Published in final edited form as:

J Mem Lang. 2007 July ; 57(1): 81–100.

The Role of Noncriterial Recollection in Estimating Recollection and Familiarity

Colleen M. Parks

University of California Davis

Abstract

Noncriterial recollection (ncR) is recollection of details that are irrelevant to task demands. It has been shown to elevate familiarity estimates and to be functionally equivalent to familiarity in the process dissociation procedure (Yonelinas & Jacoby, 1996). However, Toth and Parks (2006) found no ncR in older adults, and hypothesized that this absence was related to older adults' criterial recollection deficit. To test this hypothesis, as well as whether ncR is functionally equivalent to familiarity and increases the subjective experience of familiarity, remember-know and confidence-rating methods were used to estimate recollection and familiarity with young adults, young adults in a divided-attention condition (Experiment 1), and older adults. Supporting Toth and Parks' hypothesis, ncR was found in all groups, but was consistently larger for groups with higher criterial recollection. Response distributions and receiver-operating characteristics revealed further similarities to criterial recollection and suggested that neither the experience nor usefulness of familiarity was enhanced by ncR. Overall, the results suggest that ncR does not differ fundamentally from criterial recollection.

Keywords

noncriterial recollection; recognition; recollection; familiarity; aging; remember-know; receiver-operating characteristic; partial recollection

When trying to remember a specific detail about a prior event, people sometimes recollect other, often irrelevant, details. Memory for these irrelevant details has been dubbed "noncriterial recollection" (ncR); 'recollection' because the memory is of episodic details and 'noncriterial' because those details are not the criterial (or target) detail that one is trying to remember (Yonelinas & Jacoby, 1996). 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, perhaps even the exact location of that answer on the page (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.

Please address correspondence to: Colleen M. Parks, Psychology Department, University of California, One Shields Ave., Davis, CA 95616, Email: cmparks@ucdavis.edu, Phone: 530-754-9439, Fax: 530-752-2087.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

The Process Dissociation Procedure and ncR

ncR is one of the lesser-known and more conceptual aspects of the larger controversy that has surrounded the process dissociation (PD) procedure (Jacoby, 1991, 1998). In fact, ncR has been defined and examined only within the PD paradigm, perhaps because it presents a potential problem for the procedure—specifically, that ncR can be captured in familiarity estimates despite the fact that it is memory of episodic details (e.g., Yonelinas & Jacoby, 1996). The possibility of ncR contributing to familiarity, rather than recollection, estimates arises because of the way that recollection and familiarity are operationally defined in the PD procedure. In the original version (Jacoby, 1991), subjects typically study two lists of words, one incidentally with an orienting task (list 1) and the other intentionally, with no orienting task (list 2). There are two trial types on the subsequent recognition test—inclusion and exclusion—that are used to estimate recollection and familiarity for list-1 items. On inclusion trials, both list-1 and list-2 words should be accepted as old. On exclusion trials though, only the intentionally studied list-2 items should be accepted as old; list-1 items should be rejected. However, participants are likely to recognize some words from the study phases without being able to remember list membership; when this occurs, the items should be accepted as old. On inclusion trials then, recollection and familiarity will lead to the same response, a hit ($p(\text{"old"} | \text{list 1}) = R + (1-R)F$). However, on exclusion trials, the two processes work in opposition, such that recollection of an item from list-1 will result in a correct rejection, but familiarity for a list-1 item, in the absence of recollection, will result in an exclusion error ($p(\text{"old"} | \text{list 1}) = (1-R)F$).

Thus, recollection is defined by the exclusion task, and in this version of the procedure, it is specifically defined as memory of list membership. Memory of other details that do not specify list membership will not “count” as recollection. Ideally, participants can distinguish list-1 from list-2 items on the basis of the orienting task paired with the first list—that is, the orienting task serves to differentiate the lists from one another and makes it easier to determine list membership. But participants may sometimes recollect other details, such as an association or background noise, that are irrelevant to determining list membership but that do indicate that the item is old, and thus, the item would be accepted regardless of inclusion/exclusion trial type. Assuming that such instances occur equally often on inclusion and exclusion trials, responses based on memory of such noncriterial details will elevate familiarity estimates (i.e., both inclusion hits and exclusion errors will increase). But given that those responses are based, at least in part, on memory of an episodic detail, it seems that they should be categorized as recollection. Thus, if ncR contributes to performance on a PD recognition test, estimates of familiarity may be overestimated, and recollection underestimated.

Yonelinas and Jacoby (1996) tested this possibility in an experiment where studied words varied along two independent dimensions, location and size. Subjects used a mnemonic to remember the words’ locations (left or right on a computer screen), and were led to believe that font size (large or small) varied in order to manipulate readability (and could presumably be ignored). On the following recognition test, participants were divided into four groups corresponding to two definitions of recollection and two response speeds. Recollection was defined either as memory of location (the Easy condition) or as memory of font size (the Hard condition), and half the participants in each of those groups responded within 1.2 seconds (the Fast condition), or waited at least 1.2 seconds to respond (the Slow condition). In the Slow condition, recollection estimates were, unsurprisingly, greater for the Easy than for the Hard test (.50 and .18, respectively). More interesting though, was the opposite pattern found for the familiarity estimates, which were greater for the Hard than for the Easy test (.67 and .56, respectively). Given that encoding conditions were constant across test groups, there is no obvious reason for the difference in familiarity—except ncR. That is, participants did not recollect font-size very well, but they did recollect location, and it’s reasonable to assume that

this was true for both test groups since they had the same encoding experience. Thus, those in the Hard condition often failed to remember font size, but likely did remember location; memory of location indicated that the item had been studied, but was irrelevant to the test question (font size). Because all recognized items that were not specifically recollected were to be accepted as old, memory of location (i.e., ncR) in the Hard condition increased familiarity estimates. Similar findings of the ncR effect—that is, greater familiarity estimates in a Hard relative to an Easy condition—have been reported by others as well (Gruppuso, Lindsay, & Kelley, 1997; Mulligan & Hirshman, 1997), and these results seem to indicate that familiarity is being overestimated in the Hard condition. However, the response speed manipulation, which reduced criterial recollection by more than half in the Fast condition (.24 and .04, on the Easy and Hard tests, respectively), had no effect on the pattern of familiarity estimates. Familiarity was still elevated on the Hard test (.57 and .64 in the Easy and Hard Fast conditions, respectively). Therefore, although ncR did elevate familiarity estimates, this pattern remained invariant across a manipulation that successfully undermined criterial recollection. Had ncR been operating in the same manner as criterial recollection, it too should have been reduced in the Fast condition, eliminating the elevation on the Hard test. Thus, Yonelinas and Jacoby argued that ncR may contribute to the PD procedure's familiarity estimates under some conditions, but since it was functionally independent of criterial recollection and operated like familiarity (i.e., it was relatively automatic), ncR could be treated as familiarity without detriment to the process estimates.

Aging and ncR

The finding that ncR operates relatively automatically raises some paradoxical questions, especially with respect to aging. There is a wealth of research demonstrating the relative preservation of automatic uses of memory in older adults in the face of diminished recollection (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, Dawes, Martin, Rosenberg, & Light, 2006). Thus, if there is in fact a form of recollection that operates relatively automatically, 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 familiarity tends to be preserved in older adults)?

Toth and Parks (2006) addressed this question by examining whether older adults would show similar levels of ncR as young adults. They modified Yonelinas and Jacoby's (1996) procedure, using location (Easy condition) and font color (Hard condition) as the two encoding dimensions, and eliminating the speeded-response manipulation. They replicated the ncR effect, in the young adults, but there was no evidence of a significant ncR effect for the older adults. Toth and Parks argued that the lack of an ncR effect in older adults was due to low recollection of location. That is, young adults were fairly successful at remembering location when directly tested on it, with an average recollection estimate of .32 in the Easy condition. However, recollection in the Easy condition was approximately half that for the older group, .15. If ncR consisted of location information, it is safe to say that the older adults had little of that information available, thus making it unlikely that ncR could significantly elevate familiarity estimates in the Hard condition. Toth and Parks argued that the age differences in ncR were likely due to a proportional relationship between ncR and criterial recollection. Specifically, they hypothesized that the ncR effect is proportional to the level of (potential) recollection of the noncriterial information, and thus, ncR should be found in older adults when the noncriterial information is better encoded and is available to be recollected. Support for this hypothesis would suggest that ncR is functionally more similar to criterial recollection than it is to familiarity.

What is ncR?

The difficulty in determining just how problematic ncR is to the PD procedure has been due in part to disagreements about what ncR *is*. That is, even if ncR is functionally equivalent to familiarity, it's still not clear whether ncR truly increases subjective feelings of familiarity, whether it is a unique process that requires its own parameter estimate, or whether it is simply an artifact of the PD procedure. To date, there are two basic positions that have been taken concerning this question, with one in favor of ncR as a “real” phenomenon and the other in favor of the idea that it's merely an artifact.

The first position, that ncR is real, has been advocated in different ways by Gruppuso et al. (1997), Toth and Parks (2006), 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. 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 increase the feeling of familiarity for the item (this is much like the student's situation, in which remembering the page that the test answer is on makes the answer feel all the more *known*, even if inaccessible). 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) argued that ncR is a form of recollection that should be measured *as* recollection and that its contribution to PD familiarity estimates is a case of contamination and mismeasurement—specifically an overestimation of familiarity and a simultaneous underestimation of recollection. By this view, 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 PD procedure in experimental settings with which it is incompatible. Methodologically, this argument treats ncR as an artifact of the PD procedure, one that may invalidate the estimates it yields. Theoretically, it suggests that the only real difference between criterial recollection and ncR is the content of the memory—that is, relevant or irrelevant content—and that the functional characteristics of the two types of recollection should be the same.

Toth and Parks (2006) advocated aspects of both of the above arguments. Specifically, they argued that although ncR may sometimes increase the subjective experience of familiarity, it also appears to be conceptually distinct from traditional views of familiarity as an undifferentiated feeling of oldness. On this view, ncR is not an artifact of the PD procedure per se (i.e., it is a phenomenon that occurs outside the laboratory), but its measurement as undifferentiated familiarity is a potential problem for accurately estimating familiarity.

It seems relatively clear that ncR is indeed “real”—at least in the sense that it occurs outside of experimental contexts. However, it is still unclear whether ncR is better classified as recollection or familiarity and whether it really increases the subjective experience of familiarity. The present experiments were aimed at addressing these issues by investigating the proportionality hypothesis proposed by Toth and Parks (2006) and assessing whether ncR operates in the same way as familiarity in young and older adults. If the proportionality hypothesis holds, greater recollection of the noncriterial detail (when directly tested) should be associated with a greater ncR effect, for young and older adults alike. In Experiment 1, this idea was tested by comparing the ncR effect between young adults studying under full attention, young adults studying under divided attention, and older adults studying under full attention. If older adults' lack of the ncR effect in the Toth and Parks study was due to insufficient

information about the noncriterial detail, then dividing the attention of young adults at study should produce results similar to those of the older adults; that is, low recollection of the noncriterial detail and a reduced ncR effect relative to the young full attention group. Experiment 2 provided another test of the proportionality hypothesis, but focused more on the effect of ncR on subjective experience and its functional properties.

Both experiments were similar in design to previous ncR experiments—studied items varied along two dimensions, one of which was to be remembered and the other mentioned to subjects only parenthetically. At encoding, words spoken in either a male or female voice were presented over headphones to either the right or left ear. These Voice and Location attributes varied independently and participants were told to remember the speaker for each word and were given mnemonics to do so. The instructions noted that Location (i.e., presentation to right or left ear) would vary, but did not indicate that it should be remembered. Thus, Voice served as the Easy dimension (due to the intentional instructions and use of mnemonics) and Location as the Hard dimension.

At test, recollection was defined in terms of these two dimensions. The Remember-Know (RK) method (Tulving, 1985) was used in Experiment 1 and the definition of recollection was manipulated within-subjects, creating three tests: Broad, Easy, and Hard. In the Broad 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 for a review). Recollection was defined as the ability to remember Voice in the Easy condition, and as the ability to remember Location in the Hard condition. To date, only Easy and Hard conditions have been examined, but if ncR is created by specific definitions of recollection, then it should also be found in the Easy condition (relative to the Broad condition) since it too restricts successful recollection to memory of one detail, and will not capture all possible recollection. In Experiment 2, only the Broad and Hard conditions were tested, and confidence ratings were collected in order to construct receiver operating characteristics and to generate recollection and familiarity estimates with the dual process signal detection model (Yonelinas, 1994). This design afforded a test of the ncR effect with a different model than that used in Experiment 1, as well a detailed examination of the response distributions and receiver operating characteristics. If ncR increases the subjective experience of familiarity, it should be evident in the confidence distributions and the estimates generated from them, and if it is functionally equivalent to familiarity, it should be evident in the receiver operating characteristics.

Experiment 1

The RK method was used in Experiment 1 to obtain estimates of recollection and familiarity under Broad, Easy, and Hard test conditions with the expectation that ncR would elevate familiarity estimates in both the Easy and Hard conditions relative to the Broad condition. Young and older adults were tested, with one group of young adults studying under divided attention. On the basis of the proportionality hypothesis, the young divided attention group was expected to perform on par with the older group, such that recollection would be lower than in the young full attention group, and any ncR effect that might be found would be smaller than that observed for the young full attention group. The proportionality hypothesis would be contradicted if, despite lowered criterial recollection estimates, either the young divided attention group or the older group had an ncR effect comparable to the young full attention group.

Method

Participants—Two hundred nine participants were tested in total, with data from 54 young adults in the full attention condition, data from 54 young adults in the divided attention

condition, and data from 54 older adults (full attention) submitted to the analyses (a total of 162 participants). Data inclusion criteria were very conservative; participants had to meet a minimum performance requirement on a manipulation check (see Method and Results for details), and in the divided attention condition, a minimum performance requirement on the divided attention task. Additionally, participants with very high false alarm rates were excluded from the formal analyses in an attempt to equate false alarm rates across the three groups. Details on exclusion criteria and numbers of participants' data set aside are presented in Results.

Older adults (mean age = 71.6, SD = 4.5) were from Atlanta and the surrounding communities and were paid \$10 an hour for their participation. Young adults (mean age = 19.5, SD = 1.2) were Georgia Tech undergraduates enrolled in a psychology course who received extra credit in return for their participation. As expected, older adults performed better on the Shipley vocabulary test (Shipley, 1986) than did young adults (young mean = 30.6, SD = 2.9; old mean = 34.4, SD = 3.4; $t(160) = 7.57, p < .001, d = 2.32$), and had completed approximately one and a half more years of education on average than young adults (young mean = 13.5, SD = 1.2, old mean = 14.9, SD = 2.3, $t(68.345) = 4.36, p < .001, d = .872$).

Design and Materials—Experiment 1 was designed as a 3 (age-attention group) $\times$ 3 (test condition) mixed factorial, with age-attention group as a between-subjects factor and test condition as a within-subjects factor.

Nine lists of 12 words, of relatively low frequency (10 – 15 occurrences per million) and five to eight letters long, were constructed from the Kuçera & Francis (1967) compilation. In any given condition, six of the nine lists (72 words) were studied and the last three (36 words) were new words at test. One third of the words were assigned to each test condition (Broad, Easy, and Hard) such that each test included 24 old and 12 new words. Within each of those tests, half the old 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 voices were presented to the right ear and half to the left ear (6 right male, 6 left male, 6 right female, 6 left female, 12 new per test). Across participants, these lists rotated through the Old/New, Broad/Easy/Hard, Male/Female, and Right Ear/Left Ear conditions such that each word appeared in each of the conditions equally often, resulting in 18 counterbalance conditions per age-attention group. Studied and tested words were presented in a newly randomized order for each participant, with the exception of 4 primacy and 4 recency buffers that were presented in the same order for all participants.

To account for possible order effects three different orders were used (1. Broad, Easy, Hard; 2. Easy, Hard, Broad; 3. Hard, Broad, 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 1.0 program. Participants were primarily tested in groups of two to four, although some were tested individually.

Study: Participants studied 72 target words that were presented over headphones at a rate of 1 every 3 seconds. Half the words were spoken in a male voice and half in a female voice. In addition, half the words were presented to the right ear and half to the left. Participants were instructed to remember the words and whether they were spoken by the man or the woman. Pilot testing showed that mnemonics were necessary in order to reach desirable levels of recollection of Voice, and therefore two mnemonic strategies were provided. One strategy was to think about either the masculine or feminine aspects of a word, depending on the speaker.

The second was to associate each word to a woman or man the participant knew, depending on the speaker. Participants were strongly encouraged to use either or both strategies to improve memory of Voice. 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.) The computer presented a blank black screen for the duration of the study phase.

Young adults in the divided attention condition were given the same instructions as above; however, the experimenter noted that the use mnemonics might be difficult with a secondary task, but that if possible, they should be used. The secondary task was a visual version of the odd-digits task (Craig, 1982) presented on a second computer screen, and consisted of presenting single digits between 1 and 9 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 and to press the spacebar when they detected a series of three before the third digit disappeared from the screen. Feedback was given for both commission and omission errors visually; the word "Error" was presented centrally in red for 500 ms after each error. Participants were instructed to aim for 85-90% accuracy on the digit-monitoring task and were given a short practice session with the digit task alone prior to beginning the study session.

Test: All participants were given a Broad, 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. In the Broad condition, instructions followed typical RK instructions (Gardiner, 1988; Gardiner, Ramponi, & Richardson-Klavehn, 1998; Gardiner & Richardson-Klavehn, 2000). Specifically, *Recollect* was defined as the ability to remember clearly 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 a feeling of familiarity for the word, or recognizing the word from the earlier list without being able to remember any specific details, and *New* was defined as a state of no memory of the word from the study list.

Instructions in the Easy and Hard conditions were similar, but specific to the attribute being tested, such that *Recollect* was defined as memory of Voice or Location, respectively. 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 recollect who said it, and *New* if they did 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.

In all conditions, participants read instructions presented on-screen and were given the opportunity to ask questions. The experimenter answered any questions, reiterated the critical aspects of the instructions, went over examples of correct uses of the response options, and discouraged guessing by stressing that it was just as important to identify new words as *New* as it was to classify old words as *Recollect* or *Familiar*. Throughout each test, the response options were presented at the bottom of the screen 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.

A manipulation check was conducted after the last test 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 young and older adults were able to hear the words and distinguish between the Voices and Locations equally well. This task consisted

of the presentation of 24 new words with frequencies similar to those used in the memory tests; Voice and Location attributes were manipulated independently such that half the words were assigned to each Voice and each Location. 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 the word if they were not sure what was said. Finally, the Shipley vocabulary test (Shipley, 1985) was administered before participants were debriefed.

Results

The means for *Recollect*, *Familiar*, and *New* responses are presented in Table 1. Recollection was estimated as the proportion of *Recollect* responses whereas familiarity was estimated according to the independence assumption ($F = \text{Familiar} / (1 - \text{Recollect})$; Yonelinas & Jacoby, 1995). Alpha was set at .05 unless otherwise noted, and the basic analysis for all estimates was a 3 (age-attention group) $\times$ 3 (test condition) mixed-design ANOVA, with test condition as the within-subjects factor, although specific contrasts comparing the size of the difference between test conditions for the different participant groups served as the main focus. In some cases, degrees of freedom were adjusted to deal with violations of the assumption of homogeneity of variance, resulting in degrees of freedom with decimal places. Effect sizes, d (for t-tests) and f (for ANOVA main effects and interactions) are reported for significant results (Cohen, 1988; Dodd & Schultz, 1973). The results are organized by memory process; first, however, I address exclusion criteria and the manipulation check results.

Exclusion Criteria—Participants' data were excluded from the formal analyses for three reasons: they 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 familiarity estimates of .50 or greater for new items on any of the three 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*. Data from three young full attention subjects, 11 young divided attention subjects, and 11 older adults were excluded on the basis of high false alarm rates¹. High false recollection was similarly defined as falsely recollecting half or more of the new items on any of the tests², and data from two older adults were excluded on this basis. Finally, an 80%-correct criterion was established for performance on the divided attention task, which only one participant failed to meet (mean performance was 95% correct). The formal analyses excluded data that did not meet these criteria; however, analyses including these data from high-baseline participants showed the same effects as those presented below, with one exception described in Footnote ³.

¹In the young full attention group, 2 subjects' were excluded for high baselines only on the Hard test, and the third was excluded for high baselines only on the Broad test. In the young divided attention group, the breakdown was as follows: 2 subjects excluded due to performance on all three tests, 1 subject excluded for high baselines on two of the three tests, 4 were excluded for high baselines on the Easy test alone, and 1 for high baselines on the Hard test only. In the older adult group: 3 subjects were excluded for high baselines on all three tests, 3 were excluded for high baselines on two of the three tests, 3 were excluded for high baselines only on the Easy test, and 2 were excluded for high baselines only on the Hard test.

²This is a rather lax criterion—the mean false recollection rate in Dunn's (2004) database of 400 RK studies is 5% with a standard deviation of 4%. Thus, the majority of remember-know studies find false recollection below 10%. However, for the current study, this criterion served to exclude participants with extreme false recollection rates and to include very few participants with false recollection rates between 10 and 50%.

³Interestingly, when participants with high false alarm rates were included in the analysis, the overall interaction was significant for the corrected IRK Familiarity estimates ($f = .25$), indicating that the lack of a reliability without those participants is likely due to a lack of power. This interaction was also significant for the raw familiarity responses ($F(4, 318) = 9.988, MSE = .02, p < .001, f = .20$).

Manipulation Check—For purposes of evaluating performance on the manipulation check, the attention variable was collapsed in order to directly compare young and older adults. 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 young outperforming older adults (means = 23.4 and 22.4, respectively). The mean difference between the age groups was less than one word, and thus it is 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 Location ($t(158) = .71, p = .48$) or Voice ($t(53.21) = -1.28, p = .21$).

Recollection—Despite the exclusion of data from participants with high false recollection rates, analysis of false recollection revealed significant main effects of test condition ($F(2, 318) = 8.35, MSE = .002, p < .001, f = .14$), and age-attention group ($F(2, 159) = 12.62, MSE = .06, p < .001, f = .26$), and a marginally reliable interaction between the factors ($F(4, 318) = 2.26, MSE = .06, p < .07$). Post-hoc tests revealed that false recollection, though low across conditions, was higher in the older than the young adults (older = .042, young divided attention = .018, young full attention = .006, Tukey's HSD $p < .004$ for both tests), and higher on the Broad test than the Hard test (Broad = .031, Easy = .024, Hard = .011, alpha adjusted to .025, $F(1, 159) = 19.36, MSE = .07, p < .001$). Due to these differences, recollection estimates were corrected by subtracting false recollection from true recollection for each participant on each test. However, analyses of corrected recollection, reported next, resulted in the same conclusions as analyses of uncorrected recollection responses.

Corrected recollection estimates are presented in the top panel of Figure 1. As is evident in Figure 1, 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 ($F(4, 318) = 11.49, MSE = .02, p < .001, f = .19$). Specific contrasts showed that the average of the Broad and Easy conditions resulted in greater recollection than did the Hard condition ($F(1, 159) = 238.73, MSE = .14, p < .001$), and that the young divided attention and older groups had significantly lower recollection estimates than the young full attention group ($F(1, 159) = 50.42, MSE = .06, p < .001$). A post-hoc contrast showed that the difference between Broad and Easy conditions and the Hard condition was greater for the young 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 suggested that the Broad and Easy conditions were similar for the older and young divided attention groups, but that there may have been a difference between the two conditions for the young full attention group; however, this trend was only marginally reliable ($F(1, 159) = 3.30, MSE = .04, p = .071$).

Overall, these analyses demonstrated the expected effects: the difference between the Broad and Easy conditions and the Hard condition was greater for the young full attention group than for the other two groups. Importantly, the lack of a difference between the young divided attention and older groups indicates that the divided attention manipulation was successful in reducing the amount of information available about the criterial and noncriterial details, and therefore the proportionality hypothesis can be tested by examining the familiarity estimates. However, because there were no significant differences between the Broad and Easy conditions, contrasts testing the ncR effect in the familiarity estimates, below, focused on differences between the average of those two tests and the Hard test.

Familiarity—Because familiarity estimates for new words differed as a function of test condition ($F(2, 318) = 3.21, MSE = .008, p < .05, f = .04$), analyses of the estimates corrected for baseline (familiarity estimates for new items subtracted from estimates for old items) are reported, although the patterns were the same for analyses of uncorrected estimates. The raw

familiarity responses were also analyzed, and also produced the same results as those reported here for the familiarity estimates, with two exceptions, noted below.

Analyses of corrected familiarity estimates (bottom panel, Figure 1) revealed main effects of test condition ($F(2, 318) = 31.54, MSE = .03, p < .001, f = .29$), and age-attention group ($F(2, 159) = 24.24, MSE = .05, p < .001, f = .35$); however, the interaction between these factors was not significant ($F(4, 318) = 1.76, MSE = .03, p < .15$)³. Tukey's HSD tests on the age-attention effect showed that the familiarity estimates were higher for the young full attention group than for the other two groups (both p 's $< .001$).

The question of primary interest concerned whether the ncR effect was greater in the young full attention group than in the other two groups. A planned contrast, conducted to compare the size of the increase from the Broad and Easy to the Hard test across groups, supported the proportionality hypothesis. Specifically, the difference between the Broad and Easy conditions and the Hard condition was greater for the young full attention group than it was for the other two groups ($F(1, 159) = 6.353, MSE = .17, p < .02$). This critical finding was due to a true difference in the size of the ncR effect between the different groups, rather than to the absence of the ncR effect in the young divided attention and older adult groups: Analyses including only these two groups showed that familiarity estimates were approximately equivalent in the two groups ($F < 1$), but differed across tests ($F(1, 212) = 13.15, MSE = .03, p < .001, f = .22$; interaction $F < 1$), with greater familiarity estimates in the Hard than in the Broad and Easy conditions ($F(1, 106) = 25.68, MSE = .17, p < .001$).

In sum, ncR elevated familiarity estimates of all three participant groups in the Hard condition. However, the critical finding was that the ncR effect was significantly reduced in the young divided attention and older groups—an effect that mirrors the reduction of recollection in those groups and supports the proportionality hypothesis.

Discussion

The primary goal of Experiment 1 was to test the hypothesis that ncR is proportional to recollection of the noncriterial detail when it is specifically tested; if supported, older adults and young adults under divided attention would show the ncR effect, but to a lesser degree than young adults studying under full attention. Indeed, the familiarity estimates were clearly elevated by ncR in both the young divided attention and older groups, but in line with the proportionality hypothesis, the ncR effect was larger in the young full attention group. Given the lack of a difference between the Broad and Easy conditions, it is not possible to support the strongest version of that 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 aging or divided attention, also reduces the ncR elevation of familiarity. The reduction in the ncR effect can be traced to the fact that the young divided attention and older groups recollected less information in the Broad and Easy conditions than did the young full attention group. Therefore, there appears to be some degree of dependency between the two processes; the elevation of familiarity by ncR is, at least in part, reliant on the ability to recollect the noncriterial information when it is directly tested (i.e., when it is criterial).

The purpose of including both the Broad and Easy conditions was to include a more fine-grained manipulation of the difficulty of recollection than examined so far in ncR studies, and allow an evaluation of the ncR effect when recollection is defined in a relatively easy way. The fact that there was no reliable difference between the Broad and Easy tests indicates that when participants focus on a particular attribute at study (at least when they are given effective strategies), they are more likely to remember that attribute than anything else, as one might hope. Allowing participants to remember any detail in the Broad condition did not increase

recollection estimates, presumably because the detail(s) they remembered concerned Voice and/or the strategies they used to remember Voice. One possible exception was the trend towards greater recollection on the Broad than the Easy test for the young full attention group. Although only marginally reliable in the current study, there are likely to be conditions in which people study one detail and later remember others that would be captured in broadly, but not specifically, defined recollection estimates.

A final result of interest was the decrease in familiarity estimates for the young divided attention and older groups as compared to the young full attention group. Divided attention manipulations typically reduce familiarity, though to a much smaller extent than they reduce recollection, and thus the attention-related familiarity decrease found in the current study is consistent with past research (e.g., Gruppiso et al., 1997; Jacoby & Kelley, 1992; Gardiner & Parkin, 1990; Yonelinas, 2001; see Yonelinas, 2002 for a review). In contrast, familiarity estimates yielded by the PD procedure are typically invariant across age groups, although recent research has suggested that there may be small familiarity deficits in older adults (e.g., Light, et al., 2000; Prull et al., 2006). Although consistent with those recent findings, some caution is warranted before concluding that the age-related familiarity differences in the current experiment reflect a true familiarity deficit in the older adults. That is, the familiarity differences between the age-attention groups were relatively small in the Broad and Easy conditions and larger in the Hard condition. Indeed, a comparison of the top and bottom panels of Figure 1 suggests that the age-attention effect on recollection in the Broad and Easy conditions was forced into the familiarity estimates in the Hard condition, where ncR was inflating the estimates. In fact, follow-up tests showed that the differences in familiarity estimates in the Broad condition were actually driven by differences between young adults in the two attention conditions ($p < .004$), with the difference between the older and young full attention groups being unreliable by post-hoc standards and only marginally reliable by typical standards ($p = .062$). This apparent shift of age-attention effects between recollection and familiarity estimates renders the age- and attention-related reduction in familiarity somewhat suspect. Specifically, the age-related differences in familiarity seem likely to have been due to ncR. However, it may still be the case that the elevation of familiarity estimates by ncR reflects true increases in the subjective experience (and effectiveness) of familiarity, and thus that the age-related differences reflect real differences in familiarity. That is, it could be argued that the ncR effect should not be the same size across groups because sub-optimal encoding of the noncritical detail in the young divided attention and older groups would lead to decreased experiences of familiarity for the items. Experiment 2 addressed this issue.

Experiment 2

Experiment 2 had three main purposes: to test the findings of Experiment 1 using a different model and method of generating process estimates, to test whether ncR is functionally equivalent to familiarity, and to test whether ncR increases the subjective experience of familiarity. To these ends, the dual process signal detection (DPSD) model (Yonelinas, 1994) was used to estimate recollection and familiarity, the functional equivalence of ncR to familiarity was examined using receiver operating characteristic analyses, and the distributions of responses across confidence ratings were plotted to assess the question of subjective experience. To accommodate the methods necessary to use the DPSD model, the attention manipulation and the Easy test were eliminated, the Broad and Hard test conditions were manipulated between-subjects, and the response options were changed to include a six-point confidence scale and a *Recollect* response.

Recollection and familiarity estimates are generated with the DPSD model by fitting receiver operating characteristics (ROCs) constructed from confidence ratings (for a complete description of the model see, e.g., Yonelinas, 1994, 2001). ROCs are created by cumulatively

plotting recognition performance (hits versus false alarms) as a function of confidence levels (i.e., criterion), such that the left-most point on the curve includes only the most confident hits and false alarms, 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 (see Figure 2). The DPSD model uses a modified form of the equations of the PD model that incorporates response criteria to produce estimates of recollection (in probabilities) and familiarity (in terms of d') by fitting the model's parameters to the ROC data for each subject.

The Broad and Hard tests were defined in the same way as in Experiment 1: recollection on the Broad test was defined as the ability to remember any specific detail of a word's prior presentation and recollection on the Hard test was defined as memory of Location. If participants could recollect according to the given definition, they chose the *Recollect* response, but if not, they rated their confidence in recognizing the word on a six-point scale. Thus, there were a total of seven response options: Sure New 1 2 3 4 5 6 Sure Old Recollect, with "Sure New" and "Sure Old" describing the 1 and 6 responses, respectively.

To address the question of whether ncR increases the subjective experience of familiarity, response distributions were plotted for the two test conditions for the young and older groups. If ncR increases the subjective experience of familiarity, then it should be the case that the non-recollect old responses (responses 4, 5, and 6) should increase in the Hard, relative to the Broad, condition. That is, an increase in the subjective experience of familiarity should affect at least the accurate non-recollect old responses. Alternatively, the ncR effect may be due to a simple shift in responses created by task demands, such that those items that are recollected by the Broad definition are forced into another category by the Hard definition (e.g., the 6, Sure Old, response). If this occurs, then there should be an obvious shift between many *Recollect* responses in the Broad condition to many 6 responses in the Hard condition, with few other changes.

A quantitative evaluation of these patterns involves comparing process estimates generated from the response distributions in two ways. In the first method (the *full scale* in *Results*), the *Recollect* response was treated as the highest level of confidence and the process estimates were expected to replicate the findings of Experiment 1—greater ncR for young compared to older adults. In the second method (the *truncated scale* in *Results*), the *Recollect* response was collapsed together with the 6 responses. The ncR effect should be found in familiarity estimates generated from this truncated scale if there was an increase in all the accurate non-recollect old responses in the Hard condition. Alternatively, if the effect of the Hard test is simply to shift responses, without affecting overall levels of recollection and familiarity, then collapsing the *Recollect* and 6 responses would create response distributions that look very similar in the two test conditions, and therefore no ncR effect should be found in the process estimates.

Evaluating process estimates and response distributions addresses the question of subjective experience, but does not directly address the question of whether ncR operates in the same way as familiarity or as recollection—to do this, the ROCs were examined. Recognition ROCs are usually curvilinear functions that are almost always asymmetrical, and the direction of that asymmetry (the ROC appears pushed up on the left side, as in Figure 2) indicates that the memory strength of old items varies more than that of the new items. The DPSD model explains the increased variance of old items by assuming that recognition performance involves two processes—recollection, a probabilistic process, and familiarity, an equal-variance signal detection process (Yonelinas, 1994, 2001). The model predicts that familiarity by itself will produce symmetrical ROCs and that it is recollection, which leads to high-confidence responses relative to familiarity, that increases the variance of the old items and makes the ROCs asymmetrical. Therefore, recollection is related to ROC asymmetry in the DPSD model, and it predicts that conditions and groups that differ in recollection will also differ in

asymmetry, with greater levels of recollection resulting in greater degrees of asymmetry (depending on the contribution of familiarity). Thus, assessing the symmetry of the recognition ROCs provides a means of testing whether ncR is functionally equivalent to familiarity. To the extent that overall recollection is the same in the Broad and Hard test conditions, asymmetry of the ROCs should be approximately equal, given that participants study the same materials with the same mnemonics. However, if the processing characteristics of ncR are similar to familiarity—for example, if it is well-described by an equal-variance signal detection model—then asymmetry should differ between conditions, with less asymmetry in the Hard condition where criterial recollection would be low and ncR would be relatively high.

Method

Participants—One hundred sixty-five participants were tested in total, with data from 72 young adults (mean age = 20.0, SD = 1.4) and from 72 older adults (mean age = 70.6, SD = 4.6) submitted to the primary analyses. Data from one young and eight older adults were excluded due to high false alarms; however, analyses including data from participants with high baselines showed the same effects as those presented below⁴. Data from 12 older adults were excluded due to below-criterion performance on the manipulation check.

As expected, older adults completed approximately one more year of education than had the young adults (young mean = 14.0, SD = 1.5; old mean = 15.3, SD = 2.4, $t(116.41) = -3.71$, $p < .001$, $d = .61$), and out-performed young adults on the Shipley Vocabulary test (young mean = 31.1, SD = 2.8; old mean = 34.7, SD = 3.2; $t(142) = -7.14$, $p < .001$, $d = 1.18$).

Design and Materials—Experiment 2 was designed as a 2 (age group) $\times$ 2 (test condition) factorial with test condition as a between-subjects factor.

Because many trials are required to obtain reliable estimates for 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. A single block consisted of 80 study words, followed by a test of those and an additional 40 new words. For study items, half the words were presented in a male voice and half in a female voice. Also, half of the words in each voice were presented to the right ear, and half to the left ear. Items were rotated through the experimental conditions (Voice, Location, and Block) for each age and test condition group, such that each word appeared in each condition equally often. Item order at study and test was randomized for each participant, with the exception of three primacy and three recency buffers for each study phase.

Procedure

Study: Words were presented over headphones in a male or female voice 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. To ensure use of the mnemonics, participants were (misleadingly) told that the purpose of the experiment was to examine the effects of a type of mnemonic on memory, and that it was therefore very important that they use one of two possible strategies (the same as those used in Experiment 1). Words were presented at a 3.5-s rate with a 1-s ISI and the computer displayed a black screen during study.

Instructions for the second study session emphasized the necessity of participants' compliance with the instructions. That is, given that Voice was not directly tested in either condition, participants were told that despite the temptation to ignore Voice (and in the Hard condition,

⁴The one young adult was excluded from the Hard condition. Six of the excluded older adults were from the Hard condition, and two were from the Broad condition.

to study Location), it was essential that they continue to use the strategies for remembering Voice that they used before, and that if they did not, their data would be unusable. This instructional strategy was effective; no participants' data indicated that they ignored Voice and studied other attributes, which was particularly important in the Hard condition.

Test: After each study phase, participants were administered a visual recognition test presented on a computer screen. For both the Broad 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. As in Experiment 1, Recollect in the Broad condition was defined as memory of any episodic detail of the word's presentation during study, including, but not limited to, who said the word or the ear to which a word was presented. In the Hard condition, Recollect was defined as a memory of the ear to which the word was presented. If unable to recollect according to the definition, participants used the six-point scale to rate their confidence that the word had been studied or not. These response options were presented at the bottom of the screen throughout the test, with the Recollect option presented at the right end of the 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 eight was color-coded as the Recollect response. The tests were self-paced and the two study-test blocks typically took young adults 45 minutes to complete, and took older adults 50-60 minutes.

Following the last test, a manipulation check was conducted. This task was the same as that used in Experiment 1, but with words of frequencies approximately equal to those used in the current experiment. Finally, the Shipley vocabulary test was administered before participants were debriefed.

Results

Analyses are presented in two sections below. The first section, *Response Distributions and DPSD Estimates*, addresses the subjective experience of familiarity by examining response distributions and two ways of generating process estimates. The second section, *ROC Asymmetry* addresses the issue of whether ncR operates in a manner similar to familiarity through comparisons of ROC asymmetry.

Response Distributions and DPSD Estimates—The response distributions, presented in Figure 3, show that the only obvious difference between the test conditions was a shift from the *Recollect* response in the Broad condition to the 6 response in the Hard condition. That is, the distributions for the two tests look very similar within each age group, except for these responses. There are more *Recollect* responses than any other response in the Broad condition, but more 6 responses than any other in the Hard condition. The rest of the responses appear quite similar across test conditions. Clearly then, the effect of the Hard definition was to prevent subjects from responding *Recollect* when they otherwise would have (i.e., on the basis of the Broad definition). Thus, the patterns suggest that subjective experiences of familiarity were similar for participants in the two test conditions.

To quantify the patterns evident in the response distributions, process estimates were generated in two ways. To do this, ROCs were constructed for each participant and the DPSD model was fit to those data by minimizing sums of squared error using the solver program in Excel. Fitting the model to the ROC data is what generates estimates of recollection and familiarity (d'), and this was done in two ways for each participant. The first and most intuitive method was to fit the model to all the ROC points represented in Figure 2. This *full scale* method was expected to replicate the findings of Experiment 1 (an ncR effect for both groups, but larger for young adults). The second method, hereafter the *truncated scale*, was to exclude the far left

Recollect point of the ROC, and fit only the remaining points. Because these ROC data are cumulative, the *Recollect* responses are still included, but are summed with the $\underline{6}$ responses (e.g., the “R + 6” point on the ROC in Figure 2) and thus are simply not fit as a separate point. If the effect of the Hard condition is to change the experience of recollection and familiarity relative to the Easy condition, then the ncR effect should be found regardless of which scale is used to generate process estimates. That is, the exact values will differ but the ncR pattern should remain the same—greater familiarity estimates in the Hard compared to the Broad condition. If, however, the effect of the Hard condition was to shift what would have been a *Recollect* response with the Broad definition to a $\underline{6}$ response, without affecting overall levels of recollection and familiarity, then collapsing the two points that are creating the ncR effect should effectively eliminate it. Thus, if recollection and familiarity are essentially the same for the two tests, there should be no ncR effect found with the truncated scale estimates.

Indeed, the process estimates generated by the two scales, presented in Table 2, support the conclusions drawn on the basis of the response distributions. The fit of the model to the average ROC in each condition is presented in Figure 4. Analyses of the estimates generated from the full scale replicated the findings of Experiment 1. Recollection estimates were greater for young than older adults ($F(1, 140) = 5.42$, $MSE = .04$, $p < .03$, 95% $CI_{\text{Difference}}: .011 - .086$, $f = .13$), and higher on the Broad than the Hard test ($F(1, 140) = 122.37$, $MSE = .04$, $p < .001$, 95% $CI_{\text{Difference}}: .286 - .411$, $f = .88$), although the difference between the test conditions was larger for young than older adults ($F(1, 140) = 11.06$, $MSE = .04$, $p < .002$, $f = .19$). Familiarity (d') estimates were also greater for the young adults ($F(1, 140) = 12.11$, $MSE = .44$, $p < .002$, 95% $CI_{\text{Difference}}: .166 - .603$, $f = .26$), but more importantly, the ncR effect was evident in the familiarity estimates of both groups (main effect of test: $F(1, 140) = 18.72$, $MSE = .44$, $p < .001$, 95% $CI_{\text{Difference}}: .260 - .697$, $f = .33$; older adults only: $t(70) = -1.76$, $p < .05$, 95% $CI_{\text{Difference}}: -.549 - .034$, $d = .41$), although larger for the young than the older group ($F(1, 140) = 3.99$, $MSE = .44$, $p < .05$, $f = .13$). Thus, the full scale produced the ncR effect and, as found in Experiment 1, that effect was larger for young than for older adults⁵.

In contrast, the estimates generated from the truncated scale did not show the ncR effect. Specifically, both recollection and familiarity (d') estimates differed only as a function of age-group, favoring young adults in both cases (recollection: $F(1, 140) = 16.198$, $MSE = .05$, $p < .001$, 95% $CI_{\text{Difference}}: .076 - .224$, $f = .33$; familiarity: $F(1, 140) = 4.921$, $MSE = .340$, $p < .03$, $f = .17$). Thus, recollection and familiarity were approximately equal in the different test conditions and there was no ncR effect. As suggested by the response distributions, this pattern of results across the two scales indicates that the effect of the Hard test condition was to force what would have been a *Recollect* response in the Broad condition to a $\underline{6}$ response in the Hard condition, without affecting the overall levels of recollection and familiarity. Thus, recollection of noncritical details certainly seems to have occurred in the Hard condition, but the recollection of those irrelevant details did not appear to change the levels of recollection or familiarity relative to the Broad condition.

ROC Asymmetry—ROC asymmetry was assessed to determine whether ncR was functionally equivalent to familiarity. ROC asymmetry is evaluated by plotting the ROC in z-space, thus creating a zROC. The degree of asymmetry of the probability-space ROC is

⁵The RK data implicit in this experiment also replicate Experiment 1. The difference between recollection responses in the Broad and Hard conditions was greater for young than older adults ($F(1, 140) = 8.19$, $MSE = .032$, $p < .01$, $f = .15$). Response options “unsure old” through “sure old” were for summed to create a “Familiar” response, and then corrected for the false alarm rate. These Familiar responses were greater in the Hard than the Broad condition ($F(1, 140) = 138.62$, $MSE = .035$, $p < .001$, $f = .94$), but this difference was greater for the young than older adults ($F(1, 140) = 15.99$, $MSE = .035$, $p < .001$). IRK familiarity estimates were greater for young than older adults ($F(1, 140) = 7.95$, $MSE = .029$, $p < .01$, $f = .21$) and larger in the Hard than the Broad test ($F(1, 140) = 17.95$, $MSE = .029$, $p < .001$, $f = .33$). The interaction between age and test was not significant unless participants with high baselines were included in the analysis ($F(1, 148) = 4.44$, $MSE = .034$, $p < .04$, $f = .14$).

reflected by the slope of the zROC, such that perfectly symmetrical ROCs have a 1.0 slope in z-space, and asymmetrical ROCs have zROC slopes that are different than 1.0 (less than 1.0 for recognition memory). Based on the DPSD model, ROCs were expected to be more asymmetrical for young than older adults (i.e., young adults' z-slopes should be lower than the older adults' z-slopes), indicating a greater contribution of recollection to recognition performance. With respect to test condition, zROC slopes should differ if recollection differs in the two conditions. Thus, if ncR is functionally equivalent to familiarity, z-slopes should be greater in the Hard condition where it is occurring. Alternatively, if ncR operates in the same way as criterial recollection, then z-slopes should be about the same in the two test conditions.

Standard linear regressions were conducted to obtain slope and intercept estimates for each participant. Although analyses were done at the participant level, average zROCs are presented for each age group and test condition in Figure 5 (depicting both the full and truncated zROCs) and average slopes, intercepts, and R^2 s are presented in Table 3 for both the full and truncated scales. For several participants the ROCs included points not defined in z-space (i.e., 1.00 and .00); those undefined data points were not included in the regression analyses and zROCs with less than three points were excluded from analysis. Some participants' zROCs were curvilinear, and therefore slopes were analyzed only when standard linear regression accounted for 90% or more of the variance of the zROC. Analyses conducted with data from all participants with more than two defined zROC points led to the same conclusions as those found for this more conservative analysis.

As can be seen in Figure 5, the average zROCs were curved down for all but the young broad group, which is representative of the subject-level data. This bend reflects floor effects, primarily on false alarms with the recollect response, but also on accurate recollection (in the Hard condition), as well as on high-confidence old responses in some cases. Although such floor effects indicate that participants understood the definitions of recollection and were accurate (and/or cautious) in using that response, it is questionable whether inferential analysis of the slopes would be meaningful given the non-linearity of the functions. Therefore, analyses of the full-scale slopes are not reported.

However, the zROCs can also be examined without the recollect response represented separately. Note that because they are cumulative across confidence levels, the only difference between the z-ROCs generated from the full and truncated scales is the left-most point (the *Recollect* response). Thus, the truncated-scale zROCs are just the full-scale zROCs without the *Recollect* response, and these were more linear and appropriate for analysis. Only the main effect of age group was reliable for the truncated-scale slopes ($F(1, 126) = 7.53$, $MSE = .027$, $p < .008$, 95% $CI_{\text{Difference}}: .012 - .125$, $f = .22$), with lower slopes for young than for older adults, indicating greater asymmetry for the young adults, as expected. Thus, in contrast to the estimates derived from the full scale, but in line with those derived from the truncated scale (which showed no ncR effect), the zROCs suggest that recollection contributed to performance equally in the two test conditions, and recollection was greater for young than for older adults.

Discussion

The purpose of Experiment 2 was to test the proportionality hypothesis using the DPSD model to generate process estimates, test whether ncR is functionally equivalent to familiarity by evaluating the asymmetry of the ROCs, and to test whether ncR increases the subjective experience of familiarity by examining response distributions and different ways of generating process estimates. There was clear evidence that ncR elevated familiarity estimates when the *Recollect* response was treated as the highest level of confidence (full scale), and in line with the proportionality hypothesis, the influence of ncR was present for both age groups, but greater for the young adults.

In contrast, recollection and familiarity estimates generated from the truncated scale showed only age-related effects—there was no ncR effect. The asymmetry analysis of the ROCs revealed the same pattern—slopes differed only between the age groups, indicating no ncR effect. Overall then, these analyses show that recollection-based recognition was the same in the two test conditions, but that the estimates generated from the full scale captured different aspects of performance than did the truncated-scale estimates and slopes. Specifically, differences in response patterns across the test conditions—evident in the distributions in Figure 3—produced different levels of recollection and familiarity estimates generated from the two scales. However, the primary difference was between the *Recollect* and *6* responses, presumably because the recollected information supported a *Recollect* response with the Broad definition, but not with the Hard definition. When those responses were collapsed in the truncated scale, the estimates indicated that recollection was the same in the two test conditions and differed only between the age groups. In sum, the data demonstrate that ncR behaves like criterial recollection and does not seem to influence the experience or usefulness of familiarity for the item.

The age-related decrease in familiarity estimates found in Experiment 1 was also replicated, again suggesting a small age-related decline in familiarity-based performance in older adults. For the full-scale estimates, the age-related familiarity differences were greater in the Hard than the Broad condition, indicating that the difference may be due to ncR rather than true differences in familiarity. In contrast, the age-related difference was approximately the same size in the two test conditions with the truncated-scale familiarity estimates. The fact that the size of the decrease did not differ in the Broad and Hard conditions with the truncated scale estimates would seem to argue against the possibility that the age-related familiarity deficit could be attributed to ncR alone, but it is difficult to rule that possibility out entirely.

General Discussion

The primary aim of these experiments was to examine ncR in young and older adults as a means of determining when ncR should and should not be expected to contribute to familiarity estimates, to assess whether ncR is functionally equivalent to familiarity, and whether ncR increases the subjective experience of familiarity. The results demonstrate that (a) ncR occurs when recollection is operationally defined as a specific detail that is difficult to remember, (b) the size of the ncR effect is related to the level of recollection of the noncriterial attribute when it is directly tested, and that (c) ncR does not appear to be functionally equivalent to familiarity nor increase the subjective experience of familiarity.

ncR and Criterial Recollection

Yonelinas and Jacoby (1996) found that a speeded response manipulation, which successfully undermined criterial recollection, failed to reduce the ncR effect. Toth and Parks (2006) followed up on that finding by testing young and older adults to determine whether ncR would be preserved (given that familiarity typically is) or reduced in older adults (given that memory of episodic detail is impaired in older adults). They found no significant evidence of ncR in older adults and argued that the reason was due to low levels of (potential) recollection of the noncriterial detail. More generally, they suggested that there is a proportional relationship between the ncR effect on familiarity estimates and recollection of the noncriterial detail (when directly tested). The results of both experiments, but particularly Experiment 1, support this proportionality hypothesis. The divided attention manipulation in Experiment 1 was chosen specifically to reduce the likelihood of young adults encoding study words and thus reduce the availability of the noncriterial information, thereby undermining recollection, as well as other potential indirect influences. Thus, the parallels seen between the young divided attention and older groups in Experiment 1 indicate that the size of the ncR effect on familiarity estimates

is related to the overall level of (potential) recollection of the noncriterial information. In fact, both experiments show that groups with lower levels of recollection of the noncriterial information (as demonstrated in the Broad and Easy conditions) have smaller ncR elevations of their familiarity estimates than do groups with better recollection of the noncriterial information. Thus, as might be expected, one major precondition for observing the ncR effect is some requisite level of recollection for the noncriterial information. Exactly what level of recollection of noncriterial information is necessary to produce the ncR effect on familiarity estimates remains an open question, although Toth and Parks' study indicates that recollection estimates of .15 or less are likely to be too low to produce a significant ncR effect.

Support of the proportionality hypothesis—that is, the reduction of the ncR effect by age and divided attention—indicates that ncR is not functionally equivalent to familiarity. Rather, the data suggest that ncR operates in the same way as criterial recollection, and differs only with respect to the relevance of its content to the test decision. Not only did age and divided attention affect ncR in the same way they affected criterial recollection, but the ROCs in Experiment 2 were very similar across test conditions. In fact, the zROC slopes differed only between age groups, indicating that recollection-based recognition did not differ between the test conditions.

Furthermore, the experience of ncR in the Hard condition did not appear to affect the subjective experience, or the usefulness, of familiarity. Response distributions in Experiment 2 showed that the ncR effect (found with the full scale estimates) was due to a shift between the *Recollect* and *6* responses across test conditions, suggesting that memories classified as *Recollect* under the Broad condition were simply forced into the *6* category by the Hard definition. This was further confirmed by the fact that there was no ncR effect on the familiarity estimates generated with the truncated scale. Therefore, unless it somehow affected only the highest-confidence experiences of familiarity, ncR did not appear to influence the subjective experience of familiarity in the current study. Of course, this does not mean that ncR has no effect on subjective experience at all. Indeed, it seems likely that recollection of one detail of an event could increase, for instance, feelings-of-knowing for other details about the event when recollection of those details fails. In fact, an increase in feelings-of-knowing may best describe the student's subjective experience when remembering where on the page the answer is, but not the test answer itself. However, the ncR effect examined here did not affect either the experience or the effectiveness of familiarity in discriminating old from new items.

Measurement Implications

Overall, the results seem to fall in line with those of Mulligan and Hirshman (1997), who argued that ncR can cause familiarity to be overestimated and recollection to be underestimated in the PD procedure. However, there is an alternative explanation to consider: that the observed ncR effects were actually due to systematic misclassifications of strong experiences of familiarity as recollection. That is, if people occasionally mistake strong familiarity as a recollective experience due to misunderstanding or forgetting the instructions and this probability varied across conditions and/or groups, it could be the case that the ncR effects were due to recollection estimates that were contaminated by strong familiarity more in some conditions than in others. Note that this is a contamination account, but one which attributes the cause of the ncR effect to people's tendency to want to report strong familiarity as recollection, as opposed to the way recollection is defined. In order for this explanation to account for the ncR pattern, it would have to be the case that this mistake was more likely on the Broad and Easy tests, such that familiarity would be lower on the Broad and Easy tests and higher on the Hard. This, of course, is the ncR pattern that was observed in both experiments. The same pattern should be found for familiarity for new words too, but in fact, new-item familiarity was higher in the Broad and Easy conditions than in the Hard condition in Experiment 1 and did not significantly differ across conditions in Experiment 2, contrary to the ncR pattern. The false recollection patterns

could be argued to support the misclassification account, with greater false recollection in the Broad/Easy condition(s) than in the Hard condition in both experiments, but the magnitude of false recollection fell far short of the magnitude of the ncR effects (false recollection fell below 5% in all conditions and groups, ncR effects ranged from 10-20%). Finally, it would also have to be the case that older age and divided attention made it *less* likely to mistake strong familiarity for recollection, given that the ncR effect was smaller in the older adult and divided-attention groups. This seems somewhat counterintuitive, but if true, it should be evident in the false familiarity patterns: there should be higher new-item familiarity in the Hard condition and the difference should be greater for young than older adults. However, there were no significant differences in new-item familiarity across age/attention groups in Experiment 1, in contrast to the ncR pattern. In Experiment 2, new-item familiarity did show a significant age by test condition interaction⁶: there was a negligible difference between new-item familiarity in the two test conditions for young adults, but older adults' new-item familiarity was greater in the Hard than in the Broad condition. This pattern of age-related differences contradicts the misclassification explanation. Overall then, it is unlikely that a systematic misclassification of strong familiarity as recollection can account for the observed ncR effects.

Thus, it seems that the data support Mulligan and Hirshman's (1997) argument that ncR can cause familiarity to be overestimated and recollection to be underestimated in the PD procedure, but there are two important caveats to that conclusion. First, the present experiments demonstrate that to the extent that ncR is a threat to process estimates, it is not specific to the PD procedure—it is the result of defining recollection as memory for a specific detail that is hard to remember. Thus, some caution is warranted in using such definitions in the PD and RK methods. As for the DPSD model, the fact that the truncated scale estimates showed no effects of ncR on familiarity suggests that it may be somewhat more immune to this potential problem, but since the traditional confidence scale used in ROC studies does not include a separate *Recollect* option, there is less potential for ncR to occur with this method anyway.

Second, there was no evidence that recollection was underestimated in these experiments, at least not according to the definitions that were used. If one aims to measure recollection in the broad sense, a specific definition like that used in the Hard condition would be an unlikely choice. When specific definitions of recollection are used, it is typically because it is recollection of that particular detail that is of interest. And of course, a failure to capture other recollected details in the recollection estimate in such a case would not qualify as underestimation.

The fact remains, though, that the results suggest some caution in using specific definitions of recollection, and yet there is a clear need to do just that. Normal day-to-day memory queries most often are specific questions (Toth, 2005), and it seems relatively rare that they can be adequately answered by remembering *any* detail (“What was the talk about?” “I don’t know, but the room was cold.”). It is plainly important to quantify recollection and familiarity in conditions similar to those faced in daily life—that is, in cases where memory for a specific detail of a past event is required. And in fact, the results indicate that orienting tasks that focus attention on the dimension of interest can be used to reduce the likelihood of ncR. Experiment 1 showed that when participants focus closely on a particular attribute, that tends to be the attribute they recollect, regardless of the definition of recollection (but see Marsh, Hicks, & Cook, 2004). The similarity between the Broad and Easy conditions demonstrates that specific definitions of recollection will not invariably produce ncR, and that it is unlikely to have a significant impact on familiarity estimates when participants focus on the detail that defines recollection. Of course, excluding specific and difficult operational definitions of recollection

⁶The interaction was found for both the raw familiarity responses to new-items extracted from the confidence scale ($F(1, 140) = 5.98$, $MSE = .013$, $p < .02$) and for IRK familiarity estimates for new words ($F(1, 140) = 6.02$, $MSE = .013$, $p < .02$).

does place a constraint on experimental designs, and it may not always be possible to anticipate whether the conditions of interest will produce ncR or not. Therefore, it will be useful for future work to examine ways of estimating recollection and familiarity when recollection is specifically defined that either avoid ncR or include a way to measure it (e.g., Mulligan & Hirshman, 1997).

Familiarity and aging

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., 2006). The current studies demonstrated familiarity deficits both as a function of age group and attention, but given the topic under investigation, it's appropriate to question whether the deficits observed here reflect differences in recollection (or ncR) rather than differences in familiarity. The patterns in Experiment 1, in which the relationship between ncR effects and familiarity differences is most evident (see Figure 1), reveal very small differences in familiarity in the Broad condition and larger ones in the Hard condition. In fact, it appears as though age and attention effects switched from the recollection estimates when recollection was defined most inclusively to the familiarity estimates when recollection was defined as something specific and difficult to remember. Age-related differences in familiarity were also found in Experiment 2. The fact that the difference persisted even when the ncR effect disappeared (i.e., with the truncated scale) suggests that the differences were real and not necessarily artifacts of the ncR effect, but it is impossible to rule that possibility out completely. Thus, the current results support other recent findings of a slight deficit in familiarity in older age groups, but they also demonstrate that memory differences between age groups may be shifted from one process estimate to another depending on how recollection and familiarity are operationally defined.

Conclusions

In sum, the current findings show that ncR elevates familiarity estimates when the operational definition of recollection is both specific and difficult, and, critically, that it operates in the same way as criterial recollection. Additionally, ncR can change the pattern of age and attention effects on process estimates such that differences can appear in recollection or familiarity estimates depending on how recollection is defined. Although ncR and other types of partial recollection may represent a methodological and measurement challenge in some cases, they are also fairly common experiences, and the encoding and retrieval processes and contexts that give rise to them are theoretically interesting in and of themselves. For instance, the data thus far indicate that ncR arises (and affects familiarity estimates) when the criterial detail is poorly encoded but irrelevant ones are well encoded—however, these are unlikely to be the only conditions under which ncR will occur. Further, the experience of ncR and other types of partial recollection (e.g., Dodson, Holland, & Shimamura, 1998) may influence metacognitive strategies or factors like retrieval orientation (e.g., Rugg, Allen, & Birch, 2000), the generation of retrieval cues, as well as simply the amount of time allotted to the attempt to recollect the criterial detail. Limiting operational definitions of recollection only to the most inclusive would be unduly restrictive and would fail to capture experiences that we face on a daily basis—namely, the need to remember a specific detail of a past event. Rather, investigation of specific recollection—and related processes, such as ncR and partial source memory—will be important in developing a more complete picture of recollection and familiarity as they occur outside the laboratory.

Acknowledgements

Thanks to Jeff Toth, Andy Yonelinas, Andy Smith, Christopher Hertzog, Randy Engle, and Paul Corballis for helpful suggestions and comments on this research. This paper is based on the author's dissertation research conducted at the Georgia Institute of Technology, and was supported in part by a predoctoral traineeship from the National Institute of Aging (T32 AG0175). Parts of this research were presented at the 45th annual meeting of the Psychonomic Society, Minneapolis, MN, November 2005.

References

- Cohen, J. Statistical power analysis for the behavioral sciences. Second Edition. Hillsdale, NJ: Lawrence Earlbaum Associates; 1988.
- Craik, FIM. Selective changes in encoding as a function of reduced process capacity. In: Klix, F.; Hoffman, J.; van der Meer, E., editors. Cognitive research in psychology. Berlin, Germany: Deutscher Verlag der Wissenschaften; 1982. p. 152-161.
- Dodd DH, Schultz Roger F Jr. Computational procedures for estimating magnitude of effect for some analysis of variance designs. *Psychological Bulletin* 1973;79:391-395.
- Dodson CS, Holland PW, Shimamura AP. On the recollection of specific- and partial-source information. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 1998;24:1121-1136.
- Gardiner JM. Functional aspects of recollective experience. *Memory & Cognition* 1988;16:309-313.
- Gardiner JM, Parkin AJ. Attention and recollective experience in recognition memory. *Memory & Cognition* 1990;18:549-583.
- Gardiner JM, Ramponi C, Richardson-Klavehn A. Experiences of remembering, knowing, and guessing. *Consciousness and Cognition* 1998;7:1-26. [PubMed: 9521829]
- Gardiner, JM.; Richardson-Klavehn, A. Remembering and knowing. In: Tulving, E.; Craik, FIM., editors. *The Oxford handbook of memory*. London: Oxford University Press; 2000. p. 229-244.
- Gruppuso V, Lindsay DS, Kelley CM. The process-dissociation procedure and similarity: Defining and estimating recollection and familiarity in recognition memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 1997;23:259-278.
- Jacoby LL. A Process Dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language* 1991;30:513-541.
- Jacoby LL. Dissociating automatic and consciously controlled effects of study/test compatibility. *Journal of Memory and Language* 1996;35:32-52.
- Jacoby LL. Invariance in automatic influences of memory: Toward a user's guide for the processes dissociation procedure. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 1998;24:3-26.
- Jacoby LL. Ironic effects of repetition: Measuring age-related differences in memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 1999;25:3-22.
- Jacoby, LL.; Kelley, CM. Unconscious influences of memory: Dissociations and automaticity. In: Milner, EAD.; Rugg, EMD., editors. *The Neuropsychology of consciousness*. San Diego, CA: Academic Press; 1992. p. 201-233.
- Jacoby, LL.; Yonelinas, AP.; Jennings, JM. The relation between conscious and unconscious (automatic) influences: A declaration of independence. In: Cohen, JD.; Schooler, JW., editors. *Scientific Approaches to Consciousness*. Mahwah, New Jersey: Lawrence Earlbaum Associates; 1997. p. 13-47.
- Java RI. Effects of age on state of awareness following implicit and explicit word association tasks. *Psychology and Aging* 1996;7:108-111. [PubMed: 8726376]
- Jennings JM, Jacoby LL. Automatic versus intentional uses of memory: Aging, attention, and control. *Psychology and Aging* 1993;8:283-293. [PubMed: 8323731]
- Jennings JM, Jacoby LL. An opposition procedure for detecting age-related deficits in recollection: Telling effects of repetition. *Psychology and Aging* 1997;12:352-361. [PubMed: 9189995]
- Kucera, H.; Francis, WN. *Computational analysis of present-day American English*. Providence, RI: Brown University Press; 1967.

- Light LL, Prull MW, La Voie DJ, Healy MR. Dual-process theories of memory in old age. In: Perfect TJ, Maylor EA, editors. *Models of cognitive aging Debates in psychology*. London: Oxford University Press; 2000. p. 238-300.
- Light LL, Singh A. Implicit and explicit memory in young and older adult. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 1987;13:531-541.
- Marsh RL, Hicks JL, Cook GI. Focused attention on one contextual attribute does not reduce source memory for a different attribute. *Memory* 2004;12:183-192. [PubMed: 15250183]
- Mulligan NW, Hirshman E. Measuring the bases of recognition memory: An investigation of the process-dissociation framework. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 1997;23:280-304.
- Park DC, Cherry KE, Smith AD, Lafronza VN. Effects of distinctive context on memory for objects and their locations in young and elderly adults. *Psychology and Aging* 1990;5:250-255. [PubMed: 2378690]
- Parkin AJ, Walter B. Recollective experience, normal aging, and frontal dysfunction. *Psychology and Aging* 1992;7:290-298. [PubMed: 1610518]
- Prull MW, Dawes LLC, Martin AM III, Rosenberg HF, Light LL. Recollection and familiarity in recognition memory: Adult age differences and neuropsychological test correlates. *Psychology and Aging* 2006;21:107-118. [PubMed: 16594796]
- Rugg MD, Allan K, Birch CS. Electrophysiological evidence for the modulation of retrieval orientation by depth of study processing. *Journal of Cognitive Neuroscience* 2000;12(4):664-678. [PubMed: 10936918]
- Shipley, WC. Shipley Institute of Living Scale. Los Angeles, CA: Western Psychological Services; 1985.
- Smith AD, Park DC, Earles JK, Shaw RJ, Whiting WL. Age differences in context integration in memory. *Psychology and Aging* 1998;13:21-28. [PubMed: 9533187]
- Toth JP. Subjective states of awareness in memory: A remarkable correspondence between recognition and cued-recall. 2005 Unpublished data and manuscript
- Toth JP, Parks CM. Effects of age on estimated familiarity in the process-dissociation procedure: The role of noncriterial recollection. *Memory & Cognition* 2006;34:527-537.
- Tulving E. Memory and consciousness. *Canadian Psychology* 1985;26:1-12.
- Yonelinas AP. Receiver-operating characteristics in recognition memory: Evidence for a dual-process model. *Journal of Experimental Psychology: Learning, Memory, & Cognition* 1994;20:1341-1354.
- Yonelinas AP. Consciousness, control, and confidence: The 3 Cs of recognition memory. *Journal of Experimental Psychology: General* 2001;130:361-379. [PubMed: 11561915]
- Yonelinas AP. The nature of recollection and familiarity: A review of 30 years of research. *Journal of Memory and Language* 2002;46:441-517.
- Yonelinas AP, Jacoby LL. The relation between remembering and knowing as bases for recognition: Effects of size congruency. *Journal of Memory and Language* 1995;34:622-643.
- Yonelinas AP, Jacoby LL. Noncriterial recollection: Familiarity as automatic, irrelevant recollection. *Consciousness and Cognition* 1996;5:131-141.

Figure 1.

Corrected Recollection and Familiarity estimates 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. Error bars represent standard error of the means.

Figure 2.

Example of a typical recognition ROC curve.

Note. R = the Recollect response, and the numbers represent confidence ratings with 6 being the most confident that an item is old.

Figure 3.
Response distributions as a function of age group and test condition.

Figure 4.
Fit of DPSD model to (full scale) recognition ROCs.
Note. Obs. = Observed.

Figure 5.

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

Note. The solid + dashed lines represent the full seven-point z-ROC. The solid lines alone represent the six-point z-ROC. The young adult Hard condition includes only 5 points because only one participant made a false alarm with the “Recollect” response.

Table 1
Experiment 1 response and estimate means as a function of item status (old or new), age-attention group, and test condition.

	Old Items				New Items			
	R	Corr. R	F	N	IRK F	Corr. F	R	F
YA-FA								
Broad	0.58	0.57	0.22	0.20	0.54	0.43	0.01	0.11
Easy	0.49	0.48	0.27	0.22	0.53	0.43	0.01	0.10
Hard	0.17	0.17	0.58	0.25	0.71	0.62	0.00	0.09
YA-DA								
Broad	0.31	0.28	0.30	0.39	0.46	0.30	0.03	0.16
Easy	0.27	0.25	0.32	0.41	0.44	0.29	0.01	0.15
Hard	0.10	0.09	0.46	0.44	0.52	0.39	0.01	0.12
OA								
Broad	0.39	0.33	0.28	0.33	0.46	0.33	0.06	0.12
Easy	0.35	0.31	0.29	0.36	0.44	0.30	0.05	0.13
Hard	0.19	0.17	0.46	0.35	0.55	0.42	0.02	0.13

Note: R = Recollect responses, F = Familiar responses, N = New responses, IRK F = Familiarity estimates, Corr. R = R responses to old items minus R responses to new items, and Corr. F = IRK F estimates for old items minus IRK F estimates for new items.

Table 2

Average recollection and d' estimated from the six- and seven-point scales with the DPSD model, and SSE for YA and OA as a function of test condition for Experiment 2.

	Recollection	d'	SSE	n
Full Scale Estimates				
Young Adults				
Broad	0.49	1.59	0.0016	36
Hard	0.03	2.29	0.0038	36
Older Adults				
Broad	0.31	1.43	0.0027	36
Hard	0.06	1.69	0.0038	36
Truncated Scale Estimates				
Young Adults				
Broad	0.59	1.24	0.0008	36
Hard	0.63	1.36	0.0009	36
Older Adults				
Broad	0.45	1.14	0.0012	36
Hard	0.47	1.03	0.0009	36

Table 3

Average slopes, intercepts, R^2 s and n 's of recognition z-ROCs generated from the six- and seven-point scales for Experiment 2.

	Slope	Intercept	R^2	n
Full Scale				
Young Adults				
Broad	0.59	1.65	0.97	33
Hard	0.55	1.66	0.98	32
Older Adults				
Broad	0.69	1.39	0.97	26
Hard	0.71	1.39	0.96	30
Truncated Scale				
Young Adults				
Broad	0.58	1.70	0.97	35
Hard	0.55	1.66	0.98	32
Older Adults				
Broad	0.63	1.39	0.98	30
Hard	0.66	1.38	0.97	33