The Process Dissociation Procedure and Similarity: Defining and Estimating Recollection and Familiarity in Recognition Memory

by

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Abstract

Dual process theories propose that recognition memory is based on two independent processes: recollection (the retrieval of specific information about a prior encounter with an item) and familiarity (a less specific feeling of having encountered the item). Jacoby (1991) introduced a "process dissociation procedure" that allows one to estimate the contributions of the two processes to recognition judgments. In the "Inclusion" condition the processes act in concert (i.e., both familiarity and recollection lead to correct responses) and in the "Exclusion" condition they act in opposition (i.e., relying on familiarity alone would lead to an incorrect response but recollection leads to a correct response). Typically, subjects study two list of words and then take an inclusion test (say "Yes" to all old items) and exclusion test (say "No" to items from one of the lists). It follows that the ability to exclude items from a particular source (i.e., recollection) should depend upon the similarity between sources. The experiments reported explored the implication that recollection (R) and familiarity (F) are dependent upon similarity between sources. Similarity between two study lists was manipulated within subjects. Estimates of R and F were derived by solving simple algebraic equations using the results from the two conditions, as in Jacoby (1991). As predicted, the estimate of R was greater in the dissimilar condition than in the similar condition. The opposite pattern was found for the estimate of F. Further effects on R and F were found when similarity was crossed with a divided attention manipulation at test (Experiment 2) and at study (Experiment 3). The results indicate that recollection in Jacoby's procedure is the retrieval of information that allows one to exclude to-be-excluded items and familiarity is the retrieval of information that allows one to classify items as old but not to exclude them. Such findings have important implications for the use of the process dissociation procedure and for theories of recognition memory.

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The Process Dissociation Procedure and Similarity: Defining and Estimating Recollection and Familiarity in Recognition Memory

Introduction

Memory researchers (e.g., Jacoby & Dallas, 1981; Mandler, 1980) have proposed that the recognition of a prior episode is based on two independent cognitive processes. One process is familiarity, an undifferentiated feeling that an item was previously experienced. The other process, recollection, involves the retrieval of specific information about the prior encounter. For example, Mandler (1980) described a situation in which one meets an individual on the bus and has an initial "sense of knowing" that individual (i.e., familiarity). It is only when a successful retrieval process locates contextual information that one remembers that this is the butcher (i.e., recollection).

It is important to understand that the meaning of the term "familiarity" in dual process theories of recognition memory differs from the colloquial use of the term. Common usage defines familiarity as a feeling of "oldness" or "pastness." In dual process theories, both familiarity and recollection give rise to a feeling of oldness or pastness; the difference is that familiarity is said to be a very undifferentiated and automatic basis for oldness, whereas recollection implies controlled use of retrieved information. Independence between these two processes implies that an event may be familiar but not recollected. However, less obvious but also true is the idea that an event may be recollected but not familiar.

According to Mandler (1980, 1989, 1991), exposure to a study list word leads to the activation of a pre-existing abstract representation of that word, which in turn increases the integration of the features (e.g., perceptual information, such as phonology or orthography) that make up that representation (i.e., intra-item integration). In addition, episodic memory records may be created that contain specific aspects of the study episode (e.g., contextual information, such as information about relations between the target item and other items in the list, i.e., inter-item integration). At test, familiarity is assessed by evaluating the extent of the intra-item integration of the abstract representation. Also at test, a retrieval process engages in the search of stimulus details in order to retrieve specific information about the target. If the search is successful, then the item is classified as "old."

Implicit in Mandler's proposal is the notion that an event is encoded through an integrative and/or elaborative process and that the resultant memory "records" constructed by each of the processes are separate entities or representations (Graf, Mandler, & Haden, 1982). The familiarity value for an item is derived from an abstract perceptual representation (e.g., it includes general information such as the physical form of the word--lowercase letters, one ascending letter, one descending letter, etc.) that is independent of contextual details (e.g., specific information relating this item to other items within a list). This suggests a continuum of familiarity values such that an item with a greater degree of integration would have a higher familiarity value and be more likely to lead to a judgment of "old" than an item that is less integrated and has a low familiarity value. Retrieval processes rely on a conceptual representation that includes specific episodic information about the encounter with the item (e.g., context information).

Further developments in the study of recognition memory by Jacoby and Dallas (1981) suggested that the feeling of familiarity is based on a heuristic process that uses the perceptual fluency of processing an item (i.e., the ease with which an item is perceived or comes to mind influences whether that item will be considered familiar or not). This is a fast and automatic process. In contrast, retrieval is based on an elaborative process that is conscious, analytic, and more conservative than the heuristic process that leads to familiarity. Conscious processes retrieve contextual detail to provide a basis for recognition judgments. In contrast to Mandler, Jacoby and Dallas's discussion implies that recognition judgments, whether based on automatic and/or conscious processes, rely on the same episodic memory representation of the study episode, that is, memory for a particular instance (Jacoby, 1983; Jacoby & Dallas, 1981; Jacoby & Brooks, 1984; Jacoby, Baker, & Brooks, 1989).

<u>Importance of obtaining separate estimates</u>

The study of the separate contributions of familiarity and recollection to recognition judgments provides a means of making clear a definition of recognition memory and consequently improving interpretations of any effects upon it. For example, if a variable affects recognition accuracy, theorists must be able to determine whether the variable affects familiarity, recollection, or both. Similarly, if a variable does not affect recognition accuracy, researchers need to be able to determine whether that is because the variable has no effect on either component process, or because it has off-setting effects (e.g., increasing familiarity and decreasing recollection). Thus, it is more likely that true differences or similarities among populations will be uncovered by addressing the components contributing to recognition judgments than by basing conclusions on overall recognition scores (e.g., Jennings & Jacoby, 1993).

Failure to separate the contributions of familiarity and recollection processes within recognition tasks tends to lead to the suggestion that processes can be mapped onto tasks, that is, that tasks are process pure. For example, direct tests of memory (i.e., tests that make specific reference to a prior study episode, e.g., recognition) have been said to reflect conscious processing whereas indirect tests of memory (i.e., tests that make no reference to a prior study episode, e.g., word stem completion) have been said to reflect automatic influences of memory (Graf et al., 1982; Graf & Schacter, 1985; Graf, Squire, & Mandler, 1984; Mandler, 1980; Richardson-Klavehn & Bjork, 1988). In contrast, Jacoby (1991) has argued that tests are not process pure, and therefore tests cannot be mapped onto processes. For example, the same types of unconscious, automatic processes that contribute to performance on indirect tests also contribute to performance on direct tests (Jacoby, Toth, & Yonelinas, 1993). The converse has also been shown to occur: Controlled uses of memory that contribute to performance on direct tests may sometimes contaminate performance on indirect tests (Toth, Reingold, & Jacoby, 1994).

How to obtain separate estimates

The "process dissociation procedure" developed by Jacoby (1991) provides a method for deriving estimates of the independent contributions of familiarity (an automatic process) and recollection (a consciously controlled and intentional process) to measures of memory such as recognition judgments. The procedure takes advantage of a facilitation paradigm (i.e., trying to do something) and an interference paradigm (i.e., trying not to do something). In a facilitation or "inclusion" paradigm, such as a standard recognition memory test, subjects are asked to respond "old" to all items that they recognize from a previous study list. In a facilitation condition, reliance on familiarity (F) and/or recollection (R) leads to a correct response. In the facilitation condition, the two processes act in concert and, assuming that F and R are independent processes, the probability of responding correctly can be written as follows:

$$\text{Probability "old"} \mid \text{inclusion} = R + F - RF \quad [1]$$

That is, the probability of classifying an item as "old" is the sum of the probability of recollection and the probability of familiarity, minus the intersection. By rearranging the terms, this equation can be written as:

$$R + F(1 - R) \quad [2]$$

This equation for the probability of recognizing studied items does not originate with the process dissociation procedure. Mandler (1980) used the same formula. According to Mandler, the contribution of recollection to the recognition of an item could be estimated with the probability of recalling that item given a cue (i.e., cued-recall). Consequently, one would have to assume that one process could be mapped onto one task (i.e., that cued-recall is a process-pure measure of R). However, as stated previously, Jacoby (1991) suggested that tasks are probably never "process-pure" but rather represent a "blend of automatic and intentional processes" (p. 514). For example, Jacoby and Hollingshead (1990) found a high probability of false recall of items on a cued-recall stem completion test (i.e., complete a stem with an old word, e.g., complete the stem "tab--" with a previously studied word such as table), which suggested that some responses were provided without determining whether that response was, in fact, a previously presented item. If this is the case, then it is possible that some correct responses are actually correct "guesses" that are automatically produced without "benefit of a recognition check" (p. 445). The idea is that unconscious, automatic influences of memory (F) may contribute to such "guesses." Thus, these results question the assumption that cued-recall is a pure measure of R. In addition, the recollection process required for recall might well differ from the recollection required for a recognition test. For example, the information to be retrieved for a recall test is not necessarily that required for recognition. Hence measures of recall are unlikely to provide accurate measures of the contribution of recollection to recognition judgments.

Jacoby (1991) proposed that conscious recollection can be indexed by the difference between trying to versus trying not to do something. Thus, the process dissociation procedure compares responses from the inclusion condition, in which subjects try to select a particular set of items, with responses from an exclusion condition, in which subjects try to select against a particular set of items. For example, if subjects study two lists, the instructions for the exclusion test (which consists of items from both lists randomly mixed with new items) may be to exclude items from the first list. In this case, R and F are placed in opposition such that responding to a to-be-excluded item on the basis of F leads to an incorrect response while responding to a to-be-excluded item on the basis of conscious recollection leads to a correct response. The probability of incorrectly including an old item is a consequence of a familiarity process that is unopposed by a recollection process:

$$\text{Probability "old"} \mid \text{exclusion} = F(1 - R) \quad [3]$$

By combining the results from the inclusion and exclusion conditions one is able to derive the estimate for each of the processes. The difference between correctly responding to items in an inclusion condition and incorrectly responding to items in an exclusion condition provides the estimate of recollection. Once the estimate of recollection has been obtained it can be placed in one of the equations (1, 2, or 3), and that equation solved to produce an estimate of familiarity.

As stated previously, these equations are based on the assumption that familiarity and recollection are functionally independent processes (e.g., Mandler, 1980). Jacoby (1991) argues that one key difference between recollection and familiarity is that conscious recollection requires attention whereas familiarity is automatic. Dissociations between direct and indirect tests in which a variable has been found to affect one test but not the other provide evidence to support the independence assumption. To the extent that an indirect test primarily reflects automatic processing and a direct test primarily reflects conscious processing requiring attention, this argument is supported by previous research showing that variables such as level of processing, (Jacoby & Dallas, 1981) and retention interval (Tulving, Schacter, & Stark, 1982) affect performance on direct tests (e.g., yes/no recognition test) but not indirect tests, whereas changes in modality of presentation between study and test (e.g., auditory at study, visual at test) affect performance on indirect tests (e.g., perceptual word identification, Jacoby & Dallas, 1981) but not direct tests. Similarly, dissociations that arise using the "remember" (i.e., responses in which the subject reports recollection of specific aspects of an item in a study episode) and "know" (i.e., responses in which the subject reports only a feeling of familiarity for an item) paradigm (Tulving, 1985) also suggest independence. Factors such as level of processing, retention interval (Gardiner, 1988), and word frequency (Gardiner & Java, 1990) affect the number of "remember" responses without affecting "know" responses.

Support for the independence assumption using the process dissociation procedure can also be found (for a review see Jacoby, Yonelinas, & Jennings, in press). In Jacoby et al. (1993, Experiments 1a and 1b), attention to the study of target items was divided by asking some subjects to perform a simultaneous listening task. During test all subjects completed an inclusion and exclusion condition with full attention. They found that compared to full attention at study, the estimate of R in the divided attention condition was reduced while the estimate of F remained invariant across conditions. Similar results were found by Jacoby (1991) when he divided subjects' attention during test. Independence between R and F was also supported by a recent study by Jennings and Jacoby (1993) that compared recognition memory performance of elderly adults with that of young adults. They found that age reduced the estimate of R but left F unaffected. Also consistent with these claims of independence is a study by Toth et al. (1994) in which a level of processing manipulation had an effect on the estimate of R but not on the estimate of F.

The purpose of the following studies was to build upon Jacoby's work and explore the implications of the process dissociation procedure for recognition memory, specifically with respect to the effect of similarity on R and F. Jacoby argues that familiarity is not simply a correlate of some characteristic of a memory trace, such as strength. Instead, the familiarity of a set of items depends in part on the nature of the task (Jacoby & Kelley, 1992):

> Familiarity is better described as arising from relationships among items, in the same way that similarity is traditionally described, rather than as an absolute characteristic of memory for an item. We believe familiarity is context dependent in a way that results in its changing

across tasks and situations (p. 222).

Our common experiences with regard to remembering suggest we often recollect many details about a specific event yet remain unable to recollect other aspects of the event. For example, upon meeting an individual, one may be reminded of a shopping environment, that the encounter occurred in the recent past, etc., yet be unable to say that this familiar person is the butcher. Therefore, we would expect that recollection, like familiarity, is also dependent on the relationships among items: The ability to exclude items from a particular source should rest upon the similarity between to-be-excluded and not-to-be-excluded old items. Hence, recollection, as measured by the process dissociation procedure, is retrieval of whatever information is necessary for identifying the source of a to-be-excluded item. If these two types of items are dramatically dissimilar, relatively little memory information would be needed to exclude the to-be-excluded old items while successfully including other old items. On the other hand, if the two types of items are highly similar, relatively detailed memory information would be required in order to exclude the to-be-excluded old items while successfully including the other old items.

To explore this issue, two conditions were created by manipulating similarity between to-be-excluded and not-to-be-excluded items. In the difficult condition subjects made the same orienting judgment to to-be-excluded and not-to-be-excluded items during study, and in the easy condition subjects made different orienting judgments for each of the two classes of items. Hence in the easy condition retrieval of information about the orienting task with which an item was encoded would serve as a basis for correctly excluding that item, whereas in the difficult condition retrieval of that information would not serve as a basis for correctly excluding that item. As a result, estimates of R should be higher for dissimilar items than for similar items. Furthermore, while the information retrieved about orientation may not benefit recollection, it does provide evidence of oldness. Consequently, one would expect estimates of F to be higher in the difficult condition than in the easy condition. A divided attention manipulation at test (Experiment 2) and at study (Experiment 3) was also used to further explore the effects on R and F.

Experiment 1

Subjects studied two lists of words and took one test. Similarity was manipulated within subjects with the use of orienting tasks. Subjects estimated the monetary value of some List 1 items and estimated frequency of encounter (times) for the remaining List 1 items. Subjects made the same orienting task judgment for all List 2 items (value or times). A single test was used to set up both an exclusion and inclusion condition, thereby simplifying the procedure and eliminating the possibility of criterion shifts between inclusion and exclusion tests. The test consisted of items from Lists 1 and 2 and new items, and subjects were asked to exclude List 1 items. Consequently, responding "Yes" to to-be-excluded items (i.e., List 1) suggested that the items were familiar but not recollected whereas responding "Yes" to not-to-be-excluded inclusion items (i.e., List 2) suggested that these items were familiar and/or recollected.

Method

Subjects and Design. Twenty-four University of Victoria undergraduate students participated for extra credit in an introductory psychology course or for a $5 payment.

Subjects were informed at the beginning of the session that the experiment consisted of two study lists followed by a memory test. During the first phase of the experiment (List 1), subjects made one orienting judgment for some words and the other orienting judgment for other words, with the two orienting tasks randomly mixed across trials. In the next phase (List 2), half of the subjects made one orienting judgment for all of the words, and the remaining subjects made the other orienting judgment for all of the words. All subjects then completed one memory test composed of words from Lists 1 and 2 randomly intermixed with new words. They were instructed to say "Yes" to all items recognized as old unless they remembered them from List 1. That is, they were to exclude List 1 items and new items. List 2 test items were used as inclusion items (i.e., "Yes" responses to these items could be based on familiarity and/or recollection).

List 1 items that had been studied with the same orienting task as List 2 items constituted the "Difficult" condition, and items that had been studied with the different orienting task constituted the "Easy" condition.

Materials. A pool of 146 nouns was chosen from Kucera and Francis (1967) and Webster's New World Dictionary of American English (1991) with the restriction that subjects could potentially determine both the monetary value and how many times they had encountered the item in the past month. The items were chosen to represent a range of values (0 to greater than $1000) and times (0 to greater than 100 times) (see Appendix).

There were 52 critical items in each study list, with those in List 1 randomly divided into two sets (A and B) of 26. An additional set of 26 items was used as new items for the test and another 16 items were used as filler items, with 4 fillers placed at the beginning and end of each study list. The test consisted of 138 items (i.e., 52 from List 1, 52 from List 2, 26 new, and 8 old filler items). Four sets of two old filler items were selected from the beginning and end of each study list. Two of these sets (i.e., 4 items) were placed at the beginning of the test and the remaining sets (i.e., 4 items) were placed at the end of the test.

The words in each study list and the test list were the same for all subjects. Half of the subjects judged value for List 1-A and times for List 1-B, and this assignment was reversed for the remaining subjects. Further, half of the subjects in each List 1 assignment judged List 2 items for value and the other half for times. The study items were randomly assigned to a list position with the restriction of no more than 3 consecutive same-type judgments. Test items were also randomly assigned to a test list position with the restriction of no more than 3 consecutive same correct answers (Yes or No).

Procedure. The experiment was conducted on a IBM-compatible PC using the Micro-Experimental Laboratory (Schneider, 1988) software package. Study and test words were presented in lowercase letters in the center of the screen.

Each study trial began with the presentation of a symbol indicating the type of judgment to be made in the top half of the monitor and the appropriate response categories in the bottom half of the monitor. The "$" symbol indicated a value judgment (response categories: [1] 0 to $10; [2] $11 to $50; [3] $51 to $200; [4] $201 to $1000; and [5] more than $1000) and the "*" indicated a times judgment (response categories: [1] 0 to 5 times; [2] 6 to 30 times; [3] 31 to 60 times; [4] 61 to 100 times; and [5] more than 100 times). After 1.25 s, the item to be judged was also presented and all information remained on the monitor until the subject responded or 3.5 s elapsed. Subjects used the computer keyboard to record their responses. There was a 1-s pause between each trial. Following the presentation of List 1, the instructions for List 2 appeared on the screen. After briefly reviewing the instructions, subjects began studying List 2. Presentation was the same as for List 1, except each subject performed the same orienting task (either value or times) for all items.

In the test phase, subjects were instructed to say "Yes" to all old items unless they remembered them from the first list. Thus, subjects were to respond "Yes" to items recognized from the second list and to other items they recognized as old without recollecting in which study list they were presented. Subjects were to respond "No" to items from List 1 and to new items. Two phrases presented at the bottom of the computer screen throughout the test reminded subjects of the situations that required a "Yes" response and those that required a "No" response (e.g., "No = In first list (value and times) or new word" and "Yes = In second list (value) or not sure which list").

The proportion of "Yes" responses to easy and difficult to-be-excluded (List 1) items, to not-to-be-excluded (List 2) items, and to new items were the raw dependent measures. R and F for both the easy and difficult conditions for each subject were derived using these probabilities. The alpha level for all analyses was .05.

Results

Table 1

Mean Proportion of "Yes" Responses to List 1, List 2, and New Items in Experiment 1

Orientation Task on List 2	List 1 Value	List 1 Times	List 2	New
Value	.60 (.18)	.40 (.22)	.79 (.09)	.05 (.04)
Times	.39 (.16)	.65 (.18)	.80 (.09)	.03 (.04)

Numbers in parentheses represent standard deviations.

The mean proportions of "Yes" responses to items from List 1 and List 2 and new items are presented in Table 1. There was no difference in the false alarm rate (i.e., classifying new items as old) between subjects who judged List 2 for value and those who judged List 2 for times, $t(22) = 1.17$, $p > .25$. The raw scores from the exclusion and inclusion conditions were analyzed in a 3 (Item type: List 1-value, List 1-times, List 2) x 2 (Orientation of List 2: Value, Times) mixed-model analysis of variance (ANOVA), with item type as the within-subjects variable and orientation as the between-subjects variable. There was a main effect of item type, $F(2, 44) = 50.61$, $MSe = .013$, and a reliable interaction between item type and orientation, $F(2, 44) = 24.03$, $MSe = .013$.

Planned comparisons indicated that responses to List 2 items were unaffected by orienting task, $F < 1$, and that "Yes" responses were more frequent on List 2 items than on List 1 items, $F(1, 23) = 127.70$, $MSe = .015$. As predicted, the interaction between List 1 item type (List 1-value vs. List 1-times) and orientation of List 2 was significant, $F(1, 22) = 40.76$, $MSe = .015$. Further comparisons revealed that subjects who made the value judgment for List 2 items more often correctly excluded List 1-times items than List 1-value items, $F(1, 11) = 13.07$, $MSe = .018$, whereas subjects who made the times judgment for List 2 items more often correctly excluded List 1-value items than List 1-times items, $F(1, 11) = 31.61$, $MSe = .013$.

For each subject, estimates of the contributions of familiarity (F) and recollection (R) to responding were calculated separately for the easy and difficult conditions (Table 2). A one-way ANOVA indicated that, as expected, R was greater in the easy condition than in the difficult condition, $F(1, 23) = 41.00$, $MSe = .015$. A separate one-way ANOVA revealed that F was reliably larger in the difficult condition than in the easy condition, $\underline{F}(1, 23) = 25.67$, $\underline{MS}e = .006$.

Table 2

Mean Estimates of R and F in Experiment 1

R		F	
Easy	Difficult	Easy	Difficult
.40 (.16)	.18 (.14)	.63 (.19)	.74 (.13)

Numbers in parentheses represent standard deviations.

Discussion

The findings of Experiment 1 demonstrate that the estimate of the contribution of recollection to recognition obtained with Jacoby's process dissociation procedure depends, in part, on the similarity between to-be-excluded and not to-be-excluded items. When subjects retrieve information about a previous encounter with a to-be-excluded item, under some conditions that information is sufficient for them to identify the source of those memories and thereby correctly exclude the item, whereas under other conditions that information is not sufficient to allow subjects to exclude the item. This finding demonstrates a rather obvious fact: Recollection is not an all-or-none process (i.e., we can remember some aspects of a past encounter with an item without remembering other aspects).

Estimates of the contribution of familiarity to recognition were also affected, in the opposite direction, by the manipulation. This suggests that remembering the orienting task with which an item was studied, which contributed to estimates of R in the easy condition, contributed to estimates of F in the difficult condition. For example, consider subjects who judged the value of "kayak" in List 1. For those who made the times judgment for List 2 items, remembering that they had judged the value of "kayak" would enable then to identify "kayak" as a List 1 word and so correctly exclude it. Hence in the easy condition remembering the orienting task with which an item was studied contributed to estimates of R. For those who made the value judgment for List 2 items, in contrast, remembering that they had judged the value of "kayak" would not in and of itself enable them to identify it as a List 1 item, but would add to their sense of having encountered the word during the study phase. Hence in the difficult condition remembering the orienting task with which an item was studied contributed to estimates of F.

There are at least three interpretations of these findings. The results could be taken as evidence against the assumption that familiarity and recollection are independent processes, and as evidence for a continuum ranging from "pure familiarity" to complete recollection. This interpretation would invalidate the process dissociation procedure, because the algebraic estimates depend upon the independence assumption. This continuum account can confidently be rejected in view of the numerous studies reported by the Jacoby group that provide compelling support for the independence hypothesis (see Jacoby et al., in press). Alternatively, one might argue that the estimate of F derived using the procedure of this experiment is contaminated by recollection of episodic information. This suggests that the difference between F in the easy condition and F in the difficult condition is due to measurement error: In this experiment, the two-list procedure sets up a situation in which information that supports recollection is misclassified as familiarity. A third account, and the one I will argue for, is that F and R are independent bases for recognition judgments, but the independence is functionally (rather than structurally) defined, and the constitution of F and R depend upon the specifics of the situation. In this view, recollection is not a "thing in the head," nor is it identified with the phenomenological experience of remembering aspects of a prior encounter with an item. Rather, recollection is retrieval of information that, in a specific situation, is sufficient to enable a correct exclusion response. This view is elaborated in the General Discussion.

As noted in the introduction, Jacoby has sought evidence for the hypothesized independence between F and R in the form of "process dissociations"--manipulations that affect one parameter estimate but not the other. For example, Jacoby (1991) found that dividing attention at test had a marked effect on estimates of R, but no effect on estimates of F. Similarly, Jacoby et al. (1993) found that dividing attention at study greatly lowered estimates of R but did not affect estimates of F. Following this lead, the similarity manipulation was crossed with a between-subjects manipulation of divided versus full attention during test (Experiment 2) and study

(Experiment 3). If the estimate of F obtained with this procedure is contaminated by R then one would expect that divided attention should affect estimates of F and R in the same way.

Experiment 2

Method

Subjects and Design. Thirty-seven University of Victoria undergraduate students participated for extra credit in an introductory psychology course or for a $5 payment. Five subjects in the divided attention condition were replaced because they missed responding to more than 5 test items from any of the critical groups (i.e., List 1-value items, List 1-times items, List 2 items, or new items). Thus, the results are based on data collected from 16 subjects in each attention condition.

The materials and procedure were the same as those of Experiment 1 except as noted.

Procedure. As in Experiment 1, subjects were instructed, during test, to say "Yes" to all old items except those that they remembered from List 1. However, those in the divided attention condition did so while responding to an auditorily presented random series of numbers read at a 1-s rate. The number task involved detecting each series of 3 consecutive odd numbers (Craik, 1982). Subjects gave verbal responses to the memory test (which the experimenter entered on the computer keyboard) and those in the divided attention condition also tapped a pencil on the table every time they heard 3 odd numbers in a row. Subjects in the divided attention condition were told that their performance on both tasks was equally important.

Test items remained on the monitor until the subject responded or 5 s elapsed. It was expected that this constraint would limit the amount of time that subjects could spend on each task and therefore reduce the possibility that subjects would fully attend to and complete each task in turn. Test items in full attention were also presented with the same time constraint.

Subjects were provided with feedback in the form of a high-pitched beep when they did not respond to a test item within the allotted time, thereby encouraging them to speed up their responses on upcoming trials. In addition, feedback in the form of a low-pitched beep was provided every time subjects in the divided attention condition missed noting a series of odd numbers.

Results

Table 3 lists the mean conditionalized proportions of "Yes" responses to study list items and new items in the full and divided attention conditions of Experiment 2. The mean proportions were conditionalized upon the number of completed responses (i.e., missed responses were subtracted from the total number [26] of possible responses). On average, subjects in the divided attention condition responded on 95.7% of the items (99.6% in the full attention condition). False alarm rates did not differ as a function of attention condition or orientation of List 2, $F < 1$.

The data were analyzed in a 2 (Attention: Full, Divided) x 3 (Item Type: List 1-value, List 1-times, List 2) x 2 (Orientation of List 2: Value, Times) mixed-model

ANOVA with item type as the repeated measure. A reliable 3-way interaction, $F(2, 56) = 9.77$, $MSe = .010$ emerged, and the data were interpreted with further analyses. In the full attention and divided attention conditions, subjects less often responded "Yes" to List 1 items than to List 2 items, $F(1, 15) = 87.66$, $MSe = .066$, and $F(1, 15) = 27.90$, $MSe = .035$, respectively.

Table 3

Mean Proportion of "Yes" Responses to List 1, List 2, and New Items in Experiment 2

Attention at Test	Orientation Task on List 2	List 1 Value	List 1 Times	List 2	New
Full	Value	.69 (.14)	.33 (.17)	.77 (.08)	.03 (.03)
	Times	.30 (.15)	.53 (.11)	.76 (.09)	.04 (.06)
Divided	Value	.72 (.18)	.63 (.18)	.77 (.15)	.07 (.11)
	Times	.60 (.12)	.65 (.16)	.78 (.06)	.06 (.04)

Numbers in parentheses represent standard deviations.

There was no effect of orientation of List 2 on responses to List 2, $F < 1$. The interaction between List 1 item type (List 1-value vs. List 1-times) and orientation of List 2 (value vs. times) was reliable, $F(1, 28) = 42.58$, $MSe = .013$: As in the previous experiment, subjects were better able to exclude List 1 items that had been studied with an orienting task that differed from the List 2 orienting task. As predicted, however, that 2-way interaction was compromised by a reliable 3-way interaction between List 1 item type, orientation of List 2, and attention at test, $\underline{F}(1, 28) = 15.82$, $\underline{MS}e = .013$. The 2-way interaction between List 1 item type and orientation of List 2 was reliable in the full attention condition, $\underline{F}(1, 14) = 45.75$, $\underline{MS}e = .015$, but not in the divided attention condition, $\underline{F}(1, 14) = 4.09$, $\underline{MS}e = .010$, $\underline{p} > .06$.

Divided attention at test had no effect on the probability of responding "Yes" to List 1 items in the difficult condition, $\underline{F}(1, 30) = 1.88$, $\underline{MS}e = .025$, $\underline{p} > .18$, but reliably increased the probability of responding "Yes" to List 1 items in the easy condition, $\underline{F}(1, 30) = 31.28$, $\underline{MS}e = .023$. This suggests that the orienting task with which items were studied was sufficiently deep so that the retrieval of information about the orienting judgments easily came to mind or was facilitated at test. Consistent with this argument, dividing attention did not affect rates of responding on List 2 (not-to-be-excluded) items, $\underline{F} < 1$. Thus dividing attention did not impair retrieval of memories of the orienting task with which items had been studied, but it did impair use of that information as a basis for excluding List 1 items in the easy condition. This argument is supported by analyses of the estimates of F and R, reported below.

For some subjects, the derived estimates of recollection resulted in negative values, indicating an inability to distinguish between List 1 and List 2 items. Consequently, recollection estimates for one subject in full attention (difficult condition) and three subjects in divided attention (easy and/or difficult condition) were set to 0. Estimates of R and F are shown in Table 4.

Table 4

Mean Estimates of R and F in Experiment 2

Attention at Test	R		F	
	Easy	Difficult	Easy	Difficult
Full	.45 (.18)	.16 (.12)	.54 (.17)	.72 (.11)
Divided	.16 (.10)	.10 (.12)	.73 (.14)	.76 (.14)

Numbers in parentheses represent standard deviations.

The analysis of List 2 raw scores indicated no main effect of orientation. Thus, the estimates of recollection and familiarity were collapsed across this variable and analyzed in separate 2 (Attention) x 2 (Similarity: Easy, Difficult) mixed-model ANOVAs with similarity as a within-subjects variable. A significant interaction, $F(1, 30) = 19.29$, $MSe = .011$, between these two variables was interpreted with subsequent one-way ANOVAs for each attention condition.

The findings for R in full attention replicated those of Experiment 1: R in the easy condition was greater than R in the difficult condition, $F(1, 15) = 45.31$, $MSe = .015$. In contrast, in divided attention the difference between estimates of R in the easy and difficult conditions was not statistically reliable, $F(1, 15) = 3.74$, $MSe = .007$, $p > .07$. For the easy condition alone, R in full attention was greater than R in divided attention, $F(1, 30) = 33.39$, $MSe = .020$. There was no significant difference between estimates of R in full and divided attention for the difficult condition, $F(1, 30) = 2.03$, $MSe = .014$ $p > .16$.

There was a significant Attention x Similarity interaction effect for estimates of F, $F(1, 30) = 13.82$, $MSe = .007$. In full and divided attention, F was greater in the difficult than in the easy condition, $F(1, 15) = 23.24$, $MSe = .012$, and $F(1, 15) = 5.30$, $MSe = .002$, respectively. When estimates of F were compared within the easy condition, F in full attention was less than F in divided attention, $F(1, 30) = 11.75$, $MSe = .024$. For the difficult condition, however, there was no significant difference between estimates of F across the attention variable, $F < 1$.

Discussion

Results for subjects in the full attention condition of Experiment 2 closely replicated the findings of Experiment 1: Estimates of R were greater for items in the easy condition than for items in the difficult condition, whereas estimates of F were greater for items in the difficult condition than for items in the easy condition. As in Experiment 1, this is interpreted as evidence that memory for the orienting task with which an item had been studied served as a basis for excluding easy items (and hence contributed to the estimate of R), but served only as a basis for recognizing difficult items as old (and hence contributed to the estimate of F).

Unlike the findings of the Jacoby group (Jacoby et al., in press), dividing attention at test did not produce a process dissociation. For items in the easy condition, divided as opposed to full attention resulted in lower estimates of R (as in Jacoby's experiments), but it also resulted in higher estimates of F. The notion that the estimate of F was contaminated by R in this procedure is not supported by this finding because one would expect a decrease in the estimate of F in divided attention if it was greatly contaminated by R. These findings also suggest that dividing attention at test did not prevent retrieval of memory information about the orienting task with which an item had been studied, and that perhaps in this situation memories for the orienting task may have been automatically retrieved. This argument is also supported by the finding that dividing attention at test had no effect on the probability of responding "Yes" to List 2 items (i.e., divided attention has its effect on conscious processes). Thus the process of recollection comprises the retrieval of episodic information and the use of that information.

Consider the previous example in which "kayak" was judged for value in List 1 and all List 2 items were judged for times. The results suggest that subjects in the divided attention condition remembered that they had judged the value of "kayak," but were unable to use that information to conclude that "kayak" was a List 1 item (e.g., were unable to reason, "I thought of the value of 'kayak,' and all List 2 items were judged for times, therefore 'kayak' is a List 1 item and I should say 'No'."). Because dividing attention at test impaired subjects' ability to perform this type of reasoning, dividing attention reduced the estimate of recollection, compared to full attention. At the same time, however, retrieved information about the orienting task with which an item had been studied contributed to the familiarity of that item for subjects in the divided attention condition. Consequently, the estimate of familiarity for items in the easy condition was greater in the divided attention condition than in the full attention condition.

In contrast to the findings of the Jacoby group where estimates of recollection but not familiarity are contingent upon attention, these results suggest that information that supports estimates of F can also be affected by attention. This implies that Jacoby found attention to affect R but not F because in his paradigm any information that was retrieved (i.e., information for recollection) was essentially source-specifying information and could be used as a basis for exclusion. In the experiments reported above, retrieved information does not necessarily enable exclusion of the item and thus an additional decision-making step is required to determine the source of the item (e.g., deciding whether the retrieval of information indicating a value judgment suggests the first list [i.e., a "No" response] or the second list [i.e., a "Yes" response]).

For difficult items, dividing attention at test had no effect on estimates of R or on estimates of F. For these items, remembering the orienting task with which an item was studied did not provide a basis for excluding the item, regardless of attentional resources. Given the high degree of similarity between List 1 and List 2 items in the difficult condition (i.e., same orienting task, same presentation condition, only a brief pause between the two lists), there would be little memory information to be retrieved that would serve as a basis for recollection. Hence estimates of R were low, and estimates of F were high, for difficult items in both the full and divided attention conditions. Essentially, on difficult items, subjects had nothing to lose or gain by not being able to use the orienting task information so divided attention had no effect.

In Experiment 3, attention was divided during study so as to disrupt the encoding of source (orienting task) information and determine any effects on R and F. Specifically, evidence was sought for the proposal that R and F reflect the independent contributions of memory for multiple aspects of the study encounter (e.g., information about the orienting task may be considered to be an aspect of memory), with the composition of R and F dependent upon the specifics of the study and test situations. A dissociation between R and F (e.g., an effect on one parameter but not the other) would provide such evidence.

Experiment 3

Method

Subjects and Design. Forty-one University of Victoria students and community members participated for extra credit in an introductory psychology course or for a $5 payment. One subject in the divided attention condition was replaced because of a very high false alarm rate (46%, 3.14 standard deviations above the mean).

Half of the subjects (full attention condition) completed the study and test phases as in Experiment 1. For the remaining subjects, List 1 and List 2 were studied under conditions of divided attention and the memory test was given full attention. The same number task used to divide attention in Experiment 2 was used in this experiment during study. The materials and procedure were the same as those of Experiment 1 except as noted.

Procedure. During study, subjects in the divided attention condition were asked to make a value or times judgment for each item presented while performing the number task. They were told that it was important to detect as many target series of numbers as possible because the experimenter was particularly interested in memory for the words when attention was focused on the number task. These instructions essentially prevented the subjects from performing the orienting tasks in any meaningful way. They were asked to read the study words aloud to ensure at least minimal processing of items. The duration of symbols, items, and response categories on the computer screen remained the same as those in Experiment 1. While judging the items and entering their responses into the computer via the keyboard, subjects in divided attention were asked to respond by saying "There" every time they heard a series of 3 consecutive odd numbers. Subjects were reminded as often as necessary to repeat the words aloud and they were given verbal feedback (i.e., "Numbers") when they missed noting target series.

Results

The mean proportions of "Yes" responses to List 1, List 2, and new items in full and divided attention of Experiment 3 are presented in Table 5.

Table 5

Mean Proportion of "Yes" Responses to List 1, List 2, and New Items in Experiment 3

Attention at Study	Orientation Task on List 2	List 1 Value	List 1 Times	List 2	New
Full	Value	.64 (.13)	.26 (.10)	.83 (.08)	.02 (.03)
	Times	.29 (.21)	.56 (.09)	.77 (.11)	.02 (.04)
Divided	Value	.38 (.22)	.37 (.21)	.54 (.21)	.08 (.09)
	Times	.36 (.15)	.39 (.13)	.55 (.17)	.08 (.07)

Numbers in parentheses represent standard deviations.
List 1 and List 2 scores have been corrected for the number of false alarms.

In this experiment, subjects were more likely to respond "Yes" to new items in divided attention than in full attention, $F(1, 36) = 10.81$, $MSe = .004$. Therefore, the raw scores in the full and divided attention conditions used in the following analyses were corrected for each subject by subtracting the subject's false alarm rate from the number of "Yes" responses to items in each critical category (i.e., List 1-

value, List 1-times, List 2). (This correction had no effect on the pattern of significant and nonsignificant effects.)

A reliable 3-way interaction emerged in a 2 (Attention) x 3 (Item Type) x 2 (Orientation of List 2) mixed-model ANOVA, $F(2, 72) = 17.31$, $MSe = .014$. Consistent with the results of the previous experiments, subjects less often responded "Yes" to List 1 items than List 2 items in the full attention, $F(1, 19) = 175.53$, $MSe = .058$, and divided attention conditions, $F(1, 19) = 36.86$, $MSe = .066$. In addition, the proportion of "Yes" responses to value- and times-judged items of List 2 was similar in both divided attention, $F < 1$, and full attention, $F(1, 18) = 1.93$, $MSe = .009$, $p > .18$. However, overall, subjects in full attention recognized more items than those in divided attention, $F(1, 36) = 28.31$, $MSe = .022$. Moreover, subjects in the full attention condition reliably benefited from the difference between easy and difficult items, $F(1, 18) = 42.64$, $MSe = .025$, whereas subjects in the divided attention condition did not, $F < 1$.

Because the type of orienting task with which List 2 items were studied was not a significant variable in the recognition of items, the scores were collapsed across this variable in analyzing the estimates of F and R. As in Experiment 2, negative estimates of recollection (4 subjects in the divided attention condition) were assigned a value of 0. The mean estimates for R and F are presented in Table 6.

This experiment provides a second replication of the findings of Experiment 1. That is, in full attention, R and F moved in different directions: R in the easy condition was greater than R in the difficult condition, $F(1, 19) = 42.07$, MSe = .025, whereas F in the easy condition was less than F in the difficult condition, $F(1, 19) = 20.38$, MSe = .021. In divided attention, in contrast, R and F were constant across the easy and difficult conditions, Fs < 1. In the easy condition, dividing attention reduced the estimate of R, $F(1, 38) = 37.56$, MSe = .029, and had no effect on the estimate of F, $F(1, 38) = 2.29$, MSe = .043, $p > .13$. In the difficult condition this trend was reversed. Dividing attention had no effect on the estimate of R, $F < 1$, but decreased the estimate of F, $F(1, 38) = 33.16$, MSe = .025.

Table 6

Mean Estimates of R and F in Experiment 3

Attention at Study	R		F	
	Easy	Difficult	Easy	Difficult
Full	.52 (.20)	.19 (.12)	.54 (.21)	.75 (.11)
Divided	.19 (.14)	.17 (.13)	.44 (.21)	.46 (.20)

Numbers in parentheses represent standard deviations.

Discussion

These results suggest that dividing attention at study greatly attenuated encoding of memory information about the orienting task with which items were studied. Indeed, although subjects' responses on the orienting task were not recorded, those in the divided attention condition often reported in debriefing that the divided attention task had prevented them from making the orienting judgments in any meaningful way. Thus, in the divided attention condition information about the orienting task with which an item had been studied was not available at test, and consequently could not be used as a basis for excluding items in the easy condition (therefore reducing R but leaving F for easy items invariant across the full and divided attention conditions). For example, among subjects who had judged the value of "kayak" and made the times judgments for List 2 items, those who had studied the words with full attention were able to retrieve memory information about the orienting task and thereby identify "kayak" as a to-be-excluded item. On the other hand, those who had studied the words with divided attention could not retrieve information about the orienting task and so could not use that information as a basis to exclude the item (hence lowering estimates of R for easy items, relative to the full attention condition) or as a basis for recognizing the item as old (hence not increasing estimates of F for easy items, relative to the full attention condition). This process dissociation, like those Jacoby has reported, supports the hypothesized independence between F and R.

As one would expect, the pattern of results for F and R was reversed for items in the difficult condition: F was reduced and R unchanged by divided attention at study. Remembering the orienting task with which an item in the difficult condition had been studied could not serve as a basis for excluding that item. Therefore R was the same regardless of whether subjects had (full attention) or had not (divided attention) encoded memory information about the orienting task. However, remembering the orienting task with which an item in the difficult condition had been studied could serve as a basis for recognizing that item as old. Thus F was greater when subjects had encoded that information (full attention) than when they had not (divided attention). Although the form of this process dissociation differs from those Jacoby has reported, it too supports the hypothesized independence between R and F.

Nevertheless, the independence argument is compromised by the fact that, in the easy condition, there was a nonsignificant 10 percent difference between the estimate of F in the full attention condition and the estimate of F in the divided attention condition ($p > .13$). That is, the null effect of attention on F may be due to measurement and sampling error and represents a failure to reject the null hypothesis. If this were the case, then estimates of F and R were similarly affected (i.e., decreased) by the attention manipulation, suggesting that the estimate of F is contaminated by R in this paradigm. However, the estimates of F and R in the difficult condition clearly suggest a process dissociation (i.e., the 2 percent difference for R in the difficult condition did not approach significance [$F < 1$] and the 29 percent difference for F in the difficult condition was significant [$p < .001$]) which does not support the argument that the estimate of F is contaminated by R. Thus, the majority of the evidence fails to support the contamination account.

General Discussion

In Experiment 1, the estimate of R was greater in the dissimilar sources (i.e., easy) condition than in the similar sources (i.e., difficult) condition, whereas F was greater in the difficult condition than in the easy condition. These results were replicated in the full attention conditions of Experiments 2 and 3. These findings indicate that the retrieval of information about the orienting task contributed to R for easy items, and contributed to F for difficult items.

In Experiment 2, when attention was manipulated at test, R for easy items was greater in the full than in the divided attention condition, and F for easy items was greater in the divided than in the full attention condition. Estimates of R and F for items in the difficult condition were not affected by dividing attention at test. Thus, dividing attention at test did not interfere with the retrieval of orienting information, but interfered with the ability to use that information to exclude items. For easy items, this implies that subjects would be less able to exclude items (i.e., reduce R), and therefore would only be able to say that the item was old (i.e., increasing F). Retrieval of orienting information for items from similar sources was not useful in distinguishing between List 1 items from List 2 items in full attention, thus limiting the ability to use this information would not produce further effects on R and F.

Dividing attention at study (Experiment 3) produced results for items in the easy condition which were similar to those of the Jacoby group: A reduction in the estimate of R but no effect on the estimate of F. However, this trend was reversed for items in the difficult condition: A reduction in the estimate of F but no effect on the estimate of R. This final experiment indicates that, for items in the easy condition, divided attention at study interfered with conscious processes required to encode orienting information used to exclude easy items at test (i.e., reduced R), but not with the automatic encoding of information used to classify the item as old at test (i.e., unchanged F). As stated previously, orienting information about difficult items is not necessarily helpful in distinguishing between items from the two study lists. Thus, disrupting the encoding of such information would not further impair the ability to exclude a difficult item (i.e., unchanged R). However, orienting information could provide evidence for oldness (i.e., contribute to estimates of F), thus, the lack of such information would reduce the probability of classifying a difficult item as old (i.e., reduce F).

These findings demonstrate that whether the process dissociation procedure classifies memory for a List 1 item as familiarity or recollection depends upon the similarity between the List 1 items and the List 2 items. That is, the results indicate that subjects could remember exactly the same information about the prior occurrence of a List 1 item and either be able to use that information to exclude that item (if the List 2 items were sufficiently different from the List 1 items) or be unable to use that information to exclude that item (if List 2 items were not sufficiently different from List 1 items). Thus, recollection, as measured by the process dissociation procedure, is not a product of retrieving all information about a prior encounter with an item but is simply the retrieval of whatever information allows one to exclude to-be-excluded items. Similarly, familiarity is the retrieval of information that allows one to recognize the to-be-excluded item as old but not to identify it as a to-be-excluded item. These results support the argument that familiarity, like similarity, is contextually defined rather than a property of a memory trace (Jacoby & Kelley, 1992, p. 222).

At first glance, changes in estimates of familiarity and recollection as a consequence of similarity suggest a continuum of memory ranging from pure familiarity to pure recollection. For example, memories may be considered to vary in strength such that weak states only give rise to a feeling of familiarity and strong states lead to recollection. Similarly, memories may also vary along a scale of differentiation such that undifferentiated memories lead to familiarity and differentiated memories form the basis for recollection. These threshold-type views suggest that estimates of F and R should be affected by altering the criterion which divides familiarity-based judgments from recollection-based judgments and are thus dependent processes. Thus, moving the criterion in one direction should decrease estimates of F and consequently increase estimates of R or alternatively moving the criterion in the opposite direction should decrease estimates of R but increase estimates of F. However, studies using divided attention (e.g., Jacoby, 1991; Jacoby et al., 1993) pose problems for these views because they firmly establish that estimates of F can remain unchanged when estimates of R are dramatically reduced.

Alternatively, one might interpret the findings to suggest that estimates of F in the procedure reported here are contaminated by recollected information. However, the increase in the estimate of F in the easy condition of Experiment 2 contradicts this idea because one would expect that if F was contaminated by R, dividing attention at test which has been shown to reduce R but not affect F (i.e., a "pure" F) should have reduced the estimate of F obtained in this experiment (i.e., a "contaminated" F). The process dissociations between estimates of F and R as a result of dividing attention at study reported in Experiment 3 also support the hypothesis that the obtained estimates of F are not contaminated by R, because one would expect parallel effects on F and R if the estimate of F was contaminated by R.[1]

In contrast to the above interpretations, it is proposed that memories vary along multiple strength continua, with each strength continuum representing memory for particular aspects or features of the study episode (e.g., memory for lexical detection processes, memory for semantic processes, memory for inter-item relational processes). Figure 1 is a hypothetical portrayal of multiple strength continua. Each function symbolizes a particular aspect of memory. That is, it represents the outcome of an

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[1] As previously stated, this argument is weakened by the fact that in the easy condition the estimate of F was 10 percent lower in the divided attention condition, although this difference was not significant ($p > .13$). However, the possibility of contamination of F by R is weakened by the findings across the attention variable that clearly support a reduction of F in the difficult condition and no change in the estimate of R in the easy condition. A replication of this study would help clarify this issue.

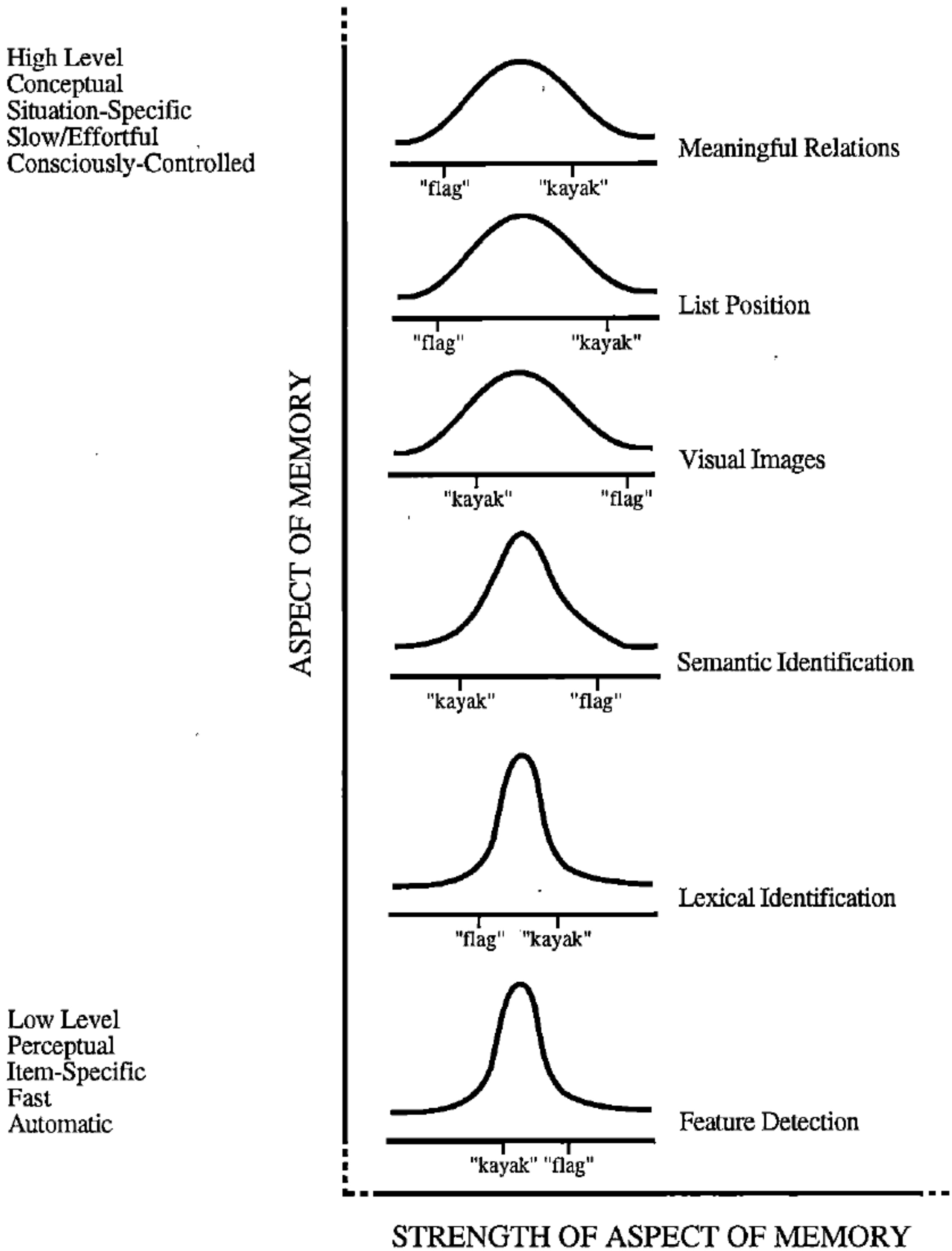

Figure 1. Various continua that form aspects of memory or features from list-learning episodes. See text for details. (This figure is for illustrative purposes only and does not imply that these are the features of memory.)

encoding process or acquisition of a specific feature of an episodic event. Some of the processes, such as the bottom three, are fast, automatic, and item-specific. Other processes, such as the top three, are slower, more conscious and controlled, and situation-specific. Low-level item-specific processes are expected to be more generic than high-level situation-specific processes. For example, low-level processes such as the detection of the letter "a" in the word "flag" would be similar to the detection of the letter "a" in the word "kayak." However, noting the value of the items or frequency of encounters with the item is specific to the task in the experiments and requires more complex processing than feature detection. Thus, low-level processes are depicted in Figure 1 as narrow functions, representing the low variability to be found across items for these aspects of memory, whereas high-level processes are drawn as wider functions and represent the high variability expected across situations for these aspects of memory. The items "kayak" and "flag" have been placed on each graph to indicate speculative strengths of memory of that feature for that item. For example, the strength of memory for feature detection processes for the item "flag" is greater than that for the item "kayak" however, the strength of memory for inter-item relationships with the word "kayak" is greater than that for "flag."

Unlike low-level processes, it is often the case that high-level processes are inherently source-specifying. Consequently, retrieval of these aspects of memories more directly lead to the identification of source and, if appropriate, the exclusion of the item. This is illustrated in the easy condition: Retrieval of orienting task information which is unique to the first study list, ultimately identifies the source of that item, and can be used to exclude the item. Furthermore, any disruption in the encoding (i.e., divided attention at study) or retrieval (i.e., divided attention at test) of aspects of memory is more likely to affect consciously-controlled features rather than automatically-controlled features and will therefore tend to affect the ability to exclude items (i.e., recollection) rather than the ability to classify an item as familiar. For example, in the first phase (i.e., List 1) of Jacoby's (1991) experiment, some items were presented as anagrams to be solved and the remaining items were words to be read, and in the second phase (i.e., List 2) subjects were required to listen to a recorded list of items. During test subjects were asked to exclude List 1 items. In this case, retrieval of information that includes modality of presentation (i.e., anagram, read, or heard) implicitly suggests the identification of the source of the item because each modality was unique to a particular list, and thus, can lead to the exclusion of a studied item. However, in the experiments reported in this paper, this is not necessarily the case (i.e., retrieved information about the orienting task did not necessarily suggest the source of the item because for items in the difficult condition the orienting task was not unique to a particular list).

Of importance is the idea that each aspect of memory is independent (i.e., one feature may be retrieved without necessarily retrieving another). A memory can be very strong in some ways and yet it may be difficult to determine the source of the memory, that is, one can remember some aspects without necessarily remembering others. The man-in-the-bus example has unfortunately been used to illustrate an unspecified feeling of "pure" familiarity when it more likely typifies a situation in which the retrieval of certain features does not compel one to determine identity. Many features may be clearly brought to mind such as remembering that the person was encountered in the recent past, you were shopping at the time, being hurried, that it was a colorful place, etc., yet you may remain unable to retrieve the criterial source information that would allow you to recognize the person as the butcher. Intuitively, the norm appears to be that in most situations one retrieves at least some information about the item to be identified rather than just a completely unspecified feeling of familiarity (i.e., pure familiarity).

In any particular exclusion task, aspects of memory can be divided into two ad hoc categories: those that, in that situation, support source identification (and hence enable exclusion) and those that do not (and hence only enable F). With respect to Figure 1, hypothetically, in a particular experiment the top three features could promote recollection whereas the bottom three would only support familiarity. In essence, the process of remembering that is proposed is one that involves the retrieval of features that may or may not be sufficient for exact specification or identification of the source of the memory. This underscores the idea that there is not a familiarity process and a recollection process per se (i.e., two distinct "thing in the head" types of memory) but that there is a remembering process and, depending upon what is retrieved and the specifics of the task, the end result gives rise to familiarity or recollection. This is not to say that there is no such thing as an automatic process or a consciously-controlled process. Information may be encoded or retrieved in a very fast and effortless manner or it may require more thought and be slow. However, the relationship between automaticity and F may not be as universal as previous work has indicated (i.e., in some situations, non-automatic processes may contribute to F).

The findings presented in this paper (i.e., that source discriminability affected estimates of R and F in opposite directions, and that dividing attention sometimes increased estimates of F as well as decreased estimates of R) are in accord with the concepts expressed above. The orienting task provided subjects with the opportunity to encode many details about each item--from item-specific to conceptual information. For example, presentation of the word "kayak" prompted automatic encoding of low-level information such as the presence of flanking ascending letters and a middle descending letter, lexical identification of the word "kayak," etc., and consciously-controlled encoding of highly integrative information, such as an image of a bright red kayak that was 12 feet long, was seen at the shop in the middle of town, and was priced at $1200. When "kayak" was presented at test, the present findings suggest that the high-level details "popped" into mind (i.e., consciously encoded and automatically retrieved), and could then be consciously used to suit the needs of the test (i.e., inclusion or exclusion). This facilitated re-processing of studied items at test is compatible with multiple-processing views such as transfer appropriate processing (e.g., Morris, Bransford, & Franks, 1977; Roediger, Weldon, & Challis, 1989), which suggest that the match between encoding processes (i.e., cognitive operations) employed at study and the retrieval processes at test predict memory performance. For example, words studied in a "shallow" rhyme condition rather than in a "deep" semantic condition are better remembered when the test orients subjects to rhymes.

When divided attention at test disrupted conscious processing, automatic retrieval of information was not impaired, but the conscious ability to use that information was impaired. Hence dividing attention at test both lowered estimates of R and increased estimates of F for items in the easy condition. Because of the great similarity between to-be-excluded and not-to-be excluded items in the difficult condition, dividing attention at test had no effect on estimates of either F or R--that is, there was very little source-specifying information about items in the difficult condition that subjects could retrieve even with full attention, so dividing attention did not affect performance on those items in the difficult conditions.

This view also suggests that in Jacoby's experiments (e.g., Jacoby, 1991; Jacoby et al., 1993) circumstances were such that automatically encoded and automatically retrieved memory features consistently contributed to estimates of familiarity whereas consciously controlled features consistently contributed to estimates of recollection. Under these conditions, dividing attention at study disrupted encoding of the kinds of source-specifying information required to later identify the source of a to-be-excluded item (i.e., consciously-controlled information) but had no effect on encoding of other information (i.e., automatically encoded information) and hence lowered R without affecting F. In Figure 1, divided attention might disrupt the encoding or retrieval of the top three features but not the bottom three features. Consequently, clean process dissociations (e.g., divided attention at test or at study affected estimates of R but had no effect on estimates of F) were a result of interfering with consciously-controlled memory features needed to identify the source of to-be-excluded items but not other types of information that would allow subjects to recognize items as old.

In Experiment 3, divided attention at study disrupted the conscious use of the orienting task to encode source-specifying information, but not automatically encoded item-specific information. Thus, the paucity of source-identifying information produced lowered estimates of R for items in the easy condition while the consistent availability of item-specific information resulted in no changes in the estimates of F. For difficult items, distinctive source-specifying information was lacking in full attention because of the similarity between sources. Thus, disrupting the encoding of source-specific information produced no further changes in estimates of R. In addition, the orienting task information would not be available to at least identify the item as old. Hence, divided attention during study for difficult items reduced the estimate of F.

Falsifiability of the Multiple Aspects Theory of Recognition Memory

This theory of remembering based on multiple aspects of memory is subject to criticism because of its potential to explain most findings (e.g., exploiting the theory to explain any variance or invariance among findings). Such a nonfalsifiable theory would not be of interest. The proposed theory, however, most likely can be falsified, and ironically, in proving that it does not hold in all situations, it will serve to be a more useful framework. Jones (1976) provides evidence to suggest that memory for different attributes is not always independent. Using picture stimuli comprised of statistically independent attributes (i.e., item [e.g., cup], color [e.g., red], location [e.g., top left corner]) and cued recall tests, he found that cueing with any of the three attributes led to the recall of the others. Jones concluded that attributes of memory were stored in a cluster or fragment and that retrieval of these attributes in cued recall occurred in an all-or-none fashion (i.e., these aspects of memory were dependent). However, other aspects of Jones's data indicate that information about the sequential order of target items was not a part of this cluster of dependent attributes. Future studies testing the assumption of independence (or dependence) among aspects of memory will be aided by the use of the process dissociation procedure.

It is probably the case that there are limits on the functional definitions of R and F: Attributes at each end of the process of remembering (e.g., extreme low-level attributes such as typeface and extreme high-level attributes such as word frequency) may always contribute to either estimates of familiarity or estimates of recollection regardless of the contrived situation. Further research regarding the theory would allow one to make a priori predictions about the constitution of familiarity and recollection in particular situations (i.e., additional aspects of the theory will be falsifiable). Consequently, a theory of remembering based on multiple aspects of memory will prove to be of interest and useful in untangling the bases of recognition memory.

Relevance to Other Findings

Source Monitoring. A theory of memory based on stored features of prior events is relevant to findings from the source monitoring literature. Source monitoring is considered to be an attribution process that operates during remembering to determine a memory's origin in the past (e.g., real vs. imagined, or self vs. other, or person 1 vs. person 2) via a set of decision-making processes (Johnson, Hashtroudi, & Lindsay, 1993). Johnson has argued that features that are required for source monitoring are not necessarily those required for old/new recognition. In fact, Lindsay and Johnson (1991) compared the effect of a level of processing manipulation on a source monitoring task and an old/new recognition task and found that, under the conditions they had contrived, a "deep" level of processing led to improved recognition performance but poor source monitoring performance. These authors noted that "memory performance is the joint product of what is stored in memory and how memory is tested" (p. 205).

The experiments presented here support this idea. The exclusion test may be considered to be a source monitoring task while the inclusion test serves as a basic old/new recognition task. The orienting task provided subjects with the opportunity to encode much detail about each item, which in turn facilitated completion of an old/new recognition task (i.e., a high probability of responding "yes" to old items in the inclusion condition). Despite this same store of information, subjects were less successful at discriminating between List 1 and List 2 items (i.e., source monitoring) when items were studied with the same orienting task than they were at identifying old vs. new items. Thus, information that supports performance on a old/new recognition task does not necessarily support performance on a source-specifying task (i.e., source-monitoring task).

Subjective Experience of Remembering. As stated above, performance is affected by the manner in which memory is tested. It can be said, therefore, that each task provides subjects with a certain goal and in turn this goal is inevitably affected by the subjects' own knowledge, beliefs, and expectations. Similarly, these types of subjective influences are at the center of discussions regarding the phenomenological experience of remembering. The subjective experience of remembering is said to reflect an attribution process in which the qualities of current mental events are used to make an attribution about the nature of those events (Jacoby, Kelley, & Dywan, 1989; Masson & MacLeod, 1992). For example, the "fluency" or the ease with which features are perceived or come to mind may, in one situation, be attributed to the pleasantness of the stimulus item (Kunst-Wilson & Zajonc, 1980), or in another situation, to memory for the stimulus item (Whittlesea, 1993).

Errors, confusions, or misattributions to the past or present may occur when some features are retrieved without the benefit of other defining features. Jacoby and

Whitehouse (1989) investigated subjects' attributions by manipulating awareness of a context word during a recognition test. When subjects were unaware (i.e., brief context duration) of the match between the context and target word they were more likely to misattribute the fluency of the item to the past (i.e., classify a new item as old) than in the aware condition (i.e., extended context duration) in which they more often correctly attributed the fluency of the item to the present (i.e., classify a new item as new). In the unaware condition item-specific features may have been retrieved without source-specifying features such as the relationship (i.e., match) between the context and target word, leading subjects to misattribute retrieved features to the past. In the aware condition additional integrative features such as the identity relationship between context and target confined the item to the present rather than the past. These results provide evidence to support the idea that high level integrative information may inherently suggest use of the past and that previous researchers obtained evidence for misattributions when they used low level information only.

Indirect vs. Direct Test Performance. Dissociations between performance on indirect and direct tests of memory (Jacoby, 1983; Jacoby & Dallas, 1981; Tulving et al., 1982; Warrington & Weiskrantz, 1974; see Kelley & Lindsay, in press, for an overview) may also be interpreted in terms of the above attributional theory of memory. Researchers have used these dissociations as evidence to support at least two different ideas for the mechanism of memory: multiple systems views of memory (e.g., Graf & Schacter, 1985; Tulving & Schacter, 1990) or processing views of memory (e.g., Jacoby, 1983; Jacoby & Dallas, 1981; Roediger et al., 1989). Indirect tests assess facilitation in performance when subjects are not asked to refer to a previous study episode and supposedly reflect implicit memory. Direct tests, on the other hand, measure performance when subjects are asked to refer to a prior event and are said to reveal explicit memory (Graf & Schacter, 1985; Richardson-Klavehn & Bjork, 1988).

In the multiple systems view, implicit and explicit memory are said to rely on separate and independent representations of a study episode. For example, implicit memory as revealed in priming (i.e., facilitation in responding) is said to depend on a perceptual representation system (Tulving & Schacter, 1990) that stores the perceptual features of studied items (e.g., Schacter, Cooper, & Delaney, 1990). An attribution theory of memory proposes that differences between implicit and explicit memory are due to sampling of non-overlapping aspects of memory stored in a unitary episodic representation, and an attribution process--in one instance subjects attribute their performance (e.g., the ease with which the stimulus item was visualized) to the stimulus item (e.g., subjects indicate a long duration for the item) and in the other case subjects attribute their performance to memory of a prior episode (i.e., the past). Thus, dissociations between direct tests (i.e., explicit memory) and indirect tests (i.e., implicit memory) (e.g., levels of processing manipulations improve performance on direct tests but leave performance on indirect tests unaffected) may be due to use of low-level perceptual information on many indirect tests (e.g., bottom three aspects of memory in

Figure 1) and high-level conceptual information on most direct tests (e.g., top three aspects of memory in Figure 1) (see Roediger et al., 1989).

Summary

This research demonstrates that the process dissociation procedure defines recollection as the retrieval of information that allows one to exclude to-be-excluded items, and familiarity as the retrieval of information that allows one to recognize to-be-excluded items as old but not to exclude them. These results fit well with a view of memory that includes multiple independent aspects of memory varying in complexity. The retrieval of these features or information in combination with an attribution process form the basis of remembering. Thus, the process dissociation procedure is a useful methodological tool for assessing memory whether information is automatically or consciously encoded, or automatically or consciously retrieved. For example, the estimate of F was increased and the estimate of R was reduced in divided attention (Experiment 2) suggesting that consciously encoded information (i.e., details encoded through the orienting task) was automatically retrieved at test.

I have argued that recognition is not a simple process that relies on two defined "in the head" operations but rather it is a complex one that relies on memory for multiple aspects of past experience. The features that form the basis for recollection and those that form the basis for familiarity depend upon the specifics of the learning and testing context.

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Appendix

Items used in Experiments 1, 2, and 3

airplane
anchor
apple
apron
arrow
bait
banana
barrel
basket
battery
bell
bench
bicycle
blanket
bolt
bottle
brick
briefcase
bullet
button
cage
calculator
calendar
camera
candle
canopy
carpet
cassette
celery
chopsticks
cigar
clamp
clock
comb
compass
corkscrew
cradle
crown
desk
dice
dock
donut
drapes
drill
drums
engine
envelope
eraser
escalator
fan
faucet
fender
flag
football
frame
fuse
gate
glove
goggles
hammer
harp
helmet
hinge
jacket
kayak
kettle
key
ladder
leash
lemon
lipstick
magazine
map
mask
mattress
microscope
mirror
necklace
nozzle
onion
peach
pencil
pendulum
piano
pillow
pitcher
pool
projector
propeller
puck
pump
purse
radio
raft
rake
rattle
rifle
ring
ruler
saddle
sail
sandwich
scissors
seed
shield
shirt
shovel
skates
sled
sponge
spoon
stapler
statue
submarine
surfboard
syringe
telephone
tent
thimble
toaster
tomato
tractor
trampoline
tray
trolley
trophy
trousers
tub
tweezers
umbrella
waffle
walnut
watermelon
wheel
wig
window
wrench
zipper

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Refereed Conference Papers

Gruppuso, V., & Lindsay, D. S. (1994, June). The effect of similarity on estimated values of familiarity and recollection. Paper presented at the 4th annual meeting of the Canadian Society for Brain, Behaviour, and Cognitive Science, Vancouver, British Columbia, Canada.

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Manuscript in Preparation

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