were no significant differences between study and test accuracy for words or nonwords in the recognition or ease groups (*p*'s > 0.05).

3.3. Recognition judgments

Recognition data (probability of "Old" responses) are presented in the top portion of Table 2. These data were analyzed using a 3 (block) × 2 (item type: word versus nonword) × 2 (study type: "Old" versus nonstudied) repeated measures ANOVA. There was a main effect of block, $F(2,46) = 3.86$, $\text{MSE} = 0.016$. A test for linear trend indicated that the probability of calling items "Old" increased across blocks ($p < 0.02$), which was expected given that each block served as an additional study trial. There was also an effect of item type, $F(1,23) = 7.81$, $\text{MSE} = 0.035$, reflecting a higher proportion of "Old" responses for words than nonwords. There was also a significant block *x* item type interaction, $F(2,46) = 6.83$, $\text{MSE} = 0.009$. This effect signified a greater increase in the probability of "Old" responses across blocks for nonwords than for words. There was a significant effect of study type, $F(1,23) = 298.76$, $\text{MSE} = 0.065$, reflecting a significantly higher level of hits ("Old" responses to "Old" items) than false alarms ("Old" responses to new items). There was a block *x* study type interaction, $F(2,46) = 10.68$, $\text{MSE} = 0.010$, reflecting a greater increase in hits than false alarms across blocks. There were no other significant effects (*p*'s > 0.10).

Recognition judgments for subjects in the recognition group were also analyzed by computing d' values (Green and Swets, 1965) for each block for words and nonwords. These data are shown at the right in the top half of Table 2. They were analyzed using a 3 (block) × 2 (item type: word versus nonword) repeated measures ANOVA. There was a main effect of block, $F(2,46) = 20.06$, $\text{MSE} = 0.277$. A test for linear trend was significant ($p < 0.01$), reflecting an increase in d' across blocks. There was also a main effect of item type, $F(1,23) = 14.34$, $\text{MSE} = 0.319$, reflecting better recognition performance for words than for nonwords. The interaction was not significant ($F < 1$).

Table 2
Proportion of items called old or "Easy" in the recognition and ease judgment conditions respectively, with d' measures for each group

	Old words	New words	Old nonwords	New nonwords	d'-words	d'-nonwords
Recognition group						
Block 1	0.792	0.315	0.659	0.249	1.49	1.14
Block 2	0.844	0.286	0.757	0.215	1.91	1.65
Block 3	0.852	0.262	0.822	0.281	2.20	1.76
Ease group						
Block 1	0.915	0.879	0.600	0.630	0.304	−0.045
Block 2	0.932	0.896	0.694	0.736	0.417	−0.168
Block 3	0.921	0.866	0.729	0.732	0.600	−0.100

3.4. Ease judgments

Ease judgment data (probability of calling decisions "Easy") are presented in the bottom portion of Table 2. A (block) × 2 (study type: old versus new) × 2 (item type: words versus nonwords) repeated measures ANOVA was performed on these values. There was a main effect of block, $F(2,46) = 3.63$, $\mathrm{MSE} = 0.029$, reflecting an increase in the probability of "Easy" responses across blocks. However, a significant block x item type interaction, $F(2,46) = 8.57$, $\mathrm{MSE} = 0.010$, signified the fact that this increase across blocks occurred only for nonwords. This may have been due to a ceiling effect for words, which began with greater than 90% "Easy" responses. There was a main effect of item type, $F(1,23) = 29.51$, $\mathrm{MSE} = 0.112$; responses to words were called "Easy" more often than responses to nonwords. This effect was accompanied by a significant item type x study type interaction, $F(1,23) = 16.26$, $\mathrm{MSE} = 0.005$; responses to old words were called "Easy" more often than responses to new words, but old nonwords were called "Easy" less often than new nonwords. This effect suggests that recognition could not be based upon ease for nonwords, because if it were it would lead to performance poorer than chance.

Ease judgments were also analyzed by computing d' values (Green and Swets, 1965) for each block for words and nonwords. This measure denotes the degree to which subjects tended to call old items "Easy" and new items "Hard" and is analogous to the analysis used on recognition responses (if "Easy" is interpreted as an "Old" response). These data are shown at the right in the bottom portion of Table 2. They were analyzed using a 3 (block) × 2 (item type: word versus nonword) repeated measures ANOVA. There was a main effect of item type, $F(1,22) = 25.60$, $\mathrm{MSE} = 0.417$, reflecting greater discriminability for words than nonwords. No other effects were significant (p's > 0.1). The fact that d' values for ease were much smaller than those for recognition (and in the opposite direction for nonwords) provides further evidence that fluency-based recognition performance could not have relied upon ease judgments.

3.5. Conditional analyses

Response times on the lexical decision task were conditionalized on subsequent responses in the recognition and ease tasks. These data are presented in Table 3. Analysis of these data was complicated by the fact that many participants did not respond "Hard" to any words in the later test blocks, so the number of observations differed between conditions and blocks. Nonparametric sign tests were used to test whether "Easy" and "Old" responses on the successive test were associated with faster lexical decision response times than were "Hard" or "New" responses. Because six sign tests were performed for each group, the significance level for each test was adjusted using a Bonferroni correction (adjusted alpha = 0.008).

In the recognition judgment condition, "Old" judgments for words were associated with faster lexical decision response times than were "New" judgments, but this association was only significant at the adjusted alpha in block 1 ($p = 0.0001$; block 2, $p = 0.04$; block 3, $p = 0.08$). For nonwords, "Old" responses were associated with

Table 3
Lexical decision response times (weighted means) associated with each recognition or ease response, for each block and subject group

Recognition group	Words: "Old" response	Words: "New" response	Nonwords: "Old" response	Nonwords: "New" response
Block 1	1035 (836)	1165 (638)	1232 (650)	1189 (798)
Block 2	1000 (830)	1075 (613)	1114 (704)	1127 (743)
Block 3	963 (813)	1047 (613)	1092 (797)	1115 (650)
Ease group	"Easy" response	"Hard" response	"Easy" response	"Hard" response
Block 1	734 (1358)	835 (113)	859 (914)	1094 (460)
Block 2	688 (1366)	943 (71)	797 (1084)	959 (307)
Block 3	694 (1346)	745 (87)	786 (1115)	960 (276)

Numbers in parentheses are the total number of responses associated with each mean across all participants.

slower response times than were "New" responses, though this association was not significant in any block (block 1, $p = 0.02$; block 2, $p = 0.08$; block 3, $p = 0.15$). This result occurred because repeated nonwords were slower than new nonwords, thus resulting in slower response times associated with this for nonwords.

In the ease judgment condition, "Easy" judgments were associated with faster responses for words in block 1 ($p = 0.0002$). In blocks 2 and 3 for words, this difference did not reach significance because of the small number of observations (block 2, $p = 0.05$; block 3, $p = 0.11$). For nonwords, "Easy" judgments were significantly associated with faster responses in blocks 1 ($p = 0.0001$) and 3 ($p = 0.002$), while in block 2 this association was marginally significant ($p = 0.01$). These data demonstrate that ease judgments were sensitive to the response time of the preceding lexical decision.

4. Discussion

The experiment reported here examined the relation between successive ease and recognition judgments to further clarify the role of fluency in successive recognition. The results showed that successive ease judgments resulted in less interference with lexical decision performance than did successive recognition judgments. This occurred even though previous experiments demonstrated that recognition performance in this task was largely based upon fluency. This finding demonstrates that the familiarity component of the two-process model of recognition memory is not based upon subjective feelings of ease in successive recognition tasks, and that fluency-based recognition is not "automatic".

4.1. Recognition and ease

The present study also discovered a dissociation between recognition judgments and ease judgments by item type. Subjects called old items "Old" more often than new items for both words and nonwords in the recognition task. In the ease task, however, lexical decisions to new nonwords were called easier than lexical decisions to old nonwords, whereas lexical decisions to old words were called easier than lexical decisions to new words. Consistent with this finding, lexical decision times for repeated nonwords were slower than those for new nonwords. These data provide further support for the notion that lexical decision involves a familiarity decision and that repetition of nonwords makes it more difficult to reject them as nonwords (e.g., Balota and Chumbley, 1984).

The present results extend those of Poldrack and Logan (1997) by further constraining the nature of fluency in recognition memory. Although a successive recognition task caused significant interference with lexical decision performance, the performance of an ease judgment did not significantly interfere with performance on the lexical decision task, suggesting that the ease judgment was automatic. The ease judgment may have caused so little interference because the information needed to perform the ease judgment was already available from the lexical decision. If lexical decision is based upon a judgment of familiarity or fluency (e.g., Balota and Chumbley, 1984), then the ease judgment might be made using that same information. The strong relation between ease judgments and item type (words versus nonwords) is consistent with this account. Recognition responses, even when based upon fluency, must involve some additional memory processes that interfere with lexical decision performance.

Another possible explanation for the differences between the ease and recognition tasks involves differences in criteria. Subjects in the ease judgment condition seemed to use a rather low criterion for calling responses “Easy”, especially for words, compared to subjects in the recognition condition calling items “Old”. It could be the case that the use of a low criterion makes the task easier to perform concurrently. In addition, there is no “correct” answer in the ease task, so subjects might be less careful in their responses. These are valid concerns, but the conditional analysis reported above suggests that subjects did not abandon all care in responding; in all conditions, easy responses were associated with faster lexical decision times than were hard responses. These data are difficult to interpret, however, because of the relatively small number of hard responses. The criterion hypothesis is also discounted by the fact that difficult responses to nonwords were common, suggesting that subjects did take adequate care in making their ease judgments. Further studies must examine whether criterion differences can account for different amounts of interference between ease and recognition tasks.

4.2. Alternative mechanisms for fluency

Having discounted processing speed and subjective ease as mechanisms for fluency in successive recognition, what other mechanisms might underlie the effects of fluency on successive recognition tests? We have argued elsewhere (Poldrack and Logan, 1997) that it is profitable to frame the question of mechanisms for fluency in terms of established processing models of response time. One such model that offers a possible mechanism for fluency is the latent network model of response times developed by Schweickert (1978). In the latent network theory, psychological processes are represented as a directed graph. None of the processes beginning at a certain point in the graph can start until all processes connected to that point have finished. Response time is determined by the path of maximal duration between the starting and finishing points.

It is usually the case when a number of processes occur in parallel that one process will finish more quickly than the others. In the latent network theory, a quantity called "slack" represents the amount of time by which the fast process could be slowed without delaying the start of the next process in the graph (and thus increasing overall response times). The concept of slack offers a possible mechanism for the effects of fluency. Suppose that item repetition were to increase slack by decreasing the amount of time necessary for some cognitive operations in the network. If the subject could gain introspective access to the amount of slack in the network, then recognition responses could be made on the basis of this quantity, even though the differences in slack would not be apparent in overall response times. Though this account is speculative, it has the advantage of being directly testable. Using a model of response times in the lexical decision task, it should be possible to manipulate fluency-related processes with or without slack and observe the effects of these manipulations on response times and recognition performance. The hypothesis that fluency is based upon slack predicts that manipulations of those fluency-related processes with slack should affect recognition but not response times. Manipulation of processes without slack should affect response times, and if the manipulation did not alter the slack of other fluency-related processes then it should not affect recognition. It should be possible to frame similarly testable accounts of fluency in other processing architectures.

There is also evidence from neurobiology about possible mechanisms for fluency. Inferior temporal cortex is known to process information about visual objects in monkeys (Mishkin, 1982) and humans (Sergent et al., 1992). Desimone and his colleagues (e.g., Desimone et al., 1995) have examined the ways that cells in this region respond to new and familiar visual stimuli, finding that these cells exhibit stimulus-specific reductions in firing rate with the repeated presentation of a stimulus. Gabrieli et al. (1997) have found a similar familiarity-related decrease in activation of the parahippocampal cortex in humans using functional MRI. Desimone et al. (1995) suggest that such familiarity-related decreases in neural activity are related to attentional orienting, such that familiar items do not capture as much attention as novel items.

Although it is speculative to draw conclusions about fluency in recognition on the basis of unit recordings in monkeys, these findings may suggest that fluency is an attentional phenomenon. When a person performs the target task, the amount of attention captured by the stimulus will depend (stochastically) upon such factors as word frequency and pre-experimental familiarity; unfamiliar or atypical items will receive more attention than familiar items. Experimentally induced familiarity will result in the same attentional effects. If the person performing the task has some level of internal awareness of the degree to which attention was captured by a stimulus, a recognition response could be made on the basis of that information. This suggestion would reconcile previous suggestions that fluency is based upon item effects (Watkins and Gibson, 1988) with other findings that it relies upon immediately successive processing (Johnston et al., 1991). Whereas the amount of attentional capture would be based upon item characteristics like familiarity, information about this attentional capture in the target task would only affect recognition responses if those responses came soon enough after the performance of the target task to prevent the loss of information about attentional capture from working memory. An attentional mechanism could also account for the lack of overlap between response time distributions and recognition responses found by Poldrack and Logan (1997), because attentional capture could operate at a processing stage that contributes only a small proportion of variance to RTs.

4.3. *Is fluency a necessary concept?*

One might argue on the basis of the present results and related findings (Poldrack and Logan, 1997) that recognition is more parsimoniously understood through a single-process model based entirely upon memory search or memory matching. This point of view is bolstered by demonstrations that data formerly thought to imply separate fluency and recollection processes (e.g., dissociations in the time course of modality effects and LOP effects on recognition) can be modeled using a single-process model that does not make reference to fluency (Mulligan and Hirshman, 1995). However, there are a number of results that are difficult to understand without reference to some attributional process that acts upon recognition and other judgments. For example, two studies by Whittlesea and his colleagues (Whittlesea et al., 1990; Whittlesea, 1993) found that manipulations of the perceptual or conceptual processing of items (such as manipulating perceptual mask density or the semantic context) had effects upon successive recognition judgments as well as a number of other successive judgments (e.g., relatedness, pleasantness, duration). These results suggest that some attributional process must be involved in recognition decisions in addition to memory search. Our current findings and the findings of Poldrack and Logan (1997) serve to demonstrate that the mechanism underlying these "fluency" effects on successive recognition judgments remains in question.

4.4. *Conclusions*

Subjects performed lexical decision at study, and then lexical decision along with successive ease or recognition judgments at test. Recognition judgments interfered with lexical decision performance at test to a significantly greater degree than did ease judgments. Ease and recognition judgments were also dissociated between words and nonwords. The data suggest that the fluency that is measured by the process dissociation procedure is only loosely related to subjective feelings of ease in successive recognition tests. Future studies of fluency in recognition should examine other specific mechanisms for these effects.

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