Noncriterial Recollection in Young and Older Adults: The Effects of Defining Recollection Specifically in the Remember-Know and Dual Process Signal Detection Paradigms

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Noncriterial Recollection in Young and Older Adults: The Effects of Defining Recollection Specifically in the Remember-Know and Dual Process Signal Detection Paradigms

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SUMMARY

When trying to remember a specific detail about a prior event, people frequently recollect other, often irrelevant, details. Memory of these irrelevant details has been dubbed "noncriterial recollection" (ncR), and despite its nomenclature, has been found to elevate familiarity estimates and to operate automatically and independently of "criterial" recollection (Yonelinas & Jacoby, 1996). To date, ncR has been considered unique to the Process Dissociation procedure, and has been examined only within that context. It also has not been found in older adults (Toth & Parks, submitted), despite the fact that automatic processes are relatively insensitive to age-related effects. To address these issues, two process estimation procedures (Remember-Know and Dual Process Signal Detection) were used under conditions likely to produce ncR in two experiments. Results showed that ncR increased older adults' familiarity estimates, and those of young adults studying under divided attention; however, that increase was larger for young adults studying under full attention. Receiver-operating characteristics (ROCs) indicated that ncR may not be functionally equivalent to familiarity, and (unexpectedly) that familiarity estimates in the control condition of Experiment 2 may have been contaminated by recollection. These experiments demonstrate that, regardless of the method, ncR is likely to elevate familiarity estimates when operational definitions of recollection are both specific and difficult. However, the degree of that elevation is at least partially dependent on recollection of the noncriterial detail when it is directly tested. That relationship, along with the ROC evidence, suggests that ncR is a process distinct from familiarity and similar to criterial recollection.

CHAPTER 1

INTRODUCTION

> "We recollect the general subject to which [the forgotten thought] relates. But all these details refuse to shoot together into a solid whole, for the lack of the vivid traits of this missing thought, the relation whereof to each detail forms now the main interest of the latter. We keep running over the details in our mind, dissatisfied, craving something more. From each detail there radiate lines of association forming so many tentative guesses. Many of these are immediately seen to be irrelevant, are therefore void of interest, and lapse immediately from consciousness. Others are associated with the other details present, and with the missing thought as well. When *these* things surge up, we have a peculiar feeling that we are 'warm'... Thus we recollect successively that when we had the thought in question we were at the dinner table; then that our friend J. D. was there; then that the subject talked about was so and so... Now all these added associations *arise independently of the will...*" p. 585-586 (original emphasis)

James (1890) was discussing the nature of associations; however, he could just as easily been talking about noncriterial recollection. Noncriterial recollection (ncR) is memory for details that are irrelevant to remembering the *one detail* we really want to remember; as James put it, ncR is what makes us feel that we are "warm", or close to remembering that one detail. Intuitively, ncR does not seem to be a rare occurrence. For instance, many students have had the unfortunate experience of reading a test question and realizing that they can remember the page in the book where they read the answer, and perhaps even the section on the page where that answer resides (noncriterial details), but are unable to remember what that answer (the criterial detail) actually is. Thus, ncR can be viewed as the somewhat common (and irritating) experience of remembering information that is often useless for successfully completing the task at hand, such as answering a test question correctly[1].

[1] There may be one important distinction that should be made between James' discussion and ncR. We may often deliberately attempt to reconstruct minor and seemingly irrelevant details about a prior event in hopes that such details may trigger our memory for the thing we are trying to remember, such as when we

The goal of the current experiments is to investigate ncR; but why bother to investigate memory for (at least what seems to be) useless information? First, examining ncR represents a place to begin to address higher level questions about recollection and familiarity because it resides at an intersection of sorts - that between defining recollection and familiarity in terms of content alone (as has been done by Atkinson & Juola, 1974; Dodson & Johnson, 1996; Mandler, 1980), and defining recollection and familiarity also in terms of controlled and automatic processes, respectively (e.g., Jacoby, 1991, 1998; see Yonelinas, 2002 for a review). As is discussed more fully below, ncR appears to be recollection in the sense that it is memory for episodic detail, but has been shown in one study to operate relatively automatically.

Secondly, experimental investigations of ncR require that we probe memory (and obtain measures of recollection and familiarity) for specific details of prior events, rather than simply asking whether one does or does not recollect an event on the basis of remembering *any* episodic detail (as is typical of many recognition experiments). Probing memory for specific details, and observing the effect on measures of recollection and familiarity, is important because it corresponds to many situations that we are faced with in daily life. That is, the occasions in which we are asked to recollect an event in general (thus corresponding to the loose definition) seem to occur less often (or often seem less important) than those in which we are asked to remember specific details of prior events (e.g., "Exactly who did you speak to about that insurance claim?", "Did you mail the bill before or after the 15^{th}?", "Was the intruder wearing black or brown

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try to retrace our steps after loosing our keys. As described more fully below, so far it appears that ncR is more similar to the exam situation where the irrelevant details (at least seem to) come to mind without intent; however, whether ncR belongs in the category of strategic behavior or unintentional memory has not been firmly established.

pants?"). Given that we are often asked to remember specific details of prior events, it will be important to understand how measures of recollection and familiarity are affected by such specific questions.

Although some of the issues motivating this study are rather lofty, the specific goals of the proposed experiments are more humble. Before addressing the high-level issues that ncR might raise (e.g., Is there such a thing as automatic recollection? What's the best way to define recollection and familiarity?), it is first necessary to gain a better understanding of the nature of ncR. To that end, two experiments, using methods that have not yet been applied to ncR, were conducted to test a hypothesis about when we should and should not expect to find ncR in both young and older adults.

Noncriterial Recollection

Although seemingly worthy of theoretical interest, the issue of ncR is actually one of the lesser known and more conceptual aspects of the larger controversy that has surrounded the Process Dissociation procedure. The Process Dissociation procedure is based on a dual-process model of memory that was introduced by Jacoby (1991, 1998) as a means of obtaining measures of recollection and familiarity from performance on a single task. In the most typical implementations of the Process Dissociation procedure, participants are presented with an incidental study list, followed by a second list that they are instructed to remember for a later memory test. A recognition test is then administered in which there are two primary within-subjects conditions: inclusion and exclusion. The inclusion condition is designed so that recollection and familiarity act in concert to produce the same response (mathematically: $INC = R + F(1-R)$); thus, for inclusion trials, participants are instructed to respond "yes" to words from both the first (incidental) and second (intentional) lists. In contrast, the exclusion condition is designed such that recollection and familiarity work in opposition to one another—that is, a response based on recollection will differ from a response based on familiarity (mathematically: EXC = F(1-R)). Therefore, for exclusion trials, participants are instructed to respond "yes" *only* to words they were instructed to remember—that is, only to words on the second list. However, they are also instructed that it is important to attempt to recognize all list-two words, and therefore if they are not sure whether the word was presented in the first or second list, they should respond affirmatively. Thus, familiarity for a word, in the absence of recollection of its source, will produce an erroneous "yes" response. Simple algebra is then used to derive estimates of recollection and familiarity from the independence equations noted above (R = INC – EXC; F = EXC/(1_R)).

There is a potential problem of ncR contributing to familiarity estimates that arises because of the way in which recollection and familiarity are defined in the Process Dissociation procedure. That is, in the procedure described above, recollection is specifically defined as the ability to recall which list an item was a member of during study; memory for any other specific details that do not identify list membership will not "count" as recollection. Typically, the lists are distinguished in terms of an experimental manipulation making list discrimination easier; for example, a levels of processing manipulation may be used for the first list and participants may simply read and try to remember the items on the second list (e.g., Toth, 1996). However, it may sometimes be the case that participants recollect some aspect of studying a word, such as a meaningful association they made (a noncriterial detail), that does not allow them to determine whether the item was part of the first or second list. Remembering a meaningful association would indicate that the item had been studied though, and participants would make an affirmative response. Assuming that such instances occur as frequently in the inclusion and exclusion conditions of the test, responses based on remembering noncriterial details will elevate familiarity estimates (i.e., both inclusion and exclusion scores will increase). However, given that memory for a noncriterial detail is still memory for an episodic detail of the prior encounter of the item, it would seem to be best classified as recollection. Thus, to the extent that recollection of noncriterial details contributes to performance on a Process Dissociation recognition test, it would appear that the estimates of familiarity would be overestimated, and recollection may be underestimated (e.g., Mulligan & Hirshman, 1997).

However, Yonelinas and Jacoby (1996) demonstrated that memory for the non-criterial information that contributes to the familiarity estimate operates automatically, and thus may be functionally the same as "true" undifferentiated familiarity. To illustrate why ncR may not be a problem in the sense of contaminating familiarity estimates, consider Yonelinas and Jacoby's experiment. They presented participants with a list words on a computer screen – half of which were presented on the right side of the screen and half on the left side. Participants were instructed to remember the word and its location on the screen and were encouraged to associate location with either two distinct people or places to help them better remember this attribute. The size of the font the words were displayed in was also varied, though participants were told that changes in font were merely to change readability (and presumably then, could be ignored). Participants were divided into four groups for the following Process Dissociation recognition test. They were either asked to remember the location of the words on the screen (the Easy condition) or to remember the size of font the word was presented in (the Hard condition), and half the participants in each of those groups were required to make their responses within a 1.2-s deadline (the Fast condition), or were not allowed to respond until at least 1.2 seconds had elapsed (the Slow condition).

Table 1. Recollection and familiarity estimates from Yonelinas and Jacoby (1996).

	Recollection	Familiarity
Slow Test		
Location (Easy) Condition	.50	.56
Size (Hard) Condition	.18	.67
Fast Test		
Location (Easy) Condition	.24	.57
Size (Hard) Condition	.04	.64

The results showed that recollection estimates were greater in the Easy condition relative to the Hard condition, and greater in the Slow condition relative to the Fast condition, as expected. More interesting however was the pattern of familiarity estimates: Within the Slow condition, familiarity estimates were greater in the Hard condition than in the Easy condition. Yonelinas and Jacoby (1996) interpreted this elevation in familiarity estimates in the Hard condition as reflecting memory for the non-criterial attribute (i.e., location). That is, participants obviously had little recollection of the size attribute, but recollection of location (the Easy attribute) was much higher. Because both groups were given the same instructions at study (i.e., to remember location), it is reasonable to assume that participants who were tested on the size (Hard) attribute would have been able to recollect location at the same level as participants in the

Easy condition, if they had been directly asked about it. Thus, Yonelinas and Jacoby argued that participants in the Hard condition often failed to remember the prior size of the item, but often did remember the location of the item. Memory for location did not allow participants to make the critical discrimination on the Process Dissociation test in the Hard (size) condition, but it did indicate that the item had been studied. And because participants were instructed to accept all studied items that they could not specifically recollect, memory for location in the Hard condition increased both the inclusion and exclusion scores, and thereby increased familiarity estimates.

Normally, this pattern of results would be problematic for the Process Dissociation procedure, because it appears that ncR is contributing to the familiarity estimates, thereby contaminating them. However, comparing the familiarity estimates across the speed manipulation revealed that this pattern was the same for the two test conditions; that is, familiarity estimates in the Hard condition were elevated relative to the Easy condition for both the Slow and Fast tests. Therefore, although it appears that recollection for a non-criterial attribute was contributing to the familiarity estimates in the Hard condition, this pattern remained invariant across a manipulation that undermined controlled processing (i.e., recollection); and given that the recollection estimates were significantly decreased by the speed manipulation, if ncR were a controlled process, it would be expected that it too would have been affected by response speed. Yonelinas and Jacoby argued that ncR may contribute to the familiarity estimates derived from the Process Dissociation procedure under some conditions, but since it appears to operate in the same manner as familiarity (i.e., relatively automatically), and was found to be functionally independent of recollection, ncR should be treated as familiarity (see also Gruppuso, Lindsay, & Kelley, 1997).

Aging and ncR

It remains unclear what the nature of ncR really is: It may be the spontaneous recollection of details that are irrelevant to the task at hand (cf., involuntary conscious memory, Richardson-Klavehn & Gardiner, 1996), or it may be the automatic and unconscious influence of that information making the item feel more familiar. As noted previously, it has been assumed thus far that the irrelevant information *is* recollected in the sense that memory of those episodic details is conscious. Thus, Yonelinas and Jacoby's (1996) finding that ncR operates automatically raises some paradoxical questions, especially with respect to aging. For instance, there is a wealth of research demonstrating the relative preservation of automatic uses of memory in older adults in the face of diminished recollection abilities, as compared to young adults (Hay & Jacoby, 1999; Java, 1996; Jacoby, 1996, 1999; Jennings & Jacoby, 1993, 1997; Light & Singh, 1987; Mäntylä, 1993; Parkin & Walter, 1992; but see Light, Prull, LaVoie, & Healy, 2000; Prull, Crandell, Martin, Backus, & Light, 2003). If there is in fact a form of recollection that operates automatically, as subjective experience might tempt us to propose, should we expect it to decrease with age (given clear indications that older adults have difficulty remembering episodic details), or should we expect it to remain invariant with age (given that automatic processes tend to be preserved in older adults)?

Toth and Parks (submitted) addressed a subset of these questions by examining ncR in the context of aging. Their procedures were the same as those used by Yonelinas and Jacoby (1996), with the exception that the two dimensions at study were location

(Easy condition at test) and color (Hard condition at test), rather than location and font size. Additionally, Toth and Parks eliminated the speeded-response manipulation at test, and instead examined whether a group of older adults (OA) would perform comparably to a group of younger adults (YA). Toth and Parks found that estimates of recollection derived from the Process Dissociation procedure were greater in the Easy than in the Hard condition, and were greater for YA than for OA. Estimates of familiarity were also decreased for OA as compared to YA. More important for current purposes however, was the pattern of familiarity estimates in the Hard condition for the YA and OA. Analyses revealed that although YA showed the ncR effect found in previous research, OA did not. Specifically, the familiarity estimates in the Hard condition were elevated compared to those in the Easy condition for YA (the ncR effect), but there was no difference between the Easy and Hard familiarity estimates for the OA. Although this pattern of results could be interpreted as suggesting that ncR does *not* operate automatically, Toth and Parks argued that a different factor was responsible for the lack of ncR in OA. In the Hard condition, ncR is presumed to consist primarily of information about the location of the words on the screen. YA were fairly successful at remembering location when directly tested on that attribute in the Easy (location) condition, with an average recollection estimate of .32. However, OA average recollection estimate in the Easy condition was approximately half that, .15. If ncR truly consisted of information about the location of the items on the screen, it is safe to say that OA had little of that information available, thus making it extremely unlikely that ncR could make a significant contribution to the familiarity estimates in the Hard condition. Essentially, the extent to which ncR will contribute to familiarity estimates in the Hard condition may depend on whether participants can recollect that non-criterial information when asked specifically about it (i.e., the contribution of ncR to the familiarity estimates in the Hard condition is likely to depend on the level of recollection in the Easy condition). Thus, Toth and Parks argued that the lack of ncR in OA was due to the fact that location information appeared to be unavailable, and therefore could not influence familiarity estimates.

To summarize, Yonelinas and Jacoby's (1996) finding that ncR was not affected by a response speed manipulation, and their subsequent argument that ncR should therefore be treated as functionally equivalent to familiarity, raises a few paradoxical questions with respect to aging. However, contrary to what would be predicted on the basis of Yonelinas and Jacoby's findings (i.e., that ncR should be approximately equal in YA and OA), Toth and Parks (submitted) found no evidence of ncR in OA, and argued that this failure was due to the low levels of recollection that OA had for the location attribute. Thus, they hypothesized that the degree of influence that ncR has on familiarity estimates depends on the level of recollection that would be found if memory for that noncriterial information were directly probed.

Vague versus Specific Questions

Investigations of recollection and familiarity often involve presenting somewhat vague questions to participants. That is, in many experiments, participants are simply asked whether or not they recollect an item as part of a previous list, with recollection defined as the ability to remember any episodic detail about the prior presentation of the item. Implementations of different procedures sometimes require a slightly greater degree of specificity—for instance, the two-list variant of the Process Dissociation procedure described earlier requires that participants not only recollect studying a word, but also whether it was a member of the first or second list (e.g., Jacoby, 1991, 1996, 1998). Nonetheless, investigations of memory for specific information has fallen largely to researchers in the domains of source memory (e.g., Johnson, Hashtroudi, & Lindsay, 1993) and memory for contextual details (e.g., Chalfonte & Johnson, 1996; Park, Cherry, Smith, & Lafronza, 1990; Smith, Park, Earles, Shaw, & Whiting, 1998). However, relatively few experiments within theses domains have specifically examined estimates of recollection and familiarity (but see Caldwell & Masson, 2001).

Because the issue of ncR arose in part from debates surrounding the Process Dissociation procedure it appears to have become pigeonholed as merely a quirk of that procedure, one that is either to be avoided (Mulligan & Hirshman, 1997), or one that is not to be worried about (Gruppuso et al., 1997; Yonelinas & Jacoby, 1996). However, there are real life situations that, at the very least, bear a striking resemblance to the experimental situation posed in ncR experiments. As noted previously, we are often faced with a recognition-like task that actually requires us to remember some specific detail about the event in order to make the desired response. Exams and police lineups are two easily generated examples, but in fact, many more common events often pose us with similar challenges; that is, as Toth (in preparation) has noted, we are often faced with the task of remembering a specific detail of a past event (e.g., "What findings did she present?"), rather than simply remembering any detail and thus asserting that we recollect the event as a whole (e.g., "Remember Jane's talk?" "Yes, she wore a white shirt."). When viewed in this light, ncR appears less likely to be a quirky effect of a particular methodology and more so a process that warrants some attention. Indeed, how recollection and familiarity estimates change when memory is probed for a specific episodic detail as opposed to cases in which any detail will suffice will be an important question to address.

Note that in recognition tests with the more inclusive definition of recollection, ncR has little to no chance to contribute to familiarity estimates because recollection of *any* detail would be criterial recollection (e.g., remembering coughing during the presentation of a studied item would be as "criterial" as remembering a meaningful association). However, the previous studies investigating ncR indicate that as the operational definition of recollection becomes both more specific and more difficult, recollection estimates will decrease and familiarity estimates will increase, due to the contribution of ncR. To illustrate, consider an extreme condition in which recollection is defined as memory of a detail that is impossible to recollect, such as the number of pixels on a computer screen that composed the to-be-remembered item; in this case recollection estimates would be zero, and all evidence of memory for the item would be measured within the familiarity estimate. The evidence to date indicates that when recollection is loosely defined, recollection estimates will be relatively high (depending on experimental conditions) and ncR will not have the opportunity to contribute to familiarity estimates. However, as recollection becomes more specifically defined and more difficult, recollection estimates will decrease and familiarity estimates will be elevated by ncR. Decreasing recollection estimates as a result of increasing difficulty of the required discrimination seem unproblematic; that is, difficulty of discrimination is, in this context, defined as asking about attributes that are presumed to be hard to remember. However, the simultaneous increase in familiarity estimates is not so intuitive, and has been suggested to pose potentially serious problems for the Process Dissociation model and its associated procedures (e.g., Mulligan & Hirshman, 1997). Yonelinas and Jacoby's findings would seem to allay worries of familiarity estimates being contaminated by controlled processes; but even if ncR does operate automatically, it is still not clear whether ncR truly increases subjective feelings of familiarity, whether it is a unique process that will require a third parameter estimate, or whether it is simply an artifact produced by these procedures.

ncR as a Methodological Artifact?

There are three positions that have been taken concerning the question of whether ncR is a real phenomenon (i.e., ncR truly increases familiarity for an item) or simply an artifact produced by using the Process Dissociation procedure in inappropriate experimental contexts. The first position, that ncR is "real", has been advocated in different ways by Gruppuso et al. (1997) and Yonelinas and Jacoby (1996). Gruppuso et al. argued that episodic information that is "too incomplete" to allow the critical discrimination to be made will increase the subjective experience of familiarity. Thus, by this view, when a participant recalls a noncriterial detail about a studied item (e.g., its location) but cannot recall the criterial detail (e.g., its size), familiarity estimates are appropriately increased because memory of location will indeed increase the feeling of familiarity for the item. This is an intuitively appealing notion, because most people can testify that remembering where a test answer was on a page in the book does indeed increase the feeling of familiarity for the answer. Yonelinas and Jacoby made a similar, but less extreme, argument: Ignoring the experiential effects of ncR, they argued that ncR operates independently of recollection and similarly to familiarity, and thus is best treated as functionally equivalent to familiarity.

In contrast to these positions, Mulligan and Hirshman (1997) have argued that ncR is a form of recollection for which the Process Dissociation model does not account, and therefore the contribution of ncR to familiarity estimates represents a case of contamination. By this view then, the elevation of the familiarity estimates by ncR does not reflect a true change in the experience of familiarity, but is due to the use of Process Dissociation procedure in experimental settings with which it is incompatible (i.e., experiments in which recollection is specifically defined as a difficult-to-remember attribute). In essence, these authors have argued that the influence of ncR on familiarity estimates represents a flaw in the Process Dissociation procedure.

A third position, advocated by Toth and Parks (submitted), is that familiarity estimates in the Process Dissociation procedure may often reflect both ncR and undifferentiated familiarity, and that it may be possible to dissociate these two influences. On the basis of research demonstrating that undifferentiated feelings of oldness can be increased or decreased through manipulations of processing fluency (e.g., Whittlesea, 1993), as well as their own findings for YA and OA, Toth and Parks argued that ncR and undifferentiated familiarity appear to be conceptually distinct. According to this argument, ncR is unlikely to be a mere artifact of the Process Dissociation procedure, although whether its contribution to familiarity estimates is appropriate or not is an issue that awaits future research.

There are two immediately evident approaches to this artifact question. One is to attempt to experimentally dissociate ncR and undifferentiated familiarity. Although this will certainly be an important step for both theoretical and methodological reasons, the goal of the present experiments was to use a different angle of attack. To the extent that ncR is a real phenomenon, and not simply an artifact of the Process Dissociation procedure, it should be possible to find ncR elevating familiarity estimates derived from other procedures. Thus far, ncR has only been examined with the Process Dissociation procedure, but it seems likely that such a pattern of results would be found using other methodological techniques, such as the Remember-Know (RK; Tulving, 1985) and the dual-process signal detection (DPSD; Yonelinas, 1994) methods. That is, the issue may have less to do with the methodology used, and more to do with how recollection is defined. For instance, defining recollection as memory for a specific detail should produce the same patterns of results for the RK procedure (elaborated below) as for the Process Dissociation procedure.

In contrast to this hypothesis, Gardiner and Richardson-Klavehn (2000) have argued that "[s]ince noncriterial or nondiagnostic recollection will contribute to remember, not know responses, in the remember/know paradigm, the extent to which estimates of recollection in the Process Dissociation procedure correspond with remembering [in the RK paradigm] must presumably reflect the relative proportions of the two kinds of recollection." (p. 237). However, this argument assumes use of the typical RK procedure, which does not probe memory for specific details; instead it defines remembering as memory of *any* detail. As noted previously though, we are often interested in memory for specific details, and therefore a variant of the RK procedure that permits the measurement of recollection for specific information was used (Toth, in preparation). Defining recollection as memory of a difficult-to-remember detail in the

RK paradigm should make it less likely that participants will be able to make the required discrimination on many trials, just as with any other method. Recollection of any other (noncriterial) details will not be 'counted as' recollection, but will provide evidence to the participant that the item was part of a previously studied list, thereby increasing the proportion of know responses. By this logic, ncR is not an artifact of a specific procedure, but is due to probing memory for specific details, and thus ncR should be found using other procedures devised for obtaining estimates of recollection and familiarity, such as the RK paradigm and the DPSD paradigm.

Overview

Summary and Purpose

Familiarity estimates have been shown to be elevated by ncR when the required discrimination is specific and difficult to make (Gruppuso et al., 1997; Mulligan & Hirshman, 1997; Toth & Parks, submitted; Yonelinas & Jacoby, 1996). Although ncR appears to be (and has been treated as) a type of recollection, it has been shown to be functionally independent of criterial recollection and to operate similarly to familiarity (Yonelinas & Jacoby, 1996). However, ncR has not been found in OA despite numerous findings indicating that relatively automatic processes differ only slightly (or not at all) between YA and OA. One reason for the lack of ncR in OA may have been due to low levels of recollection for the noncriterial detail (Toth & Parks, submitted). In addition, although ncR does appear to represent a real phenomenon, it is an issue that arose within debates concerning the use of the Process Dissociation procedure and has been examined only within that context. It therefore remains to be seen whether ncR is merely an artifact of the Process Dissociation procedure, or whether it will be found using alternative methods as well. Finally, studies of ncR are somewhat unique relative to other studies of recognition memory because memory is probed for a specific piece of information. The patterns found thus far suggest that testing memory for specific details in a recognition test context will decrease recollection estimates and increase familiarity estimates relative to cases in which recollection is defined as memory for any prior detail; however, these comparisons have not actually been made.

To address each of these issues, I conducted two experiments involving YA and OA and using different methods of obtaining estimates of recollection and familiarity. The first experiment was designed to address four major issues: (1) the Toth and Parks (submitted) hypothesis, (2) comparing ncR between YA, YA studying under divided attention, and OA, (3) examining ncR with the RK method, and (4) comparing estimates of recollection and familiarity when recollection is specifically defined to when recollection is loosely defined. The pattern of results from the RK method was expected to be the same as those that would be expected using the Process Dissociation procedure. Additionally, I expected to support the Toth and Parks hypothesis, to find ncR in OA (when there is noncriterial information available to be recollected), and to find that estimates of recollection decrease as definitions of recollection become specific and difficult, and a simultaneous increase in estimates of familiarity across the same conditions.

The second experiment was designed primarily as a conceptual replication and extension of the first. The goal of the second experiment was to use the DPSD method to compare estimates of recollection and familiarity when recollection is vaguely defined to when it is defined as a difficult-to-remember detail (i.e., under two extreme conditions).

The estimates obtained using the DPSD method were expected to parallel previous Process Dissociation experiments, as well as the findings of Experiment 1: Estimates of recollection should be greater when recollection is loosely defined than when it is specifically defined, and the opposite pattern should obtain for the familiarity estimates. Additionally ncR was expected to be found for OA, thus providing a replication of the first experiment. Finally, replicating the ncR influence on familiarity estimates across these different methods should demonstrate that ncR is not a mere quirk or artifact of the Process Dissociation procedure, but is to be expected whenever recollection is defined as memory of a specific detail.

General Methods

For both experiments, participants studied a list of aurally-presented words spoken in either a male or female voice and presented to either the right or left ear. These Gender and Ear attributes were varied orthogonally, and participants were told that their primary concern was to remember the speaker's gender for each word. The Gender attribute was selected as the Easy dimension and the Ear attribute as the Hard dimension. Pilot testing showed that in order to reach the desirable levels of recollection for the Gender attribute, mnemonics were necessary. Thus, participants were given two possible mnemonics to use to improve their memory of the Gender attribute.

Although the specific methods of deriving estimates of recollection and familiarity differed between the two experiments, the definitions of recollection were similar. In Experiment 1, each participant was tested under three conditions: Vague, Easy, and Hard. In the Vague condition, recollection was defined as the ability to remember *any* episodic detail of the studied words (i.e., the definition used in RK experiments; see Gardiner & Richardson-Klavehn, 2000). In the Easy condition, recollection was defined as the ability to remember the Gender attribute, and in the Hard condition, recollection was defined as memory for the Ear attribute. In the second experiment, only the two extreme conditions were tested (the Vague and Hard conditions), which were manipulated between participants. Following both experiments, a manipulation check was performed to determine participants' ability to (a) correctly identify relatively low-frequency words spoken out of context, (b) identify the ear to which a word was presented, and (c) to distinguish between the male and female voices. The purpose of this manipulation check was to ensure that YA and OA were able to hear the words and distinguish between the genders and ears equally well. Data from participants who correctly identified less than 21 words (out of a total of 24) were set aside, and the primary analyses included only those individuals who correctly identified 21 or more words during the manipulation check.

CHAPTER 2

EXPERIMENT 1

Experiment 1 used the RK method to obtain estimates of recollection and familiarity under Vague, Easy, and Hard test conditions with the expectation that ncR would be found to elevate familiarity estimates in both the Easy and Hard conditions. Both YA and OA were tested, with one group of YA studying under divided attention as an attempt to simulate the performance of the OA. If it is the case that the absence of ncR in OA found by Toth and Parks (submitted) was due to a lack of available information about the noncriterial detail for OA, then dividing the attention of YA during study should produce a similar lack of available information, and thereby either reduce or eliminate the ncR effect that would otherwise obtain. As such, the YA divided attention group was expected to perform on par with the OA group, such that recollection estimates would be lower than those of the YA full attention group, and any ncR effect that might be found would be smaller than that observed for the YA full attention group.

There are two aspects of the procedures that should be noted. First, a Guess response was not offered to participants. There has been some debate about providing a Guess response when using the RK procedure; it is typically found to reduce the proportion of Know responses, and to be approximately equivalent for both studied and unstudied items. The lack of effect of prior study on the Guess response suggests that it reflects decision strategies (Gardiner & Richardson-Klavehn, 2000). However, it has also been argued that Guess responses are similar to Know responses in terms of subjective experience, the difference between them reflecting degrees of confidence, with Guess responses representing the low end of the confidence scale (Gardiner, Ramponi, &

Richardson-Klavehn, 1998; Hirshman, 1998; Yonelinas, 2002). In a review of dual-process findings, Yonelinas (2002) reported that studies using Guess responses did not lead to different conclusions than did studies which did not incorporate guessing. Because the absolute quantitative estimates of recollection and familiarity are of less interest in these studies than are the patterns of those estimates across experimental and age conditions, in combination with the fact that the inclusion of a guess response does not appear to lead to different patterns of results, and because participants in the proposed experiment were discouraged from guessing, "Guess" was not offered as a separate response.

The second aspect of the procedure to consider is the change to the typical implementation of the RK method. In the Vague condition, participants were given the normal response options of the RK procedure—that is, Remember, Know, and New. However, in the Easy and Hard conditions, the remember response was specifically defined as memory of the attribute being tested (e.g., in the Easy condition, "Remember" was defined as memory for the speaker's gender). These conditions represent a combination of source monitoring and RK experiments, thus effectively creating a source-remember/know (SRK) procedure (Toth, in preparation). It has been argued that remembering in the RK paradigm is different than source monitoring (Gardiner & Richardson-Klavehn, 2000), and different from the estimates of recollection derived from the Process Dissociation procedure. With respect to recollection estimates derived from RK and the Process Dissociation procedures, there is a continually growing amount of evidence suggesting that in fact these two procedures are tapping the same process under many different (even if not all) conditions (e.g., Jacoby, Yonelinas, & Jennings, 1997;

Toth, in preparation; Yonelinas, 2001, 2002; Yonelinas & Jacoby, 1995). With respect to differences between remembering and source monitoring, it may be the case that these are not isomorphic processes, but it is clear that source monitoring does involve the kind of remembering (i.e., recollection) that Tulving, Gardiner, and their colleagues describe. Further, the SRK procedure allows participants to indicate that they recognize a word as studied by making a know response, without being forced guess the source when they truly have no memory for it, unlike experiments in the source monitoring literature. Note also that use of this SRK procedure produces a situation very much like that found in Process Dissociation experiments; that is, recollection will be specifically defined, and thus memory for any noncriterial information will be measured by know responses.

Method

Participants

Two hundred ten participants were tested in total, with data from 54 YA in the full attention condition, data from 54 YA in the divided attention condition, and data from 54 OA (full attention) being submitted to the analyses (a total of 162 participants). The data from the remaining 48 participants were excluded from analyses for the following reasons: Data from three YA participants in the full attention condition were excluded on the basis high false alarm rates (see Results for full explanation), and one was excluded due to perfect performance. Data from 11 YA in the divided attention condition were excluded on the basis of high false alarm rates, and data from 1 YA in this condition were excluded on the basis of below-criterion performance on the divided attention task. Finally, data from 11 OA were excluded on the basis of high false alarm rates, data from another 16 OA were excluded due to below-criterion performance on the manipulation check, and data from two OA were excluded for high false recollection rates.

Older adults (mean age = 71.6) were from Atlanta and the surrounding communities and were paid $10 an hour for their participation. Young adults (mean age = 19.5) were Georgia Tech undergraduates enrolled in a psychology course towards which they applied extra credit they were allotted in return for their participation. As expected, OA performed better on the Shipley Vocabulary test than did YA (mean YA = 30.6, mean OA = 34.4, t (160) = 7.57, $p < .001$, d = 2.32), and had completed approximately one and a half more years of education on average than had YA (mean YA = 13.5, mean OA = 14.9, t (68.345) = 4.36, $p < .001$, d = .872).

Design and Materials

Experiment 1 is a 3 (age-attention group) x 3 (test condition) mixed factorial, with age-attention group as between-subjects factor and test condition as a within-subjects factor.

Nine lists of 14 words, of relatively low frequency (10 – 15 occurrences per million) and five to eight letters long, were constructed. In each counterbalance condition, six of the nine lists (84 words) were studied and the last three (42 words) were new words at test. One third of the study words were assigned to each test condition (Vague, Easy, and Hard). Within each of those test conditions, half the words were assigned to the male voice and half to the female voice. Additionally, half of the words in each of the male and female conditions were presented to the right ear and half to the left ear. Across participants, these lists rotated through the Old/New, Vague/Easy/Hard, Male/Female, and Right Ear/Left Ear conditions such that each word appeared in each of the conditions equally often; this resulted in 18 counterbalance conditions per age-attention group (YA full attention, YA divided attention, and OA), with three participants per counterbalance group in each of the age-attention groups (resulting in 54 participants per age-attention group).

Although order effects of the different test conditions were a concern, a full counterbalance of all possible test orders (six), in combination with the list counterbalance described above, would have resulted in an unwieldy 108 counterbalance conditions. Thus, to account for possible order effects three different orders were used (1. Vague, Easy, Hard; 2. Easy, Hard, Vague; 3. Hard, Vague, Easy). These orders were randomly assigned to participants in each of the counterbalance conditions described above, such that 18 participants in each age-attention group were assigned to each order. No effects of order were found to be reliable.

Procedure

The experimental materials and tests were presented to participants aurally (study) and on computer screens (test), and were controlled by the E-prime program. Participants were primarily tested in groups of two to four, although some participants were tested individually.

<u>Study</u>

Participants studied 84 words that were presented aurally over headphones at a rate of 1 every 3 seconds. Half the words were spoken in a male voice and half in the female voice. In addition, half the words were presented to the right ear and half to the left. All participants were instructed to remember the words and whether they were spoken by a man or a woman. Two mnemonics were strongly suggested to help participants improve their memory for gender. One strategy was to think about either the masculine or feminine aspects of a word, depending on whether it was spoken by the man or woman. The second strategy was to associate words spoken by the woman to a woman the participant knew, and to associate words spoken by the man to a man the participant knew. Instructions presented on the computer screen noted parenthetically that the words would also be presented to different ears; however the experimenter did not mention this dimension in verbal instructions unless specifically asked about it. (In such cases, the experimenter simply noted that the most important aspect to remember was who said each word.)

YA in the divided attention condition were given the same instructions as above; however, the experimenter noted that use of the strategies might not be possible given the secondary task. The secondary task was a visual version of the odd-digits task (Craik, 1982) presented on a second computer screen. Pilot testing indicated that performance on the secondary task was quite high, and therefore participants were instructed that they should divide their attention somewhat equally between the two tasks, and that although they should be careful not to make too many mistakes on the digit task, they should not do so well on the digit-task that they missed most of the words in the study list. Thus, participants were instructed to aim for 85 - 90% performance on the digit-monitoring task. This task consisted of presenting single digits between 1 and 9 (inclusive) every 900 ms (800 ms digit duration plus 100 ms ISI). Participants' task was to monitor these digits for a series of three odd numbers in a row; participants indicated detection of three odd digits by pressing the spacebar before the third digit disappeared from the screen. Participants were given feedback for both commission and omission errors visually; the word "Error" was presented centrally in red for 500 ms after each error. Participants were given a short practice session with the digit task alone prior to beginning the study session proper.

Test

All participants were administered a Vague, Easy, and Hard recognition test. In each of the test conditions, participants classified the state of their memory for each test item using Recollect, Familiar, or New response options[2]. In the Vague condition, instructions followed typical RK instructions (Gardiner, 1988; Gardiner, Ramponi, & Richardson-Klavehn, 1998). Specifically, recollect was defined as the ability to remember any episodic detail about the word, including but not limited to the gender of the speaker or the ear to which it was presented. Familiar was defined as feeling or knowing that the word was in the prior list, but without being able to recall any specific details.

Instructions in the Easy and Hard conditions were similar, but specific to the attribute being tested, such that recollect was defined in terms of either memory of Gender or Ear, respectively. For example, in the Easy condition, participants responded "Recollect" only if they could specifically remember who said the word (i.e., the man or woman), "Familiar" if they recognized the word but could not clearly recollect who said it, and "New" if they could not remember the word. Likewise, in the Hard condition, "Recollect" was defined as the ability to specifically remember which ear the word was presented to, and "Familiar" as recognition of the word without being able to remember the ear to which the word was presented. Thus, in both conditions, the familiar response

[2] The actual response option terms presented to participants are different from other RK experiments, with the typical response options of "Remember" "Know" and "New"; in previous work, the terms "Recollect" and "Familiar" have been easier to explain to participants (e.g., Toth, in preparation).

had a definition similar to that in the Vague condition; participants used the familiar response when they either had feelings of familiarity for the item (without episodic detail) or when they knew that the word was studied, but were unable to recollect the dimension of interest (i.e., either Gender or Ear).

In all conditions, participants read instructions presented on-screen and were then given the opportunity to ask questions. The experimenter answered any questions, reiterated the critical aspects of the instructions, and discouraged guessing by indicating that it was just as important to identify new words as "New" as it was to identify old words as "Recollect" or "Familiar" and that approximately one-third of the items on the test would be new words. Response options (Recollect, Familiar, and New) were presented at the bottom of the screen, throughout each test, in colors that corresponded to colored keys used for each response. Test words were presented centrally in 16-point white font on a black background. Participants completed each test at their own pace.

Following the last test, a manipulation check was administered. This test consisted of the presentation of 24 words with frequencies similar to those used in this experiment. These words were presented at a 12-s rate and participants wrote the word, indicated which ear it was presented to, and whether it was in the male or female voice. Participants were instructed to guess at the word if they were not sure of what was said. Finally, the Shipley Vocabulary test was administered before participants were debriefed.

Results

Due to the exclusivity of the RK procedure (i.e., that a remembered item cannot also be known), paradoxical effects tend to occur, such as finding that know responses do not differ to old and new items (e.g., Jacoby, et al., 1997; Schacter, Verfaelli, & Pradere, 1996; Toth, in preparation; for other paradoxical effects see Parkin & Walter, 1992; Rajaram, 1993; Rajaram & Roediger, 1997). Yonelinas and Jacoby (1995) developed the Independence-Remember-Know (IRK) procedure as a means of directly comparing estimates of recollection and familiarity derived from the RK and Process Dissociation procedures. One benefit of IRK is that it typically eliminates the paradoxical finding of no difference between know responses to old and new items. IRK simply entails combining the assumption of independence and the RK paradigm. Assuming that participants use the recollect response only when they do in fact recollect items, the raw probability of a recollect response from the RK method will correspond with the estimate of recollection derived from the Process Dissociation procedure (e.g., Jacoby, et al., 1997; Yonelinas, 2001; Yonelinas & Jacoby, 1995), and thus no transformation of the raw recollect responses is necessary. However, the know responses will underestimate familiarity because they only reflect familiarity in the absence of recollection. Therefore, to obtain a probability estimate of familiarity, the proportion of know responses is divided by the proportion of times that a know response is possible, which is one minus the proportion of recollect responses $(F = K / (1-R))$. Both the original responses and the familiarity estimates were analyzed in the current experiment, and the following results are organized by memory process, with the raw familiar responses and the IRK familiarity estimates presented together. Also note that "familiar responses" indicates raw scores whereas "familiarity estimates" refers to estimates produced by the IRK model. Alpha was set at .05 unless otherwise noted. Effect sizes (f) are reported for significant t-tests, and ANOVA main effects and interactions (Cohen, 1988; Dodd & Schultz, 1973).

Exclusion Criteria

Participants' data were excluded from the formal analyses for three primary reasons: Participants did not meet the criterion on the manipulation check (i.e., correctly identifying at least 21 out of 24 words), they had high false alarm rates, and/or they had high false recollection rates. Participants' data were excluded on the basis of high false alarm and false recollection rates as a means of trying to equate baselines between the three groups. High false alarm rates were defined as IRK familiarity estimates of .50 or greater for new items on any of the three tests, which was more than 2 standard deviations from the mean for all participant groups and all tests. A .50 or greater estimate of familiarity for new items indicates that a participant responded familiar to half the new words (or more) to which they had not responded recollect. High false recollection was similarly defined as falsely recollecting half or more of the new items on any of the tests, which was far more than two standard deviations from the mean for all groups and conditions. Finally, an 85% correct criterion was established for performance on the divided attention task, which only one participant failed to meet (mean performance was 95% correct).

Manipulation Check

For purposes of evaluating performance on the manipulation check, the full and divided attention variable was collapsed in order to directly compare YA and OA. Despite the exclusion criteria, differences remained between the two age groups for the number of words correctly identified ($t(72.39) = -5.64$, $p < .001$, d = 1.10), with YA (mean = 23.4 out of 24) outperforming OA (mean = 22.4). The mean difference between YA and OA was less than one word, and thus it seems unlikely that this difference would provide much in the way of explanation of the age-related differences reported below. No significant differences were found between age groups for identification of Ear ($t(158) = .71$, $p = .48$) or Gender ($t(53.21) = -1.28$, $p = .21$).

Recollection

Recollection estimates were expected to decrease as a function of test condition, with the Vague and Easy conditions producing similar levels of recollection and the Hard condition resulting in low levels of recollection. Additionally, the purpose of including a YA divided attention group was to attempt to simulate the performance of OA. Thus, differences between participant groups were expected to show that YA divided attention and OA groups performed similarly, with both producing lower recollection estimates than the YA full attention group. As can be seen in Figure 1, the means support both of these expectations.

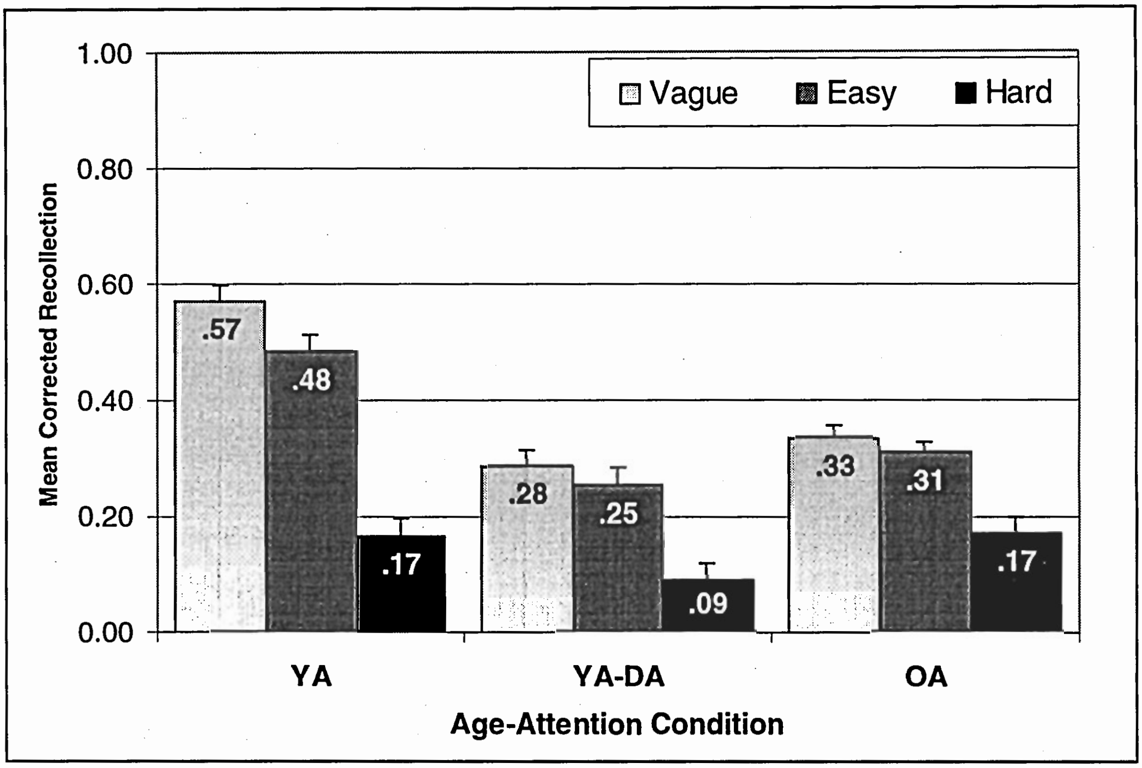

Figure 1. Corrected recollection as a function of age-attention group and test condition. Note. YA = young adult full attention, YA-DA = young adult divided attention, OA = older adult.

Before testing recollection proper, false recollection (recollection responses to new words) was submitted to a 3 (age-attention group) x 3 (test condition) mixed-design ANOVA, with test condition as the within-subjects factor. Significant main effects of test condition ($F(2, 318) = 8.35$, $MSE = .002$, $p < .001$, f = .14), and age-attention group ($F(2, 159) = 12.62$, $MSE = .06$, $p < .001$, f = .26) obtained, though the interaction between the factors was not reliable ($F(4, 318) = 2.26$, $MSE = .06$, $p = .062$). Post-hoc tests comparing test conditions (with alpha adjusted to .025) revealed no difference between the Vague and Easy conditions (means = .031 and .024 respectively), but a significant difference between the Hard (mean = .011) and Vague conditions ($F(1, 159) =$

19.36, *MSE* = .07, $p < .001$). Additionally, Tukey's HSD revealed significant differences between the OA and both groups of YA (OA = .042, YA divided attention = .018, YA full attention = .006, $p < .004$ for both tests). Due to these differences, recollection estimates were corrected by subtracting false recollection from recollection of old words for each participant on each test. Analyses of corrected recollection, reported next, resulted in the same conclusions as analyses of uncorrected recollection responses.

To test the trends noted above, corrected recollection estimates were submitted to a mixed-design 3 (age-attention group) x 3 (test condition) analysis, with test condition as the within-subjects factor. As is evident in the figure, both main effects of test condition (F (2, 318) = 139.11, *MSE* = .02, $p < .001$, f = .54) and age-attention group (F (2, 159) = 27.78, *MSE* = .02, $p < .001$, f = .20) were significant, as was the interaction between those factors (F (4, 318) = 11.49, *MSE* = .02, $p < .001$, f = .19). A planned contrast on test condition supported the expectation that the average of the Vague and Easy conditions was greater than that found in the Hard condition (F(1, 159) = 238.73, *MSE* = .14, $p < .001$). Also as expected, the YA divided attention and OA groups had significantly lower recollection estimates than did the YA full attention group (F(1, 159) = 50.42, *MSE* = .06, $p < .001$). A post-hoc partial interaction contrast was conducted to investigate the specific nature of the differences detected in the overall analysis and planned comparisons. This contrast showed that the difference between the average of the Vague and Easy conditions and the Hard condition was greater for the YA full attention group than it was for the other two groups (F(1, 159) = 33.059, *MSE* = .14, $p < .001$). The pattern of means also suggests that the Vague and Easy conditions are similar for the OA and YA divided attention groups, but that there may be a difference between the two conditions for YA full attention group. However, a second (nonorthogonal) partial interaction contrast that was conducted to assess this apparent trend revealed no reliable difference ($F(1, 159) = 3.30$, $MSE = .04$, $p = .071$).

Familiarity: RK and IRK Analyses

Unlike many RK experiments, familiar responses to old words did in fact exceed familiar responses to new words. More importantly, there is clear evidence of an increase in both familiar responses and familiarity estimates from the Vague and Easy conditions to the Hard condition (see Figure 2 for familiar responses and Figure 3 for familiarity estimates).

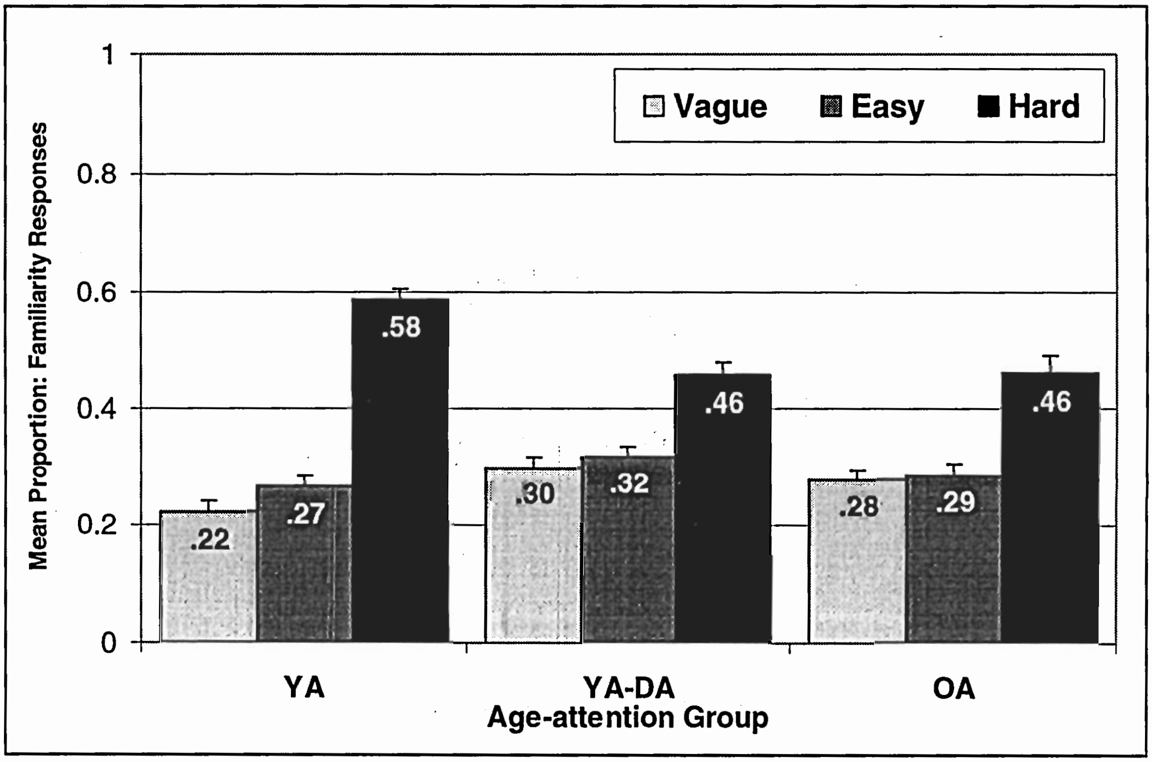

Figure 2. Familiar responses as a function of age-attention group and test condition.

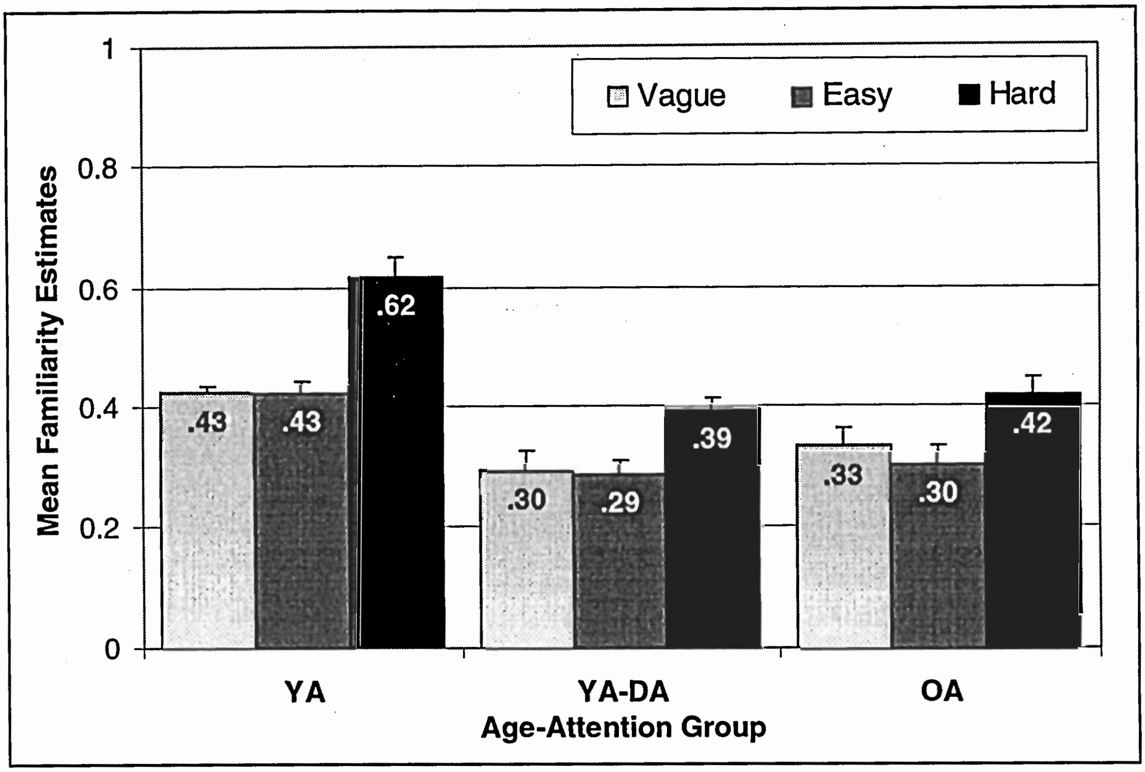

Figure 3. Corrected IRK familiarity estimates as a function of age-attention group and test condition.

No significant effects were found for familiarity responses to new words, and thus the uncorrected familiar responses were analyzed. To test the observations noted above, familiar responses were submitted to a mixed-design 3 (age-attention group) X 3 (test condition) ANOVA, with test condition as the within-subjects factor. Both the main effect of test condition ($F(2, 318) = 141.55$, $MSE = .02$, $p < .001$, f = .66) and interaction between the factors ($F\ (4, 318) = 9.988$, $MSE = .02$, $p < .001$, f = .20) were significant. However, the primary question of interest concerned whether the difference between the average of the Vague and Easy conditions and the Hard condition would be greater for the YA full attention group than for the other two groups. This partial interaction contrast was significant ($F(1, 159) = 27.93$, $MSE = .15$, $p < .001$). The question naturally following this effect is whether the ncR elevation of familiar responses is in fact significant for the OA and for the YA under divided attention, or whether the significant contrast is due to finding ncR in the YA full attention group alone. Thus, a separate set of analyses excluding the YA full attention group was conducted. In this analysis, the comparison of interest is between the average of the Vague and Easy conditions and the Hard condition; however, the overall ANOVA is also illustrative. The overall analysis revealed a significant main effect of test ($F(2, 212) = 52.16$, $MSE = .02$, $p < .001$, f = .25), but a nonsignificant main effect of age-attention group and a nonsignificant interaction between the factors (F's < 1). Thus, the overall analysis indicates a difference in familiar responses between the test conditions, but no differences between the YA under divided attention and the OA. The comparison of interest specified the nature of that difference between test conditions: There was a greater proportion of familiar responses in Hard than in the Vague and Easy conditions ($F(1, 106) = 77.36$, $MSE = .15$, $p < .001$). In sum, the ncR elevation of familiarity was found with the RK method, was found to be significant in the OA and YA divided attention group, and ncR was found to elevate the proportion of familiar responses more so for the YA full attention group than it did for the other two groups.

IRK familiarity estimates were submitted to the same analysis as were the familiar responses; however because the baseline estimates (familiarity estimates to new words) were found to differ as a function of test condition ($F(2, 318) = 3.21$, $MSE = .008$, $p < .05$, f = .04), analyses of the estimates corrected for baseline are reported. (However, the patterns are the same for analyses of uncorrected estimates). The corrected IRK familiarity estimates appear to mimic the patterns seen in the familiar responses.

Specifically, the estimates increase as a function of test condition, with the Vague and Easy conditions producing approximately equivalent levels of familiarity, both of which are substantially lower than in the Hard condition, which according to the hypothesis should be elevated due to the contribution of ncR. In addition, and unlike the familiar responses, there also appears to be a decrease in overall familiarity estimates in the YA divided attention and OA groups as compared to the YA full attention group. These trends were supported by the analyses. Significant main effects of test condition ($F(2, 318) = 31.54$, $MSE = .03$, $p < .001$, f = .29), and age-attention group ($F(2, 159) = 24.24$, $MSE = .05$, $p < .001$, f = .35) obtained, however, the interaction between these factors fell shy of significance ($F(4, 318) = 1.76$, $MSE = .03$, $p = .138$)[3]. Tukey's HSD tests showed that OA familiarity estimates were lower than those of the YA full attention group, and the estimates of the YA divided attention group were lower than those of the YA full attention group (both p's < .001). The analysis of most interest, the partial interaction contrast, showed that the difference between the average of the Vague and Easy conditions and the Hard condition was greater for the YA full attention group than it was for the other two groups ($F(1, 159) = 6.353$, $MSE = .17$, $p < .02$). As with the familiar responses, the next question with respect to the familiarity estimates was whether the ncR elevation of the estimates is in fact significant for the OA and for the YA under divided attention, or whether the significant contrast is due to finding ncR solely in the YA full attention group. Thus, an analysis with only the OA and YA divided attention groups was conducted, which led to the same conclusions as that analysis of the familiar

[3] Interestingly, this is the one analysis that differed when participants with high false alarm rates were entered into the analysis; specifically, the overall interaction was significant for the corrected IRK Familiarity estimates (f = .25), indicating that the lack of a significant overall interaction here is likely due to a lack of power. The power to detect an effect of this magnitude with 54 participants per condition is approximately 26.

responses—namely, a significant main effect of test condition ($F(1, 212) = 13.15$, $MSE = .03$, $p < .001$, f = .22), a nonsignificant effect of age-attention group and a nonsignificant interaction (both F's < 1). Also like the familiar responses, the contrast between the average of the Vague and Easy conditions and the Hard conditions when examining only the YA divided attention and OA groups was significant ($F(1, 106) = 25.68$, $MSE = .17$, $p < .001$). Thus, ncR elevated familiarity estimates of both the OA and YA divided attention groups, but this elevation was greater in the YA full attention group.

Discussion

To summarize, Experiment 1 was designed (1) to determine whether ncR can be found in OA and YA under divided attention, (2) to test the hypothesis that ncR is proportional to recollection of the noncriterial detail when specifically tested (the Toth and Parks hypothesis), (3) to determine whether the ncR influence on familiarity would emerge in a paradigm other than the Process Dissociation procedure, and (4) to compare specific and nonspecific definitions of recollection and the resulting effects on familiarity estimates. First, ncR is not a phenomenon restricted either to the Process Dissociation paradigm, nor to YA under ideal study and test conditions; there was clear evidence of an elevation of familiarity by ncR in the RK familiar responses and the IRK familiarity estimates for both the YA divided attention and OA groups. However, in line with the Toth and Parks hypothesis, ncR had a greater effect in the YA full attention group. Given the lack of differentiation between the Vague and Easy conditions, it is not possible to support the strongest version of the Toth and Parks hypothesis, namely that the effect of ncR on familiarity estimates is directly proportional to the level of recollection for the noncriterial detail. Nonetheless, the contrast of age-attention groups and test conditions indicates that undermining recollection, whether due to natural aging or divided attention, also reduces the ncR elevation of familiarity. Therefore, although the nature of the relationship between ncR and recollection will require further probing, the current experiment shows that there is some degree of dependency between the two processes such that the elevation of familiarity by ncR is reliant on the ability to recollect the noncriterial information when it is directly queried.

The original purpose of including both the Vague and Easy conditions was to include graded levels of difficulty of recollection, such that when the modal definition of recollection was given, participants would have a greater chance of recollecting than in either the Easy or Hard conditions. However, after pilot testing it was clear that mnemonics would have to be supplied to participants so as to obtain appropriate levels of recollection of the Gender attribute in the Easy condition. Pilot testing also showed that supplying such mnemonics eliminated differences between the Vague and Easy conditions, a trend that was fully supported in the current experiment. The fact that there was no reliable difference between the conditions indicates that when participants have focused on a particular attribute at study (at least when they have been given strategies to remember that attribute), they are more likely to remember that attribute than anything else (as one might hope). Allowing participants to remember any detail, as was the case in the Vague condition, did not increase recollection estimates because the detail(s) they remembered concerned Gender and/or the strategies they used to remember Gender. One possible exception was the trend towards greater recollection on the Vague than the Easy test for the YA full attention group. Although not reliable in the current study, it may be possible that when YA focus on one detail during study, they may still remember other details that could be captured in broadly defined recollection estimates but not specifically defined recollection estimates.

A final result of interest was the decrease in familiarity estimates for the YA divided attention and OA groups as compared to the YA full attention group. Divided attention manipulations typically do reduce familiarity, though to a smaller extent than they reduce recollection, and thus the attention-related familiarity deficit found in the current study is consistent with past research (e.g., Gruppuso et al., 1997; Jacoby & Kelley, 1992; Gardiner & Parkin, 1990; Yonelinas, 2001; see Yonelinas, 2002 for a review). On the other hand, familiarity estimates yielded by the Process Dissociation procedure are typically invariant across age groups. Despite the invariance of familiarity found in a number of studies, recent findings have suggested that there may be familiarity deficits in OA (e.g., Light, et al., 2000; Toth & Parks, submitted). In a comparison of the three main procedures for deriving estimates of recollection and familiarity (Process Dissociation, RK, and DPSD) Prull, Crandell, Martin, Backus, and Light (2003) concluded that the different methods can result in different conclusions about the changes in familiarity with age. In their study, familiarity estimates were invariant across age groups with the Process Dissociation procedure (cf., Toth and Parks, submitted), but were decreased in an OA group with both the RK and DPSD procedures. In the current study, application of the independence assumption to RK methodology revealed age and attention-related differences though the original familiar responses did not. These findings are basically consistent with those of Prull et al. Thus, there appears to be a slowly accumulating body of evidence suggesting that familiarity may in fact decline in older age.

CHAPTER 3

EXPERIMENT 2

Experiment 2 was a conceptual replication of Experiment 1 using the DPSD model to obtain estimates of recollection and familiarity. To accommodate necessary changes in design for implementing the DPSD methods, the attention manipulation and the Easy test condition were eliminated and test conditions were manipulated between-subjects.

Implementing the DPSD model requires gathering confidence ratings from participants for each of their recognition judgments (see Appendix A for complete (i.e., mathematical) description of the DPSD model). Receiver operating characteristic (ROC) curves are then created by plotting recognition performance (hits versus false alarms) as a function of confidence levels (i.e., criterion), such that the first point on the curve includes only the most confident responses, the second point includes those responses along with the second most confident responses, and so on for n-1 of the points on an n-point response scale[4]. The DPSD model uses a modified form of the independence equations that incorporate response criteria to produce estimates of recollection (in terms of probabilities) and familiarity (in terms of *d'*) for each point on the ROC curve by fitting the predicted parameters to those observed in the ROC data. Thus, estimates of recollection and *d'* are computed for each point on the curve, although in actually fitting the model recollection and *d'* are held constant across levels of confidence, while the criteria measure (c) is allowed to vary.

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[4] Thus a 6 point response scale produces a curve with only 5 points because cumulative proportions are plotted.

ROCs are usually curvilinear functions, which, if perfectly described by Signal Detection Theory (SDT), will be symmetrical along the major diagonal. Thus, if recognition performance relied solely on familiarity (which has been shown to be well described by SDT), one would expect to find perfectly symmetrical ROCs. In actuality though, ROCs for recognition are typically asymmetrical around the diagonal, suggesting that a simple signal-detection process cannot fully account for recognition performance. Although this asymmetry could be due to variance differences between the old and new item distributions, Yonelinas (1994, 1997, 1999, 2001) has shown that it reflects the contribution of recollection to recognition performance. Thus, in line with other dual process models, the DPSD model maintains that recognition performance reflects the operation of two processes, recollection and familiarity. The unique aspects of this model are that familiarity is assumed to be well-described as a simple equal variance signal-detection process, whereas recollection is assumed to be a high-threshold (i.e., all-or-none) retrieval process. Thus, recollection-based responses are assumed to remain constant across varying levels of confidence. In contrast, as confidence decreases (or as the criterion becomes more lax), recognition responses based on familiarity should increase (representing changes in criterion, not *d'*). Like Process Dissociation, the DPSD model assumes that these two processes contribute to performance independently. However, unlike the Process Dissociation procedure, a response bias parameter is incorporated into the DPSD model's estimate of familiarity.

Results of Experiment 2 were expected to replicate the findings of Experiment 1. Specifically, ncR was expected to elevate familiarity (*d'*) estimates in the Hard condition relative to the Vague condition, and more so for YA than for OA. In addition, the symmetry of the ROCs was expected to provide a test of the finding that ncR is functionally equivalent to familiarity. This was achieved by assessing the symmetry of both the overall recognition ROCs as well as examining the familiarity ROCs, in which the recollection contribution has been removed (see *Results, Familiarity z-ROC Analysis*). Recognition ROCs were expected to be asymmetrical, and more so for YA than for OA, reflecting a greater contribution of recollection to recognition performance for YA than for OA. Expectations concerning recognition ROC symmetry as a function of test condition were more ambiguous. To the extent that overall recollection is the same in the two conditions the slopes should be approximately equal, given that participants study the same materials with the same mnemonics in the two conditions. However, if ncR shares processing characteristics similar to familiarity—for example, if it is well-described by SDT—then it should be the case that the slopes would differ between conditions, with greater symmetry in the Hard condition where criterial recollection would be relatively low and ncR would be contributing to performance. The *familiarity* ROCs reflect performance characteristics after removing responses based on criterial recollection and thus they were expected to be symmetrical in the Vague condition. However, the symmetry of the familiarity ROCs the Hard condition depends largely on whether ncR operates in the same ways as familiarity.

Method

Participants

One hundred sixty-five participants were tested in total, with data from 72 YA (mean age = 20.0) and from 72 OA (mean age = 70.6) submitted to the primary analyses. Data from the remaining participants were excluded due either to below-criterion performance on the manipulation check, or to high false alarm rates. Data from one YA in the vague condition, two OA in the vague condition, and six OA in the hard condition were excluded due to high false alarms. Data from four OA in the vague condition and eight OA in the hard condition were excluded due to below-criterion performance on the manipulation check.

As expected, OA out-performed YA on the Shipley Vocabulary test (YA M = 31.1, OA M = 34.7, t (142) = -7.14, $p < .001$, d = 1.18), and completed approximately one more year of education than had the YA (YA M = 14.0, OA M = 15.3, t (116.41) = -3.71, $p < .001$, d = .61).

Design and Materials

Experiment 2 is a 2 (age group) x 2 (test condition) factorial with test condition as a between-subjects factor.

Because many trials are required to obtain reliable estimates for the ROC curves, the experiment was broken down into two study-test blocks. A total of 240 target items of low frequency (5 – 15 occurrences per million), ranging from five to eight letters in length were selected and randomly assigned to one of six lists (within the constraint of approximately equal average frequencies for the lists). A single block consisted of three lists of 40 words with two lists (80 words) presented during the study phase, and the last list (40 words) presented as new items on the test. For study items, half the words were presented in a male voice and half the words were presented in a female voice. Also, half of the words in both the male and female voices were presented to the right ear, and half to the left ear. Finally, half of the words in each of the four voice conditions (i.e., Male-Left, Male-Right, Female-Left, Female-Right) were tested in the Vague condition and half were tested in the Hard condition. Across participants, the six lists were rotated through these experimental conditions (Gender, Ear, and Block) for each age and test condition group, such that each word will appear in each condition equally often, resulting in 12 counterbalances.

Procedure

Study

Study words were presented through headphones in a male or female voice and to the right or left ear. All participants were instructed to remember the words and whether they were spoken by a man or a woman. Participants were (misleadingly) instructed that the purpose of the experiment was to examine the effects of a type of mnemonic on test performance, and that it was therefore very important that they use one of two possible strategies. These strategies were the same as those used in Experiment 1 (i.e., think of masculine or feminine aspects of the words depending on who spoke them, and/or associate words to a man and woman they knew, depending on who said them). Participants were told that they could either choose one strategy at the beginning and use it throughout the study list, or use the strategies flexibly. Words were presented at a 3.5-s rate with a 1-s ISI. During study the computer displayed a black screen.

Instructions for the second study session emphasized the necessity of participants' compliance with the instructions. That is, given that speaker Gender was not directly tested in either condition, participants were told that despite the temptation to ignore Gender (and in the Hard condition, to study which ear the words were presented to), it was absolutely essential that they continue to use the strategies for remembering Gender that they used in the first study session, and that if they did not, we would not be able to use their data. This instructional strategy was effective; no participants' data indicated that they ignored the Gender attribute and studied other attributes, which was particularly important in the Hard condition.

<u>Test</u>

Immediately following each study phase, participants were administered a visual recognition test via computer screen over words they had just studied and new words. For both the Vague and Hard tests, participants reported whether they recollected the item, or if they did not recollect the item, they made a confidence rating on a six-point scale (sure new 1…6 sure old). (Recollect responses were treated as the highest level of confidence for the ROC analyses, thus effectively creating a seven-point scale.) The difference between the two conditions consisted of different definitions of recollection; in the Vague condition "Recollect" was defined as memory of an episodic detail about the word's presentation during study, including but not limited to remembering who said the word or the ear to which a word was presented. In the Hard condition, "Recollect" was defined as a clear memory of the ear to which the word was presented. If unable to recollect, according to the definition provided, participants used the 6-point scale to rate their confidence in having studied the word or having not studied the word. These response options were presented at the bottom of the screen throughout the test, with the "Recollect" option presented at the end of the 6-point scale. Numbers 1, 3, 4, and 6 were labeled as "Sure New", "Unsure New", "Unsure Old" and "Sure Old" respectively. Participants used the number keys on the keyboard to enter responses and the number 8 was color-coded as the "Recollect" response. These tests were self-paced and the two study-test blocks typically took YA 45 minutes to complete, and took OA 50-60 minutes.

Following the last test, a manipulation check was conducted. As in Experiment 1, this check consisted of the presentation of 24 words with similar frequencies to those used in this experiment. These words were presented at a 12-s rate and participants wrote the word, indicated which ear it was presented to, and whether it was in the male or female voice. Participants were instructed to guess at the word if they were not sure of what was said. Finally, the Shipley Vocabulary test was administered before participants were debriefed.

Results

DPSD Model and Estimates

Several levels of analyses were conducted. First, the primary goal of this experiment was to determine whether the *d'* estimates in the Hard condition were elevated relative to the Vague condition (thus demonstrating an influence of ncR with the DPSD method), as well as to examine potential age-related differences with respect to ncR. In order to statistically assess differences between the age groups and test conditions, ROCs were generated for each participant and the DPSD model was fit to each participant's data by minimizing sums of squared error (SSE) using the solver program in Excel, which generated recollection and *d'* estimates for each participant. Recollection was expected to follow the same patterns found in Experiment 1, namely, higher for YA than for OA, and higher in the Vague condition than in the Hard condition. If ncR can be found in the ROCs, *d'* should be greater in the Hard condition than in the Vague condition, and if the Toth and Parks hypothesis is supported, that increase of *d'* in the Hard condition should be greater for young than for OA.

Table 2. Average recollection, *d'* generated by the DPSD model, and SSE for YA and OA as a function of test condition.

	Recollection	d'	SSE	n
Young Adults				
Vague	0.49	1.59	0.0016	36
Hard	0.03	2.29	0.0038	36
Older Adults				
Vague	0.31	1.43	0.0027	36
Hard	0.06	1.69	0.0038	36

The average DPSD generated estimates of recollection and *d'*, as well as the average SSE reflecting the fit of the model are presented in Table 2 and are generally consistent with expectations. The fit of the model to the average ROC in each condition is presented in Figure 4. As reflected both in the figure and by the average SSE, the model fit the data well. Both memory estimates were submitted to a 2 (age group) X 2 (test condition) between-subjects ANOVAs. Recollection estimates were greater for YA than for OA ($F(1, 140) = 5.42$, $MSE = .04$, $p < .03$, f = .13), and were greater in the Vague than in the Hard condition ($F(1, 140) = 122.37$, $MSE = .04$, $p < .001$, f = .88). These main effects were qualified by an interaction between the two factors ($F(1, 140) = 11.06$, $MSE = .04$, $p < .002$, f = .19), indicating that there was little to no difference between the age groups in the Hard condition, but a relatively sizeable difference in favor of the YA in the Vague condition. Significant main effects of age group ($F(1, 140) = 12.11$, $MSE = .44$, $p < .002$, f = .26) and test condition ($F(1, 140 = 18.72$, $MSE = .44$, $p < .001$, f = .33) also obtained for *d'* estimates, with higher *d'* estimates for YA than OA, and higher estimates in the Hard than in the Vague condition, thus demonstrating the ncR effect. These effects were also qualified by a significant interaction ($F(1, 140) = 3.99$, *MSE* = .44, $p < .05$, f = .13) which reflects a larger difference in *d'* estimates between the test conditions for the YA than for the OA. Given the interaction, it may be the case that the ncR effect is greater for YA than for OA, or that it was present for YA and not present for the OA. The pattern of means supports the first case, as does a specific comparison of the two test conditions within the OA group ($t(70) = -1.76$, $p < .05$, d = .41). Overall then, the DPSD estimates replicate the pattern found for YA and OA in Experiment 1.

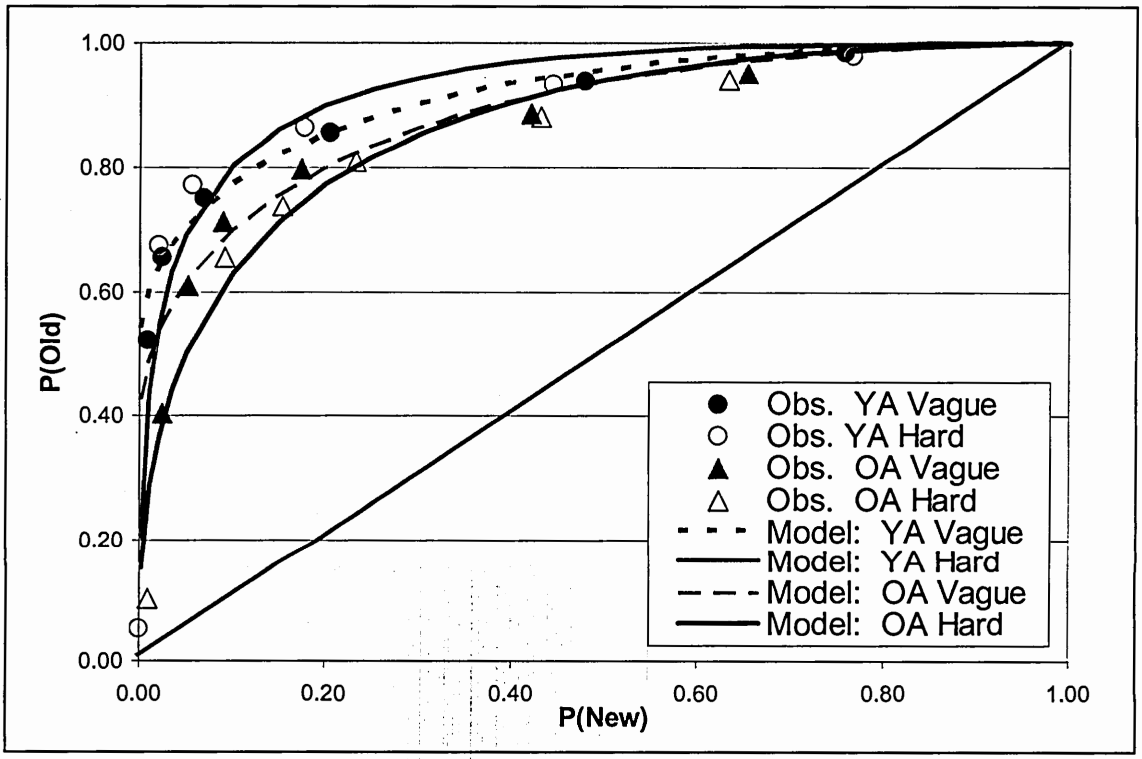

Figure 4. Fit of model-generated ROCs to observed ROCs as a function of age group and test condition.

Recognition z-ROC analyses

The second level of analysis was aimed at evaluating the symmetry of the recognition ROCs, which was done by plotting each participant's ROC in z-space. z-ROCs are typically linear and provide two important measures: The intercept of the z-ROC represents discriminability (*d'*) and the slope of the line provides a measure of the symmetry of the ROC (plotted on probability coordinates). Perfectly symmetrical ROCs will have a 1.0 slope when plotted on z coordinates, and asymmetrical ROCs will have z-ROC slopes that are less than 1.0. Thus, overall recognition performance for each age group and test condition was expected to produce curvilinear and asymmetric ROCs. Because the contribution of recollection to recognition performance has been shown to produce asymmetrical ROCs, the symmetry of overall recognition ROCs was expected to differ between age groups. Recognition ROCs should be more symmetrical for OA than for YA (and therefore the z-ROC slope for OA should be closer to 1.0 than the z-ROC slope for YA), indicating a smaller contribution of recollection to recognition performance. With respect to test condition, z-ROC slopes should differ if recollection contributes to recognition performance differentially in the two conditions.

Standard linear regressions were conducted to obtain slope and intercept estimates for each participant. Although analyses were conducted at the participant level, z-ROCs averaged across participants are presented for each age group and test condition in Figure 5, and average slopes, intercepts, and R^2s are presented in Table 3. For several participants the ROCs included points not defined in z-space (i.e., 1.00 and .00). Missing data were handled in two ways: In one stage of analysis, those undefined data points were simply not included in the regression analyses; thus data from any participant with less than three defined z-ROC points were excluded from analysis. In a second stage of analysis, all ROCs (and thus also the z-ROCs) were corrected by adding 1/n (where n is the number of confidence ratings) to each frequency and increasing the total number of items by 1 (cf., Snodgrass & Corwin, 1988). Additionally, some participants' z-ROCs were noticeably curvilinear. Thus, in order to make meaningful inferences, slopes and intercepts were analyzed only for those participants for whom the standard linear regression accounted for 90% or more of the variance of the z-ROC. (Analyses conducted with data from all participants with more than two defined z-ROC points led to the same conclusions as those found for this more conservative analysis.) This criterion resulted in a minimal loss of participants for the analyses of uncorrected z-ROCs, but a substantial loss for the analyses of the corrected recognition z-ROCs (see tables for Ns for each analysis). Due to the amount of data lost with this criterion for the corrected scores, I will present analyses of the uncorrected scores and note different conclusions based on the corrected scores when applicable.

Table 3. Average slopes, intercepts, R^2s and n's of recognition z-ROCs.

	Slope	Intercept	R^2	n
Young Adults				
Vague	0.61	1.63	0.97	32
Hard	0.56	1.61	0.98	29
Older Adults				
Vague	0.69	1.39	0.97	26
Hard	0.73	1.39	0.96	29

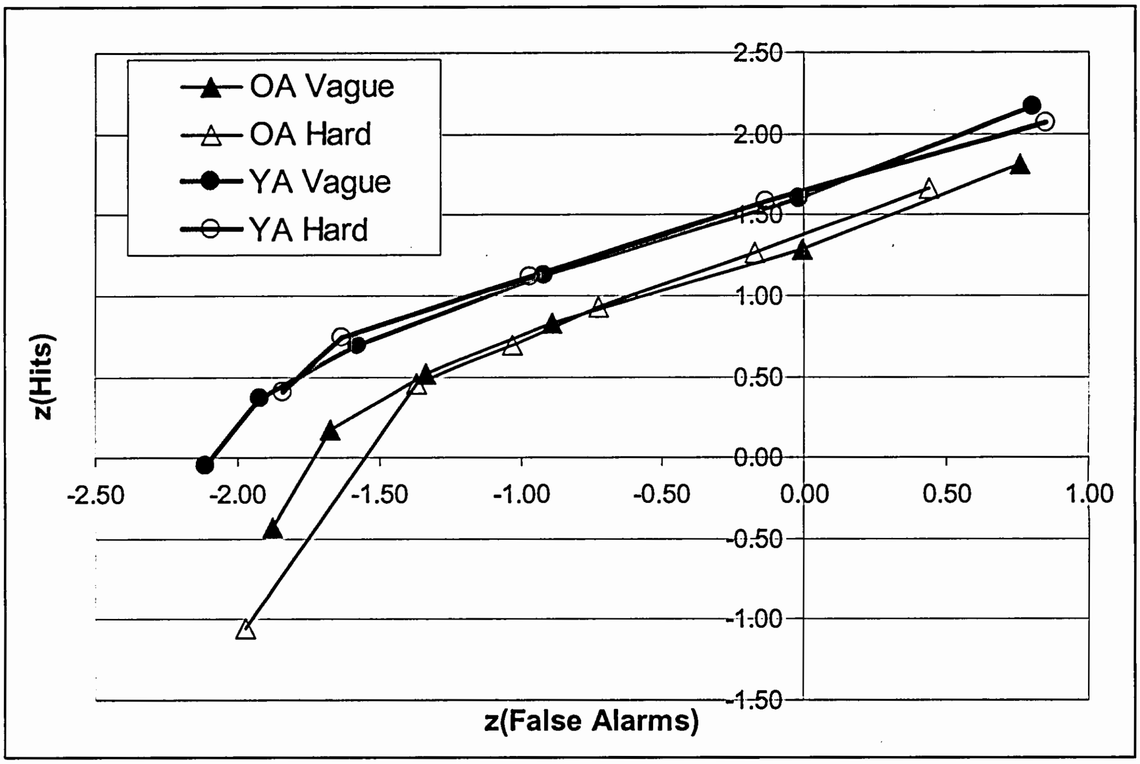

Figure 5. Average recognition z-ROCs as a function of age group and test condition.
Note. The young adult hard condition z-ROC has only five points because only one participant made false alarms with the recollect response.

Estimates of slopes and intercepts were submitted to 2 (age group) X 2 (test condition) between-subjects ANOVAs. Considering slopes first, only the main effect of age was significant[5] ($F(1, 112) = 12.4$, $MSE = .037$, $p < .002$, f = .31). The OA slopes were greater than those of YA indicating that the ROCs were less symmetrical for YA than for OA, as expected. Intercepts also differed between the age groups ($F(1, 112) = 8.43$, $MSE = .20$, $p < .005$, f = .26), indicating decreased memory performance for OA relative to YA. No other effects were significant for either slopes or intercepts. Thus, in contrast to the memory estimates derived from the DPSD model, the z-ROCs suggest that

[5] Both main effects and the interaction between age group and test condition were significant when the corrected recognition z-ROCs were analyzed.

recollection contributed to recognition performance equally in the two conditions, but similar to the model's estimates, there was a larger recollection contribution to YA than to OA recognition decisions.

Familiarity z-ROCs

The final level of analysis involved decomposing the recognition ROCs into familiarity ROCs. This was achieved by excluding recollection responses (i.e., effectively examining the six-point ROC). Excluding the recollection responses from consideration is the same as dividing the proportion of responses for each confidence level by one minus the number of recollect responses, thereby providing familiarity estimates based on the independence assumption for each confidence level. The number of responses contributing to the familiarity ROCs differs across participants (and between conditions) such that the more recollection responses a participant made, the less number of responses that participant had to contribute to the familiarity ROC. Although this does have the disadvantage of reducing the reliability of each participant's ROC (mainly for YA in the Vague condition), it also has the advantage of eliminating criterial recollection from the ROC. As such, the familiarity z-ROCs should have slopes of approximately 1.00, if in fact recollection has been effectively removed. To attempt to counteract the loss of reliability with the reduced number of trials contributing to the six-point z-ROCs, only data from participants with at least 50 non-recollect responses to old words were submitted to the analyses of the familiarity ROCs and z-ROCs, although conclusions based on analysis of all participants did not differ from those presented here. The same R^2 criterion that was applied to the recognition z-ROCs was applied to the familiarity z-ROCs as well, such that only z-ROCs with 90% or more variance accounted for by standard linear regression were analyzed.

Slopes, intercepts, and R^2s are presented in Table 4, and the familiarity z-ROCs are displayed in Figure 6. Examination of the familiarity z-ROC slopes revealed a significant main effect of test condition ($F(1, 110) = 19.99$, $MSE = .03$, $p < .001$, f = .39), with larger slopes in the Vague than in the Hard condition. The interaction between age group and test condition was also reliable ($F(1, 110) = 7.41$, $MSE = .03$, $p < .009$, f = .22), and reflects a greater slope difference between test conditions for the YA than for the OA, though both age groups had smaller slopes in the Hard condition. The symmetry of the ROCs of the two age groups were approximately equal in the Vague condition, suggesting that recollection-based recognition was approximately equal for YA and OA when using the six-point scale. In the Hard condition however, the symmetry patterns indicate a greater contribution of recollection to YA performance than to the performance of the OA. As with the recognition z-ROCs, intercepts were greater for YA than for OA ($F(1, 110) = 5.04$, $MSE = .19$, $p < .03$, f = .18), but unlike the recognition z-ROCs, intercepts were also greater in the Hard than in the Vague condition ($F(1, 110) = 15.82$, $MSE = .19$, $p < .001$, f = .35), indicating that memory performance based on the six-point scale alone was better in the Hard than in the Vague condition. No other effects were significant. Together, the slope and intercept findings from the familiarity z-ROCs suggest that when criterial recollection is removed, ncR may still be contributing to responses, thereby increasing memory performance (intercepts) in the Hard condition and skewing the ROCs away from symmetry (slopes).

Table 4. Average slopes, intercepts, and R^2s of the familiarity z-ROCs.

	Slope	Intercept	R^2	n
Younger Adults				
Vague	0.78	1.18	0.97	26
Hard	0.56	1.61	0.98	31
Older Adults				
Vague	0.75	1.10	0.97	25
Hard	0.69	1.32	0.97	32

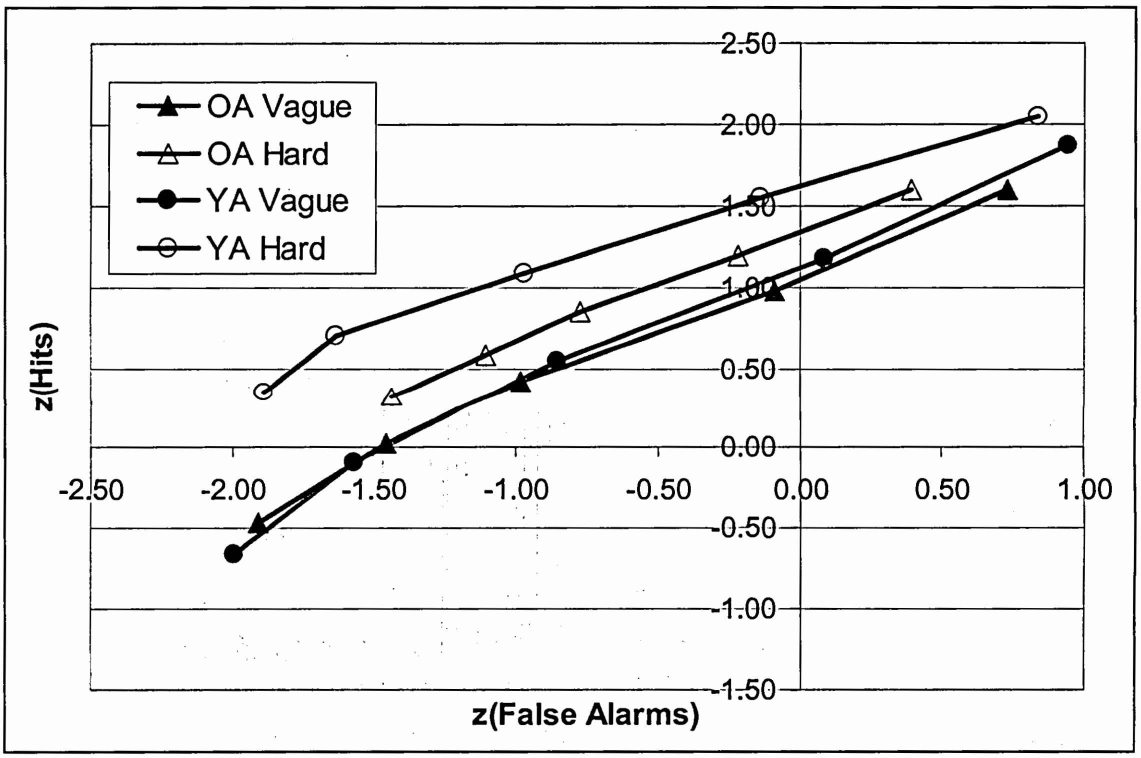

Figure 6. Familiarity z-ROCs as a function of age group and test condition.

This conclusion is supported by comparisons between the recognition and familiarity z-ROC slopes, which were significant for both age groups in the Vague condition (with larger slopes for the familiarity z-ROCs) but for neither age group in the Hard condition (YA: Vague, $t(25) = -7.41, p < .001$, d= .85, Hard $t(28) = -.74, p = .468$; OA: Vague $t(20) = -2.93, p < .009$, d = .68, Hard $t(28) = .55, p = .588$). Importantly though, *all* of the slopes from each condition and from the both the recognition and familiarity z-ROCs were found to differ from 1.0 (all *p*'s < .001, all d's > 1.00). The differences between the recognition and familiarity Vague slopes indicate that removing criterial recollection *did* increase the symmetry of the ROCs. However, the fact that the slope of that condition was still less than 1.0 suggests that excluding the criterial recollection response did not serve to fully remove recollection from the ROCs. In addition, removing the criterial recollection response had no effect on the symmetry of the Hard ROC; given that the DPSD estimates of recollection in that condition were essentially zero, this is not particularly surprising because there was no criterial recollection to remove. Overall then, it appears that recollection (criterial or not) was still contributing to non-recollect responses in both conditions, although more so in the Hard condition than in the Vague condition, and more so for YA than OA in the Hard condition.

In past research, removing recollection from recognition ROCs has produced familiarity ROCs that are well-described by the equal variance signal detection model (Jacoby, et al., 1997; Yonelinas, 2001). That is, once recollection has been removed the slopes of the z-ROCs are usually not different from 1.0. In such cases, the equal-variance signal detection model can be used to generate *d'* estimates, which can then be compared between groups and conditions. However, because the familiarity ROCs were not symmetrical (i.e., all z-ROC slopes were significantly less than 1.00), the equal variance model cannot fully account for the familiarity ROCs in the current experiment. Therefore, the DPSD model, instead of the equal variance model, was fit to the familiarity ROCs. As can be seen in Figure 7, the model fit the data well. The process estimates generated (see Table 5) suggest that even in the Vague condition, where participants were given the standard RK definition of recollection, familiarity estimates derived from the recognition ROCs may have reflected some contribution of recollection. In fact both main effects and the interaction between age group and test condition were significant for estimates of recollection derived from the familiarity ROCs (age group: $F(1, 122) = 5.23$, $MSE = .04$, $p < .03$, f = .15; test condition: $F(1, 122) = 64.216$, $MSE = .04$, $p < .001$, f = .68; interaction $F(1, 122) = 5.93$, $MSE = .04$, $p < .02$, f = .16). The pattern of recollection estimates from these six-point familiarity ROCs parallel the symmetry analysis reported above: There was no difference in recollection estimates extracted from the familiarity ROCs between the age groups in the Vague condition, but YA had much higher recollection estimates than did OA in the Hard condition. As for *d'* however, only the main effect of age group was significant ($F(1, 122) = 4.32$, $MSE = .32$, $p < .05$, f = .16), with greater *d'* values for YA than for OA, suggesting that familiarity-based responding with the six-point scale was approximately the same in the two test conditions, but greater for YA than for OA. Although there was a numerical trend toward an interaction between age group and test condition, this effect was not reliable ($F < 1.00$).

Table 5. DPSD memory estimates and SSE for familiarity ROCs.

	Recollection	d'	SSE	n
Younger Adults				
Vague	0.22	1.13	0.0020	26
Hard	0.61	1.35	0.0011	36
Older Adults				
Vague	0.23	1.08	0.0023	28
Hard	0.44	0.99	0.0012	36

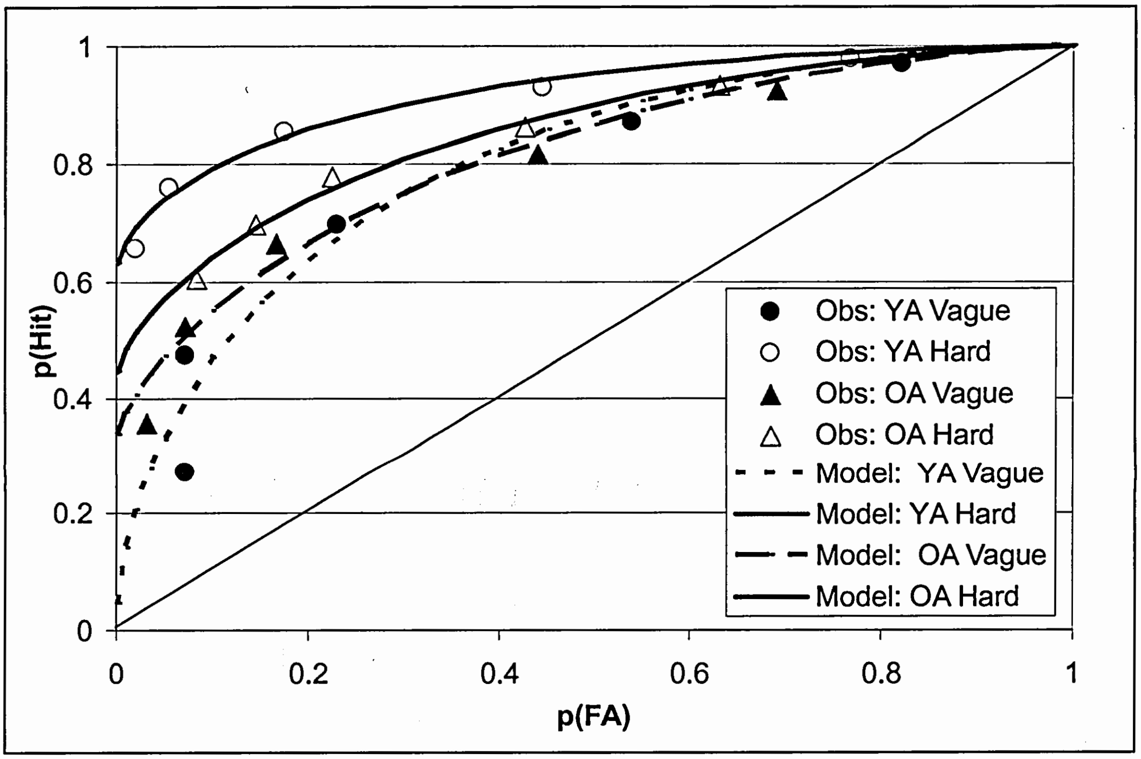

Figure 7. DPSD Model fit to observed familiarity ROCs as a function of age group and test condition.

Discussion

The purpose of Experiment 2 was to (1) determine whether the ncR effect would be found using confidence ratings and the DPSD model to obtain process estimates (2) whether the ncR effect would differ for YA and OA, and (3) to test the finding that ncR is functionally equivalent to familiarity by evaluating the symmetry of the familiarity ROCs. First, there was clear evidence that ncR elevated familiarity (*d'*) estimates yielded by the DPSD model, and in line with the Toth and Parks (submitted) hypothesis, the influence of ncR was present for both age groups, but greater for YA than for OA. The age-related decrease in familiarity estimates found in Experiment 1 was also replicated, again suggesting either a general age-related decline in familiarity, or a decline that is related to focusing on a specific attribute during study. Given other recent findings (e.g., Light et al., 2001; Prull et al., 2003) that have shown familiarity to be less invariant than once thought, along with the absence of any known mechanism that would produce age-related differences in familiarity only when attention is focused on one particular attribute during study, it would seem that this finding demonstrates a general age-related decline in familiarity.

One particular benefit of examining ROCs was the ability to evaluate their symmetry. The symmetry of the recognition ROCs revealed only differences between the age groups, indicating different contributions of recollection for the two age groups, but no differences between test conditions. The symmetry analysis of the recognition ROCs differed from the analysis of the DPSD *d'* estimates, with the *d'* estimates showing the ncR effect for the recognition ROCs. Thus the contrast between these two analyses suggests that recollection-based recognition was the same in the two groups, but that the process estimates captured different aspects of performance for the two conditions. Put simply, the DPSD estimates of recollection appear to be driven largely by responses in the highest confidence level (as should be expected on the basis that recollection typically produces high confidence responses). Thus, differences in response patterns across the response options in the two test conditions produced different levels of recollection and *d'* estimates—however, the slopes of the recognition z-ROCs suggest that in fact overall recollection was the same, and the intercepts indicate that discriminability differed only between the age groups.

In contrast to the recognition ROCs, the slopes of the familiarity z-ROCs were approximately the same for YA and OA in the Vague condition, but greater for YA than OA in the Hard condition. Thus, the pattern of asymmetry of the Hard ROCs indicates a larger ncR effect in YA than OA—put simply, the greater asymmetry for YA suggests that they recollected more Gender information than did OA. The fact that the familiarity ROCs in the Hard condition were asymmetrical suggests that ncR may not be functionally equivalent to familiarity. Unexpectedly though, the familiarity ROCs in the Vague condition were not symmetrical, as would be expected if those ROCs were based solely on a signal-detection familiarity process. Indeed, both the recollection estimates and the symmetry of the familiarity ROCs suggest that although there was more recollection-based responding with the six-point scale in the Hard condition, and particularly for YA, it was also present in the Vague condition as well. Thus, it appears that there was contamination of the familiarity responses even in the Vague condition, in which the typical RK definition of recollection was used.

It should be noted that it is possible that the remaining asymmetry in the familiarity ROCs could be attributable in part to variance differences between the old and new item distributions—especially in the Vague conditions, given that recollection should have been effectively removed by excluding recollection responses. That is, the unequal variance signal detection model, like DPSD, predicts asymmetrical ROCs but accounts for that asymmetry entirely by assuming that the variance of the old and new item distributions differ, as opposed to the addition of a high-threshold recollection parameter. Unfortunately, comparison between the unequal variance signal detection model and the DPSD model is difficult because they predict very similar ROCs (Yonelinas, 1994; Yonelinas, 1997; Yonelinas, Dobbins, Szymanski, Dhaliwal, & King, 1996). Because the unequal variance signal detection model can account for any intercept by slope relationship (because it has a free parameter for each), these two models are best tested against one another by examining observed ROCs under conditions in which the two models predict considerably different ROCs[6], which the current experiment was not designed to do. Though the fits of different models may be informative to some degree, and are thus presented in Appendix B, the unequal variance and DPSD models are best pitted against one another on turf other than that available in the current experiment. Nonetheless, the equal variance model cannot fully account for the current findings due to the asymmetry observed in the familiarity ROCs. It may be the case that variance differences between the old and new item distributions could account for at least part of the asymmetry observed. However, given the success of the

[6] Differences between the two models are best observed when recognition performance is based more on recollection than it is on familiarity. In such cases, DPSD predicts that the recognition z-ROCs will exhibit a small concavity in the left side of the function whereas the unequal variance signal detection model predicts straight lines.

equal variance model in explaining familiarity-based recognition performance in the past, in conjunction with the fact that participants studied the same information in the Vague and Hard conditions and thus should have had approximately equivalent recollection of Gender information, the most plausible explanation of the current findings is that recollection was contributing to responses on the six-point scale, though more so in the Hard condition, and within that condition, more so for YA than OA.

CHAPTER 4

GENERAL DISCUSSION

The primary aim of these experiments was to examine ncR in YA and OA using methods other than the Process Dissociation procedure as means of determining when ncR should and should not be expected to contribute to familiarity estimates, as well as determining whether ncR is simply an artifact of the Process Dissociation procedure, or whether it is due to specific operational definitions of recollection. The current study shows that ncR is not restricted to YA under optimal testing conditions, that ncR can elevate familiarity estimates in procedures other than Process Dissociation, and that the extent of that elevation is at least in part dependent on the level of recollection of the noncriterial attribute when it is specifically tested.

Recall that the purpose of including a YA divided attention group in Experiment 1 was to simulate the performance of the OA; however, that could have been achieved in a variety of ways. Divided attention was specifically chosen to reduce the likelihood of YA encoding study words to the extent that they could be recollected, as opposed, for example, to simply imposing a response speed manipulation at test, in which case the noncriterial information could still influence responses (e.g., Yonelinas & Jacoby, 1996). The idea was that the lack of an ncR effect in OA in the Toth and Parks (submitted) study was due to the unavailability of information to OA; that is, ncR could not contribute to their familiarity estimates because their recollection of the noncriterial attribute was too low. Thus, the parallels seen between the YA divided attention group and OA in Experiment 1 indicate that the influence of ncR on familiarity estimates is related to the overall level of possible recollection for the noncriterial information. Due to the lack of differentiation between the Vague and Easy conditions in Experiment 1, the strongest form of this argument cannot be fully supported—that is, that there is a direct proportional relationship between the level of ncR and the level of recollection for the noncriterial information. Nonetheless, the findings from both experiments show that groups with lower levels of recollection for the noncriterial information have smaller ncR elevations of their familiarity estimates than do groups with better recollection of the noncriterial information. Thus, as one might expect, one major precondition for observing an ncR elevation of familiarity estimates is some requisite level of recollection for the noncriterial information. Exactly what level of recollection of noncriterial information is necessary to produce ncR elevations of familiarity remains an open question, although the Toth and Parks (submitted) study indicates that recollection estimates of .15 or less are too low to produce an ncR effect.

One of the most intriguing aspects of ncR is the fact that it seems to have properties of both recollection and familiarity. Yonelinas and Jacoby (1996) demonstrated that ncR was invariant across a response speed manipulation, which is typically effective in undermining recollection. Thus ncR was argued to be functionally equivalent to familiarity. Nonetheless, the current experiments demonstrate that when recollection is reduced by age or divided attention, the elevation of familiarity estimates by ncR is likewise reduced. Because ncR has been assumed to be a type of recollection, the apparent dependency between ncR and recollection of the noncriterial information when it is directly tested is not particularly surprising. But is ncR a *type* of recollection, or is it really just the "same old" recollection that dual process theorists have been studying for years? The relationship between the ncR elevation of familiarity estimates and the level of recollection for that noncriterial information is redolent of ordinary recollection. Indeed, the ROC evidence is certainly pointing in that direction. The *d'* estimates derived from the familiarity ROCs did not differ between test conditions, suggesting that items were equally discriminable on the basis of familiarity in the two conditions. Also, removing criterial recollection changed the symmetry only of the ROCs in the Vague condition (and yet even those were still far from the symmetrical form predicted by the equal variance signal detection model). In fact, there was no significant difference between the slopes of the recognition and familiarity z-ROCs for the Hard condition. If ncR were functionally equivalent to familiarity, one would expect it to "behave" like familiarity has been shown to behave in ROC space—namely, to produce symmetrical curves around the major diagonal (Jacoby et al., 1997; Yonelinas, 2001). The asymmetry that remained after recollection was removed from the recognition ROC is therefore suspicious.

While some investigators have found ncR to be either harmless to process estimates (Yonelinas & Jacoby, 1996), or to provide reason for adopting different conceptions of recollection and familiarity (Grupposo, Lindsay, & Kelley, 1997), some have argued that ncR compromises process estimates obtained in the Process Dissociation procedure. Mulligan and Hirshman (1997) noted that not only are familiarity estimates compromised by ncR, but that recollection estimates are underestimated as well. The current experiments demonstrate that to the extent that ncR is a threat to process estimates, this threat is not specific to the Process Dissociation procedure. Nonetheless, whether recollection estimates are underestimated when they fail to capture ncR depends on what one is investigating. If one is investigating recollection as broadly defined, and uses an operational definition of recollection more specific and, importantly, more difficult than the typical definition, then yes, recollection estimates may be compromised and artificially diminished due to the failure of the operational definition to capture all possible recollection. However, Experiment 1 demonstrated that when participants focus heavily on a particular attribute at study, that tends to be the attribute they recollect (above all else) at test, regardless of the definition of recollection (cf., Marsh, Hicks, & Cook, 2004). The similarity between the Vague and Easy conditions demonstrates that specific definitions of recollection will not always produce ncR. Thus, the potential threat of ncR is rendered relatively innocuous when participants focus on the detail that defines recollection. The caveat, however, is that even the typical definition of recollection does not necessarily guarantee relatively pure process estimates.

None of the evidence presented here indicates *conclusively* that ncR is a controlled process that artificially decreases recollection and contaminates familiarity estimates. Though the ROC evidence supports a contamination position (i.e., the idea that items in the two conditions are equally familiar and ncR elevations of familiarity estimates represent contamination), it still fails to explain Yonelinas and Jacoby's (1996) finding that familiarity estimates, which were clearly elevated by ncR, remained invariant across a response speed manipulation that successfully reduced criterial recollection. Additional evidence supporting the idea that ncR may be functionally equivalent to familiarity has also been reported in the source memory literature. Dodson, Holland, and Shimamura (1998) developed a method of investigating partial and specific source memory in which participants heard words spoken by four speakers. The conditions relevant to the current findings were those in which participants heard words spoken by two men and two women and completed a source test under full or divided attention. Relative to the full attention condition, dividing attention at retrieval undermined only memory of the specific speaker, leaving both old-new recognition and memory for gender (partial recollection) intact. Interestingly though, in a follow-up study Simons, Dodson, Bell, & Schacter (submitted) found deficits in partial recollection for OA as compared to YA. Although partial source recollection and ncR are not identical phenomena (the details of the stimuli in partial source studies are related), there is an intriguing parallel in the patterns of results: The combination of relatively ideal encoding conditions with manipulations at test which undermine recollection fail to disrupt ncR and partial recollection. Yet when encoding conditions are compromised (due to age or divided attention), recollection, ncR and partial recollection are adversely affected. This pattern suggests that once the necessary information is encoded to produce ncR, it may be functionally equivalent to familiarity. However, further work will be necessary to provide a complete answer to that question and to reconcile the current ROC findings with the previous results.

It was anticipated that the familiarity ROCs in the Hard condition might prove to be asymmetrical due to the contribution of ncR, but the familiarity ROCs for the Vague condition *were* expected to be symmetrical, as has been found in previous work with familiarity ROCs (e.g., Jacoby et al., 1997; Yonelinas, 2001). In fact, the DPSD model specifically predicts symmetrical ROCs once recollection has been removed. The asymmetry found in the Vague familiarity ROCs therefore reflects either contamination of the familiarity estimates by recollection, variance differences between the old and new item distributions, or both. Although the unequal-variance explanation cannot be ruled out entirely, given that familiarity-based recognition performance has been well-described by the equal variance signal detection model in past research, the remaining asymmetry is suggestive of recollection. But given that all recollection was criterial in the Vague condition by definition, why would recollection contribute to non-recollect responses? One answer is that participants are unable to fully distinguish between recollection and familiarity in all circumstances. However, a large number of studies have successfully used the RK procedure, and therefore it seems unlikely that this can fully account for the current finding. Rather, it may be due to the overall recollection level in combination with cautious responding. Introspection suggests that not all recollection is accompanied by a 100% certainty that what one is recollecting is in fact what happened, and indeed, some evidence for this lack of complete certainty does exist. Yonelinas (2001) conducted a study in which participants made confidence ratings followed by remember, know, or new responses for each word. The distribution of remember responses was concentrated almost entirely at the highest level of confidence, but with a few remember responses at the second highest level. So although recollection is most often associated with extremely high confidence, this need not always be the case. Given the instructional emphasis on not guessing when responding recollect in the current study, in addition to overall good recollection of the Gender attribute, it may be the case that participants were overly cautious, and occasionally responded 5 or 6 when in fact they were recollecting according to the typical RK definition. Indeed, Bodner and Lindsay (2003) have shown that the percentage of remember responses can change depending on the context of the test. After shallow, medium, and deep processing of study items, the percentage of remember responses to items from the medium set depended on whether the other test items were from the shallow or deep set; remember responses were made more often to the items from medium when the other test items were from the shallow set. Thus, recollection of an item (or what people are willing to call recollection) can be influenced by memory of other items. In the current study, participants either associated each of the study items to a man or woman they knew or thought about the masculine or feminine aspects of the words. These mnemonics were effective strategies and led to high levels of recollection. Thus, the apparent contamination of familiarity estimates in the Vague condition in Experiment 2 may have been due to a situation similar to that studied by Bodner and Lindsay: Some items may have been recollected by the typical RK definition, but perhaps not as well as some other items, and thus were relegated to a 5 or 6 response.

Until recently, most research in aging and memory conducted from a dual-process perspective demonstrated the preservation of familiarity across age groups in contrast to often large recollection deficits. However, recent findings have called that preservation into question (e.g., Light et al., 2000; Prull et al., 2003). The current studies demonstrated familiarity deficits both as a function of age group and attention, but given the contamination of the familiarity estimates in Experiment 2, it is pertinent to question whether the deficits observed here may reflect differences in recollection (or ncR), rather than true differences in undifferentiated familiarity. One piece of evidence suggesting that it is a true familiarity difference is the age-related difference observed in the familiarity (*d'*) estimates obtained from the six-point (familiarity) ROCs. Those familiarity estimates showed no differences between testing conditions, but a reliable difference between the age-groups—after criterial recollection had been removed and after the DPSD model extracted further recollection from the ROCs. Thus, along with other recent findings, the current studies indicate that there is a slight deficit in undifferentiated familiarity in older age groups.

One aim of these experiments, and particularly Experiment 1, was to investigate the relationship between recollection, familiarity, and ncR for different definitions of recollection that range from relatively vague (the typical definition) to more specific, source-like, definitions. Of particular interest was whether the elevation of familiarity estimates found in studies using specific definitions of recollection reflected true increases in familiarity when recollection was specifically defined. The use of mnemonics rendered the difference between the Vague and Easy conditions in Experiment 1 negligible, thus effectively creating the standard two-condition (Easy and Hard) experiment that has been used to study ncR to date. Nonetheless it is clear that as one moves from the typical definition of recollection to more specific and difficult definitions, the likelihood of observing ncR also increases. Evidence garnered from familiarity ROCs in Experiment 2 suggests that increases in familiarity estimates due to ncR may not reflect true increases in undifferentiated familiarity, but instead may reflect contamination. Toth and Parks (submitted) argued that familiarity estimates in the Process Dissociation procedure may often reflect both ncR and undifferentiated familiarity, and given that these processes seem conceptually distinct, it should be possible to dissociate them. The current studies support the idea that ncR and undifferentiated familiarity are distinct processes, and further show that ncR is not merely an artifact of the Process Dissociation procedure, and does not appear to be functionally equivalent to familiarity. However, the current studies were not designed to experimentally dissociate ncR and familiarity, nor to fully compare the processing characteristics of familiarity, criterial recollection and ncR. These will be important issues to address for measurement, methodological, and theoretical reasons. If ncR truly contaminates familiarity estimates, and thereby decreases recollection estimates, it will be necessary to design future studies to take this potential problem into consideration so as to obtain the best process estimates possible. However, if ncR is functionally equivalent to familiarity, our theoretical definitions of recollection and familiarity may require revision to accommodate a process that spans both definitions.

APPENDIX A

Estimating Recollection and Familiarity with DPSD

The DPSD model entails three primary assumptions: Familiarity is assumed to reflect a normally distributed (Gaussian) equal variance signal-detection process. In short, this means that the probability of accepting an item as old on the basis of familiarity is a function of both d' (i.e., sensitivity) and response criterion (c), with d' reflecting the overall strength or magnitude of familiarity. The second assumption is that recollection is a high-threshold process, meaning that recollection is either successful or not. Because recollection is assumed to be an all-or-none process, recollection is measured as a probability. Finally, the last major assumption of the model is that recollection and familiarity are independent processes. As such, the probability of accepting a studied item is:

$$p(\text{“yes”} \mid \text{studied}) = R + (1-R)F_{Old} = R + F_{Old} - RF_{Old} \quad (1)$$

That is, the DPSD model treats the hit rate as the probability of accepting an item because it was recollected, plus the probability of accepting an item because it was familiar, but not recollected. The DPSD model also assumes that participants adopt a response criterion that is in part responsible for accepting new items as old (the other part of that "responsibility" resides in the variance of baseline familiarity in the new items). Thus, the probability of accepting a new item is:

$$p(\text{“yes”} \mid \text{new}) = F_{New}. \quad (2)$$

Equations 1 and 2 represent the DPSD model in broad strokes. However, as noted above, response criterion is incorporated into this model. Therefore, with respect to the familiarity parameters, we are actually interested in the probability that familiarity exceeds the response criterion (i.e., $p(F_{Old} > c)$ and $p(F_{New} > c)$). Thus, familiarity for studied items will follow the function

$$F_{Old} = \Phi[(d'/2) - c], \tag{3}$$

and familiarity for new items will be described by

$$F_{New} = \Phi[-(d'/2) - c)]. \tag{4}$$

The phi symbol (Φ) notation represents the probability that a variable is less than or equal to a particular value [e.g., $p(x \leq a) = \Phi(a)$]. This probability corresponds to an area under a curve (see Figure 4), and therefore, Equations 3 and 4 simply entail finding areas under curves. In this case, those areas represent the proportions of items that exceed the response criterion for each distribution, given a *d'* value as the distance between the new and old item distributions. Thus, the full DPSD model for accepting studied items as old is

$$p(\text{"yes"} \mid \text{studied}) = R + (1-R)\ \Phi[(d'/2) - c] \tag{5}$$

and for accepting new items as old is

$$p(\text{"yes"} \mid \text{new}) = \Phi[-(d'/2) - c)]. \tag{6}$$

Note that equations 5 and 6 can also be combined so to account for corrected recognition:

$$p(\text{"yes"} \mid \text{studied}) - p(\text{"yes"} \mid \text{new}) = [R + (1-R)\ \Phi[(d'/2) - c]] - [\Phi[-(d'/2) - c)]]. \tag{7}$$

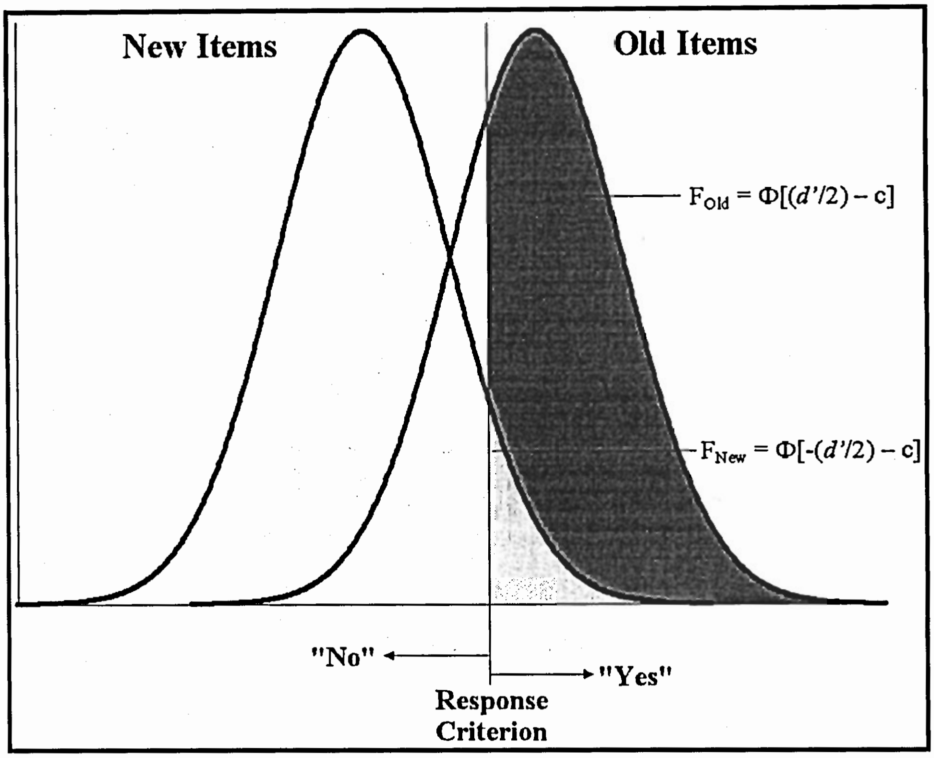

Figure 8. Familiarity distributions for old and new items in the SD model. Shaded areas represent old and new items accepted because their familiarity exceeds the response criterion.

Fitting the DPSD Model to Observed ROC Data.

Equations 5 and 6 describe performance in terms of R, d' and c for one point of the ROC curve. Experiment 2 is designed with a seven-point response scale (Sure New 1…6 Sure Old, and Recollect), and thus the ROCs will have six observed data points and 12 equations to estimate R and d' at each of those points. Determining the fit of the model to the observed ROC data involves using a search algorithm that varies the c, R, and d' parameters until the sums of squared errors have been minimized. However, in practice, only the c parameter is allowed to vary freely across the different confidence levels because both R and d' are assumed to remain constant across different levels of confidence.

APPENDIX B

Four models were fit to the familiarity ROCs from Experiment 2: The equal variance signal detection model, the unequal variance signal detection model, the DPSD model, and a modified version of the DPSD model which allowed the variance of the old and new item distributions to differ. The purpose of relaxing the equal variance assumption of the DPSD model was to allow for the possibility that the asymmetry observed in the familiarity ROCs was due both to recollection and to variance differences between the old and new items. Indeed, because the probability of any two empirical distributions having the *exact* same variance is zero, the unequal variance model should (and does) fit the data better than the equal variance model, and the modified DPSD model should (and does) fit the data better than the original (equal variance) DPSD model. Thus, comparisons are best made between the equal variance and the original DPSD model, and between the unequal variance and the modified DPSD model so as to determine whether the addition of a recollection parameter can better account for performance than familiarity alone. (As already noted, model fitting is not the best way to distinguish between the unequal variance and DPSD models in this experiment; because these models are best distinguished on the basis of their predictions about z-ROCs in conditions in which recognition performance relies more on recollection than on familiarity, the current experiment does not provide a good test of these models.) The estimates from Table 5 (the original DPSD model fit presented for the familiarity ROCs) are reproduced in Table 6 for easy comparison to the other models. Model generated process estimates are presented for the unequal variance models in Table 7.

Table 6. Memory estimates and SSE for the original DPSD and the equal variance signal detection model.

		Equal Variance Models				
		DPSD			Signal Detection	
	n	Recollection	*d'*	SSE	*d'*	SSE
Young Adults						
Vague	26	0.23	1.13	0.0020	1.38	0.0044
Hard	36	0.61	1.35	0.0011	2.27	0.0043
Older Adults						
Vague	28	0.24	1.08	0.0022	1.31	0.0053
Hard	36	0.44	.99	0.0012	1.67	0.0044

Table 7. Memory estimates and SSE for the modified DPSD and the unequal variance signal detection models.

		Equal Variance Models				
		DPSD			Signal Detection	
	n	Recollection	*d'*	SSE	*d'*	SSE
Young Adults						
Vague	26	0.13	1.29	0.0009	1.54	0.0011
Hard	36	0.46	1.86	0.0003	3.06	0.0005
Older Adults						
Vague	28	0.15	1.32	0.0010	1.64	0.0011
Hard	36	0.35	1.26	0.0005	2.26	0.0007

In both the equal variance and the unequal variance cases, the DPSD model fit the data better than did the pure signal detection models, although all models fit the data fairly well. The patterns of memory estimates between the equal and unequal variance DPSD models are quite similar, although the recollection estimates are lower in the unequal variance model, the *d'* estimates are higher, and the *d'* difference between the test conditions is increased for YA. Nonetheless, both the original and the modified DPSD models indicate that recollection did contribute to the familiarity ROCs in both test conditions. Thus, both models support a contamination position, and do so for both the Vague and the Hard conditions. In contrast, both the equal and unequal variance models suggest that all participants were better able to discriminate items in the Hard condition than in the Vague condition. Such a pattern is to be expected if recollection were contributing more to the non-recollect responses in the Hard than in the Easy condition, or if undifferentiated feelings of familiarity were increased by the specific and difficult definition of recollection in the Hard condition, or both. Given that participants studied the same information using the same strategies in the two conditions, logic would seem to compel the conclusion that both recollection of Gender information and undifferentiated feelings of familiarity were likely the same in the two conditions. However, research has shown that feelings of familiarity can be manipulated at test (e.g., Whittlesea, 1993), and thus it is possible that a specific and difficult definition of recollection could affect undifferentiated feelings of familiarity. It will be necessary to experimentally dissociate ncR and undifferentiated familiarity in order to make definitive conclusions.

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