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Metacognitive Monitoring and Dementia: How Intrinsic and Extrinsic Cues Influence Judgments of Learning in People with Alzheimer's disease

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Abstract

Objective—The present research compared metamemorial monitoring processes among younger adults, non-demented older adults, and older adults diagnosed with early stage Dementia of the Alzheimer's Type (DAT).

Method—In three experiments we examined the influence of intrinsic and extrinsic cues on Judgment of Learning (JOL) accuracy. Changes in association strength between cue-target word pairs served as our intrinsic manipulation in Experiments 1 and 2. Changes in encoding orientation served as our extrinsic manipulation in Experiment 3.

Results—Across all experiments we found that young adults, non-demented older adults, and individuals in the early stages of DAT effectively used intrinsic and extrinsic factors to guide JOL predictions.

Conclusions—We conclude that while certain aspects of metacognition may be impaired in both the normal and demented older populations, these groups remain able to use theory-based processing, or general knowledge about how memory works, to make metamemory monitoring predictions.

Metamemory refers to the higher order cognitive processes involved in memory function, and encapsulates beliefs, attitudes, sensations and knowledge about memory function (e.g., Flavell, 1979). In the context of the framework proposed by Nelson and Narens (1990), metamemory is defined as one's own knowledge and control of memory. Knowledge of memory is determined through a monitoring process that requires the learner to be self-aware. Control processes require the learner to regulate his own behaviors (Nelson, 1996). In this way, monitoring should directly influence control. That is, when a learner is aware that he has not effectively mastered some information, he can institute specific controlled processes to reduce the discrepancy between the initial state and the goal state of mastery (Dunlosky & Hertzog, 1998). As such, the accuracy of memory monitoring is crucial for effective control. The present research examined monitoring processes in non-demented older adults and older adults diagnosed with early stage Dementia of the Alzheimer's Type (DAT). Specifically, we examine how both normal and pathological cognitive aging affects the accuracy of Judgments of Learning (JOL).

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A JOL is a prediction of how likely some piece of information will be remembered in the future (Arbuckle & Cuddy, 1969). Typically, a JOL is made at the time of encoding, when individuals encounter new information. When presented with new information, such as a series of cue-target word pairs, participants are asked to make a prediction as to how likely they will be to remember each pair on a later test of memory. In this type of immediate JOL design, participants would first be presented with a cue-target word pair (e.g., dog-spoon), and immediately after study, they would make a JOL. Specifically, they would be asked to predict how likely they would be to recall the target when prompted with the cue. After study and predictions, participants would be given a cued recall test.

The goal of the present study was to investigate the conditions under which non-demented older adults and people with DAT demonstrate impaired and preserved prediction accuracy in an episodic JOL task. We hypothesized that people with DAT would be able to accurately monitoring memory performance when intrinsic properties of studied material served as an obvious and easily accessible cue. However, in conditions where intrinsic properties were highly accessible, but inappropriate for monitoring effectiveness, we hypothesized that people with DAT would not be able to discount these cues. This failure would result in a monitoring deficit when compared to non-demented older adults. We first begin with a discussion of how assumptions of the Cue-Utilization Framework can be used to inform these hypotheses. We then discuss relevant metamemorial research in people with AD.

Cue Use in JOL Predictions

According to the cue-utilization framework, JOLs are an inferential judgment based on specific cues associated with the studied material and the conditions of learning (Koriat, 1997). Both intrinsic and extrinsic factors have been shown to influence JOLs (Castel, 2008; Castel, McCabe, & Roediger, 2007; Dunlosky & Matvey, 2001; Kelemen, Frost, & Weaver, 2000; Koriat, 1997; Koriat & Bjork, 2005). Intrinsic cues consist of the properties and characteristics of the studied items that are thought to disclose ease or difficulty of learning. For example, at the objective level, abstract nouns are more difficult to remember than concrete nouns. At the meta level, individuals may be able to use the cue of abstract-ness to inform JOLs. In this example, individuals would use some a-priori knowledge about the studied material to inform JOLs in an episodic memory task. In the case of paired associates, the degree of associative relatedness between members of a pair can serve as a predictor of memory performance (e.g., Dunlosky & Matvey, 2001; Koriat, 1997; Matvey, Dunlosky, & Schwartz, 2006; Rabinowitz, Ackerman, Craik, & Hinchley, 1982). That is, when predicting later recallability participants may note the inherent relationship between the cue and target and use that relationship to inform their prediction. Confirming this hypothesis, Koriat and Bjork (2005) demonstrated that both memory and JOL magnitude were affected by associative strength. Higher JOLs were given to strongly associated pairs (see also Koriat, 1997).

The cue utilization framework also postulates that extrinsic factors, such as the conditions of learning or encoding operations applied by the learner exert an influence on JOLs (Koriat, 1997). For example, levels of processing at encoding (Rabinowitz et al., 1982; Shaw & Craik, 1989), as well as interactive imagery (Begg, Duft, Lalonde, Melnick, & Sanvito,

1989) have been shown to affect JOLs. An individual may deduce that information that is deeply encoded will be better remembered than information that is shallowly encoded. Therefore, in addition to intrinsic factors, the present study also examined the role of extrinsic cues on JOL magnitude and prediction accuracy in older adults and people with DAT.

Importantly, the influence of both intrinsic and extrinsic factors is dependent on a-priori knowledge of how memory generally works. Participants must be able to effectively apply previously acquired knowledge about general memory functioning to an in-progress episodic memory task. Utilizing knowledge of how memory may be affected by type of material and conditions of test requires the effective application of previous experience with memory, or semantic knowledge about memory, on the on-going episodic task. For example, learners may use knowledge of differences in memory for concrete vs. abstract nouns, or knowledge of differences in memory when full attention as compared to divided attention is committed to a task. In both of these instances, a-priori knowledge of how memory typically works can effectively guide metamemorial predictions. Thus, semantic knowledge about memory seems to affect metamemory in episodic tasks.

Intrinsic and extrinsic factors have both been shown to directly influence JOLs in a younger adult population. In addition, numerous studies have demonstrated that non-demented older adults can predict future memory performance with the same level of accuracy as younger adults (Dunlosky & Connor, 1997; Hertzog, Kidder Powell-Moman, & Dunlosky, 2002; Dunlosky, Kubat-Silman, & Hertzog, 2003; Rabinowitz, et al., 1982). The question of interest in the present study is whether intrinsic and/or extrinsic factors also positively influence prediction accuracy in people with DAT. Further, few studies have investigated the value of extrinsic cues on JOL prediction accuracy in an aging population. Thus, the present study investigated the separate influences of intrinsic and extrinsic factors on JOL prediction accuracy in non-demented older adults and people with DAT.

Monitoring in Demented and Non-Demented Older Adults

Two techniques are commonly used for measuring the accuracy of JOLs: resolution and calibration. For the former, each participant’s JOLs are correlated with that individual’s subsequent item recall by using Goodman–Kruskal gamma (*G*) correlations (T. O. Nelson, 1984). These ordinal correlations measure the resolution of people’s judgments, ignoring discrepancies in magnitude or scaling of the JOLs with respect to recall outcomes. Calibration involves comparing the overall likelihood of predicted recall for a set of items (in this case, mean JOL for a participant) with actual level of recall (overall percentage correct). Therefore, calibration captures the absolute correspondence between subjective probabilities and the actual proportions correct. However, it is good resolution that is critical for the effective operation of the control mechanism. That is, for control processes to be effectively implemented, individuals must be able to determine which items will pose more of a memorial challenging, thereby requiring addition and/or more elaborate study. When resolution has been measured, non-demented older adults have been shown to be as effective at predicting future recall in an episodic JOL task as younger adults (e.g., Dunlosky & Connor, 1997).

Only a handful of studies have examined episodic JOL-recall resolution in people with DAT. In one study using a small sample of DAT participants, resolution was not found to be significantly different than zero, suggesting that people with DAT may not be able to accurate monitor memory (Moulin, Perfect, & Jones, 2000). Consistent with this finding, people with DAT have also been shown to be less accurate than older adult controls in predicting memory performance insofar as these individuals tend to overestimate performance (Ansell & Bucks, 2006; Barrett, Eslinger, Ballentine, & Heilman, 2005; Moulin et al., 2000; Moulin, 2002). This overestimation has been found for different types of memory material, such as words in episodic memory tasks (Ansell and Bucks, 2005; Barrett et al., 2005; Moulin et al., 2000; Moulin, 2002) and flashbulb memory (Budson et al., 2004). That being said, when people with DAT studied and made item-by item JOLs for normed easy and difficult words, they were able to modulate their JOLs based on item difficulty. That is, they gave lower JOLs to objectively difficult words (Moulin, et al., 2000). Thus, with the accessibility of a single intrinsic factor, people with DAT did demonstrate an appropriate change in average predictions as a function of item difficulty.

Differences in both kinds of metamemorial tasks and ways in which metamemorial accuracy can be measured have directly impacted conclusions regarding dementia related deficits in metamemory. Specifically, research measuring JOL-recall resolution in people with DAT has demonstrated DAT-related deficits in monitoring accuracy in episodic task (Moulin et al, 2000; Souchay, Isingrini, & Gil, 2002; for review see Souchay, 2007). However, people with DAT have been shown to be sensitive to intrinsic factors by modulating average JOLs based on a priori objective difficulty. In addition, to task and measurement, heterogeneity in memory and metamemory ability in people with DAT may also impact findings and conclusions regarding metamemorial deficits. The majority of studies that have examined metamemory in people with DAT have treated this group as homogenous in the presentation of cognitive ability (cf., Cosentino, Metcalfe, Butterfield, & Stern, 2007). This treatment likely has obfuscated complex metamemorial patterns in people meeting the diagnosis of DAT. In order to minimize complications of group heterogeneity and measurement, the present study focused specifically on individuals diagnosed with *very mild* DAT as measured by the Clinical Dementia Rating (CDR) scale (Berg, 1988; Hughes et al., 1982). The choice to focus on this early DAT stage allows for a direct and systematic test of the boundaries of and between non-demented and very mild DAT older adults in an episodic JOL task. In addition, the present study attempts to elucidate the ostensible conflict in the JOL literature regarding people with DAT. Toward this end, we focused on a subset of the broad DAT range, and limited our investigation to the use of intrinsic and extrinsic cues on JOL prediction accuracy.

The studies examining metamemory in older adults and people with Alzheimer's disease suggest two hypotheses relevant to the present study: 1) Non-demented older adults are able to accurately monitoring memory in a JOL task; 2) People in the very early stages of DAT will also demonstrate monitoring accuracy in conditions where intrinsic cues are effective for guiding predictions. In Experiment 1, we investigated whether older adults and people in the early stages of DAT would be sensitive to intrinsic differences among paired associates. Participants were presented with cue-target word pairs that were unrelated, weakly associated, or strongly associated. We hypothesized that all participants would be sensitive to this intrinsic cue, and demonstrate changes in JOL magnitude as a function of the a priori association between cues and targets. Further, we hypothesized, that all groups of participants would demonstrate prediction accuracy, as measured by *G*, when using intrinsic cues to guide judgments. In Experiment 2, participants were presented with cue-target word pairs that were high in forward (FA) or backward (BA) associative strength. In both cases, the cue and target were related; however in the latter case, when presented with a cue of a BA word pair, the a priori relatedness between the cue and the target should not facilitate retrieval. Rather, accurate retrieval is dependent on only associative episodic memory. For participants to successfully predict future recallability in this case, they must discount the influence of the strong intrinsic semantic relationship between the cue and target. That is, participants are required to ignore the BA relationship when making predictions, and rely solely on idiosyncratic and self-relevant metamemorial cues. We predicted that people with DAT would be captured by the obvious relationship between the cue and target. The result would be a deficit in monitoring accuracy. In Experiment 3, we held intrinsic cues constant and manipulated levels of processing within participants. We predicted that when the extrinsic cue of processing was the only accessible cue, all participants would appropriately modulate JOL magnitude. That is, we expected that JOLs would be lower when processing was shallow as compared to when processing was deep.

Experiment 1

In Experiment 1, we capitalized on a priori relatedness between cues and targets. A priori relatedness refers to the likelihood that the cue word in a paired associate will bring to mind the target word. A priori relationships are best measured using word association norms. Previous studies have demonstrated effects of a priori word pair relatedness on JOLs and cued recall performance (Koriat & Bjork, 2005; Castel et al., 2007); however, none have examined how normal and pathological cognitive age-related impairments might impact the effective use of this particular intrinsic cue. Thus, this is the first experiment that compared younger adults, non-demented older adults, and people with DAT in a task that varied the relationship between cues and targets.

Method

Participants—Twenty-seven younger adults (ages 18 – 24) and 31 non-demented older adults (CDR = 0) and 24 older adults with a diagnosis of very mild DAT (CDR = 0.5) successfully completed Experiment 1. The age range for older adults was 65 – 85. Table 1 includes a full description of the samples tested. Younger adults were recruited from the undergraduate population at Washington University in St. Louis and were paid $10 for their participation. Two groups of older adults were recruited from the Alzheimer’s disease Research Center at Washington University in St. Louis. Older adults were categorized as either non-demented or in the very early stages of AD. Older adults were screened for depression, severe hypertension, possible reversible dementias, and other disorders, which could affect cognitive performance. The severity of the dementia was scaled according to the Clinical Dementia Rating (CDR) scale developed at Washington University (Berg, 1988; Hughes et al., 1982). Older adults that presented as non-demented were categorized as

CDR=0. Older adults with very mild dementia of the Alzheimer's type (DAT) were categorized as CDR=0.5. DAT individuals were included or excluded based on criteria set by the National Institute of Neurological and Communicative Disorders and Stroke and Alzheimer's disease and Related Disorders Association (McKhann et al., 1984). The diagnosis of Alzheimer's disease by the clinical core at Washington University has been excellent (93% diagnosis accuracy confirmed at autopsy) and well documented (e.g., Berg et al., 1998). This experiment received institution review board approval from Washington University in St. Louis, and written informed consent was obtained for each participant.

Materials and Procedure—A list of 45 word pairs representing three levels of associative strength: unrelated (e.g., door-nurse), weakly associated (cat-tiger), and strongly associated (boy-girl) were presented to all participants in a mixed list design. Associative strength was defined as the probability of producing the second word of a pair (target) as an associate of the first (prime) (see Koriat, 1981). Associative strength norms were based on younger adult (18 – 24) data. Experiment 1 consisted of a mixed factorial design with three levels of associative strength (unrelated, weakly related, strongly related) and three groups (very mild DAT, non-demented older adults, young adults). In Experiment 1 participants first engaged in a short practice session, then encoded 45 paired associates, were then given a short distractor task, and finally completed a cued-recall test.

All participants were tested individually. After the informed consent process, but before the experimental session, basic demographic information was collected. The two groups of older participants did not statistically differ in years of education, $t<1$.

In order to orient participants to the experimental task, a short practice session preceded the experimental phase. The practice session consisted of an encoding/JOL phase followed by a cued-recall test. Eight unrelated paired associates were presented in the practice phase on a computer screen. Participants were told to study each pair for 4 s. After each pair was presented, participants made a JOL. Specifically they were asked to use the following to make a JOL: "How confident are you that you will remember the SECOND word when given the first?" This JOL was made on a zero – ten scale, where zero indicated "not likely to remember" and ten indicated "extremely likely to remember". The JOL question immediately followed each pair and the experimenter read the question out loud to the participant. After eight pairs were studied, the practice cued recall phase began. Participants were instructed to try to recall the target word that was studied with the presented cue. Participants had eight seconds in which to make a response. Responses were made verbally and recorded by the experimenter.

After practice, the experimental session began. Participants were instructed that they would study 45 word pairs and would indicate their JOLs about each pair as soon as it disappeared from the screen. During this study phase, each word pair was presented for 4 s at the center of the screen, side-by-side. Participants were told to study each pair so that they later would be able to recall the second word when the first was presented. Participants were urged to use the entire 4 s for studying. After 4 s of study has elapsed participants were instructed to rate on a scale from zero to ten how likely they will be to later recall the second word of the pair when prompted with the first. A short (1 minute) break followed study to eliminate recency effects. A cued-recall test followed. During the cued recall test the cue words were presented one after the other for up to 8 s each. Order of presentation of the items was randomly determined for each participant in the study and cued-recall phases. No feedback was given.

Results and Discussion

Recall and JOLs—To begin with, we examined cued recall performance as a function of associative strength and group. Average cued recall scores were computed for each group as a function of each level of associative strength. Cued recall proportions, computed by taking the total number of correct answers out of the total possible for a given level of associative strength, can be found in Table 2. A 3 (Associative Strength: strong, weak, unrelated) × 3 (Group: younger, old CDR = 0, old CDR = 0.5) mixed design ANOVA found a main effect of Association, $F(2, 158) = 77.52$, $p < .001$, and a main effect of Group, $F(2, 79) = 29.79$. $p < .001$. Cued recall performance was poorest for unrelated word pairs ($M = .33$) and best for highly related word pairs ($M = .59$). Two planned comparisons that employed Bonferroni corrections ($p = .025$) revealed that cued recall associated with unrelated word pairs was significantly worse than that associated with weakly related pairs, $t(81) = 9.47$, $d = 1.04$. Cued recall associated with weakly related pairs was not significantly different from that associated with highly related pairs. In addition, younger adults ($M = .70$) yielded the best cued recall performance, followed by non-demented older adults ($M = .48$) and then by older adults with DAT ($M = .32$). Planned comparisons employing Bonferroni corrections ($p < .025$) revealed that the difference between younger and non-demented older adults was significant, $t(56) = 4.71$, $d = 1.25$. The difference between non-demented older adults and people with DAT was also significant, $t(53) = 3.51$, $d = 1.00$. Finally the interaction between Association and Group was significant, $F(4, 158) = 7.08$, $p < .001$. As can be seen in Table 2, all groups of participants demonstrated relatively low cued recall performance for unrelated pairs. However, both non-demented older and younger adults demonstrated dramatic increases in cued recall performance for weakly and highly associated word pairs. Older adults with DAT also demonstrated improvement in cued recall as associative strength increased, but the increase was not as great as in the other groups.

The pattern in JOL predictions was somewhat different than that observed in cued recall. As with average cued recall responses, we performed a 3 (Associative Strength: strong, weak, unrelated) × 3 (Group: younger, old CDR = 0, old CDR = 0.5) mixed design ANOVA on average JOLs. Similar to the cued recall analysis, we found a main effect of Association, $F(2, 158) = 134.38$, $p < .001$. Average JOLs were lowest for unrelated pairs ($M = 4.9$) and highest for highly associated pairs ($M = 6.4$). Planned comparisons that employed Bonferroni corrections ($p < .025$) revealed that JOLs associated with unrelated pairs were significantly lower than those associated with weakly related pairs, $t(81) = 11.30$, $d = 0.96$. In addition JOLs associated with weakly related pairs were significantly lower than those associated with highly related pairs, $t(81) = 6.69$, $d = .30$. Unlike with cued recall, we did not find a main effect of Group, $F < 1$. However, the interaction between Group and Association was significant, $F(4, 158) = 5.55$, $p < .001$. As Table 2 demonstrates, all groups of participants demonstrated changes in JOLs as a function of Association; however, the changes demonstrated by non-demented older adults and people with DAT were much greater than the changes demonstrated by younger adults. This pattern suggests that people with DAT expected cued-recall performance to be enhanced by association strength to a greater extent than did younger adults.

Resolution: Goodman-Kruskal gamma (*G*) correlations between JOLs and cued recall were computed to examine JOL predictive accuracy, or resolution. These correlations reflect the degree to which individual differences in predictions accurately reflect individual differences in recognition performance. By examining the changes across trials, participants' knowledge of the relative effectiveness of specific cues can be assessed. For the *G* correlation index, large positive values correspond to a strong association between memory performance and judgments, values close to 0 correspond to no association, and negative values correspond to an inverse relationship. A 3 (Associative Strength: strong, weak, unrelated) × 3 (Group: younger, old CDR = 0, old CDR = 0.5) ANOVA was also performed on average gamma correlations to assess resolution. Neither the main effects nor the interaction were significant, *F's* < 1.5. That is, all groups of participants demonstrated similar levels of item-by-item prediction accuracy. In addition, prediction accuracy did not vary by associative strength. Finally, all average gamma correlations were significantly greater than chance prediction performance.

Discussion: Several important findings emerged from Experiment 1. Importantly, all groups of participants demonstrated above chance prediction accuracy as measured by *G*. In addition, all groups of participants evidenced changes in JOL magnitude as a function of association strength between cue-target pairs. Unrelated pairs were given the lowest JOLs and strongly associated paired were given the highest JOLs. These data suggest that younger adults, non-demented older adults, and people in the early stages of DAT are sensitive to intrinsic factors when making JOL predictions. The results of Experiment 1 also suggest that associative relationship exerted a weaker influence over JOLs than cued recall. This evidenced itself in greater differences in cued recall performance as compared to JOLs across the three levels of associative strength. In fact, the magnitude of JOLs was comparable across group, whereas cued-recall performance was significantly impacted by group status. From these data we can conclude that associative relationship is a cue that non-demented older adults and people with DAT can use to guide metamemorial predictions. That is, like younger and non-demented older adults, people with DAT gave higher JOLs to items that they correctly recalled and lower JOLs to items that they failed to recall. In addition, changes in average JOLs as a function of association did parallel changes in cued recall.

Experiment 2

Koriat and Bjork (2005) suggested that when both the cue and target are presented in the context of a prediction of future memory, participants misperceive a weak link between the pair as a moderately strong link. This perception may result in overconfidence. Experiment 1, and the following experiments used a 0 – 10 rating scale to assess JOLs as opposed to a 0 – 100 percentage scale. As such, we did not compute calibration scores, nor did we directly measure overconfidence. That being said, all groups of participants reported high JOL scores relative to cued recall performance for unrelated pairs in Experiment 1. Further, non-demented older adults and people with DAT reported high JOL scores relative to cued recall performance for weakly related pairs. These results suggest that participants may have inflated the utility of the relationship between cue-target word pairs when making predictions. In order to test this hypothesis, we designed a condition where the relationship between the cues and targets were strong, but unhelpful to JOLs in the context of a cued-recall experiment.

In the present experiments, JOLs were made immediately following the cue-target presentation; therefore both the cue and target were likely available to participants during a given prediction. For participants to accurately predict memory performance, they are required to discount what they know during study and adopt the perspective of the examinee. Results from Experiment 1 indicate that this may be a difficult endeavor for older adults and people with DAT. Experiment 2 further examined whether older adults and people with DAT were more likely than younger adults to be inappropriately biased by perceived relationships between cue-target word pairs. Interestingly, this sort of bias would demonstrate that the aging population is in fact sensitive to intrinsic cues when making JOLs; however, an increased biasing effect would suggest that some groups of participants have more difficulty adopting a test-taker perspective when making prediction of future recallability.

In Experiment 2, we manipulated associative strength between the cue and target. Participants were presented with forward associated (FA) word pairs and backward associated (BA) word pairs. To illustrate the difference between FA and BA pairs, take for example the pair *cats* – *kittens*. According to the word association norms, the probability that *kittens* will elicit *cats* is .72; however, the probability that *cats* will elicit *kittens* is only .02. Research suggests that direction of association affects cued recall performance and has concluded that backward associations are less beneficial for recall than forward associations, (D. L. Nelson, McKinney,Gee, & Janczura, 1998; D. L. Nelson & Zhang, 2000). While less beneficial for cued recall performance, the presence of the target (*kittens*) along with the cue (*cats*) may highlight the relationship between the pair. Results from Experiment 1 suggest that older adults and people with DAT may not be able to discount this relationship will making prediction about future retrievability (for similar ideas see Koriat & Bjork, 2005). This hypothesis was tested in Experiment 2.

Method

Participants—Three new groups of participants were compared in this experiment. Twenty-six younger adults (ages 18 – 23), 58 non-demented older adults CDR=0 (ages 54 – 100), and 29 CDR=0.5 older adults (ages 65 – 88) successfully completed Experiment 2. As in Experiment 1, younger adults were recruited from the undergraduate population at Washington University in St. Louis and were paid $10 for their participation. All older adults were recruited from the Alzheimer's Disease Research Center at Washington University in St. Louis. The cognitive screening procedures used in Experiment 1, were also used in Experiment 2. The two groups of older participants did not statistically differ in years of education, $t<1$ (see Table 1 for further details). This experiment received institution review board approval from Washington University in St. Louis, and written informed consent was obtained for each participant.

Materials and Procedure—A list of 45 word pairs was compiled, representing three levels of association: unrelated, forward association, backward association. Strength of association was defined according to Palermo and Jenkins (1964). For the 15 pairs developed to be high in forward associative strength (e.g., imagine – dream) the mean associative strength in the forward direction was 0.36; mean backward associative strength was 0.10. For the 15 pairs developed to be high in backward associative strength (e.g., welcome – thanks) the mean strength level in the backward direction was 0.34; mean forward associative strength was 0.11.

Experiment 2 consisted of a mixed factorial design with three levels of associative strength (forward, backward, unrelated) and three groups (younger adults, non-demented older adults, very mild DAT CDR = 0.5). The methodology of Experiment 2 was identical to that used in Experiment 1. Participants first engaged in a short practice session. Following they encoded 45 paired associates, were then given a short distractor task, and finally completed a cued-recall test. All participants were tested individually.

Results and Discussion

Recall and JOLs—As in Experiment 1, here we examined cued recall performance as a function of associative strength and group. We used the same procedure for deriving cued recall proportions as described in Experiment 1. A 3 (Associative Strength: FA, BA, unrelated) × 3 (Group: younger, old CDR = 0, old CDR = 0.5) mixed design ANOVA found a main effect of Association, $F(2, 220) = 204.98$, $p < .001$, and a main effect of Group, $F(2, 110) = 23.61$. $p < .001$. Cued recall performance was poorest for unrelated word pairs (M = .32) and best for highly related word pairs (M = .64). Planned comparisons employing a Bonferroni correction ($p < .025$) revealed that cued recall associated with unrelated word pairs was significantly worse than that associated with BA pairs, $t(112) = 12.38$, $d = .76$. Cued recall associated with BA pairs was also significantly worse than that associated with FA pairs, $t(112) = 8.60$, $d = .55$. In addition, younger adults (M = .66) yielded the best cued recall performance, followed by non-demented older adults (M = .49) and then by older adults with DAT (M = .35). The difference between younger and non-demented older adults was significant, $t(82) = 4.85$, $d = 1.29$. The difference between non-demented older adults and people with DAT was also significant, $t(85) = 3.41$, $d = .82$. Finally the interaction between Association and Group was significant, $F(4, 220) = 3.20$, $p < .01$. Similar to cued recall results of Experiment 1, all groups of participants demonstrated relatively low cued recall performance for unrelated pairs. However, younger adults demonstrated dramatic increases in cued recall performance for highly associated word pairs. Older adults with DAT also demonstrated improvement in cued recall as associative strength increased, but the increase was not as great as in that found in younger adults.

As with average cued recall performance, we performed a 3 (Associative Strength: strong, weak, unrelated) × 3 (Group: younger, old CDR = 0, old CDR = 0.5) mixed design ANOVA on average JOLs. The only significant effect was a main effect of Association, $F(2, 220)$ =

209.84, $p < .001$. Average JOLs were lowest for unrelated pairs ($M = 4.3$) and highest for FA pairs ($M = 5.6$). Planned comparisons reveal that JOLs associated with unrelated pairs were significantly lower than those associated with FA pairs, $t(112) = 16.20$, $d = 0.65$. In addition JOLs associated with unrelated pairs were significantly lower than those associated with BA pairs, $t(112) = 16.96$, $d = .77$. Importantly, the difference in average JOLs between BA and FA pairs was not significant, t = 1.19, $p = .24$. Interestingly, all groups of participants demonstrated a difference in cued recall performance between FA and BA pairs, [young: $t(25) = 3.61$, $d = .60$; non-demented older adults, $t(57) = 7.40$, $d = .80$, older adults with DAT, $t(28) = 3.23$, $d = .51$.]

Resolution: A 3 (Group: young, non-demented older, DAT) X 3 (Association: forward, backward, unrelated) ANOVA was conducted on average *G* correlations to examine resolution. Unlike in Experiment 1, we found main effects for Association, $F(2, 236) = 3.88$, $p < .001$, and Group, $F(2, 118) = 9.69$, $p < .001$. Planned comparisons employing Bonferroni corrections ($p < .01$) revealed that resolution was significantly worse for BA pairs ($M = .01$) as compared to FA pairs ($M = .31$), $t(120) = 3.99$, $d = .52$. Resolution was also significantly worse for BA pairs as compared to unrelated pairs ($M = .35$), $t(120) = 5.34$, $d = .65$. There was no difference in resolution between FA and unrelated pairs, $t < 1$. Planned comparisons also revealed better resolution in younger adults ($M = .38$) as compared to non-demented older adults ($M = .22$), $t(90) = 2.54$, $d = .60$. Resolution was better in non-demented older adults as compared to people with DAT ($M = .07$), $t(87) = 2.31$, $d = .57$. Finally, the interaction between Association and Group was significant, $F(4, 236) = 5.34$, $p < .001$. The interaction was driven by the difference in resolution for BA pairs. There was no difference in resolution among the three groups for FA or unrelated pairs. However, for BA pairs, younger adults had higher resolution than non-demented older adults, $t(90) = 2.57$, $d = .69$. Further, non-demented older adults demonstrated better resolution that people with DAT, $t(87) = 3.41$, $d = .62$.

Importantly, all average *G* correlations were significantly greater than zero, or significant better that chance, with two notable exceptions. When presented with BA pairs, non-demented older adults demonstrated chance-level prediction accuracy, $t(59) < 1$. In addition, when presented with BA pairs, people with DAT were significantly worse than chance at predicting future performance, $t(28) = 4.40$, $p < .001$.

Discussion: Experiment 2 confirmed that older adults and people with DAT were sensitive to intrinsic cues when making JOL predictions. Specifically, average JOLs were lower when participants were presented with unrelated as compared to related word pairs. In addition, all groups demonstrated prediction accuracy under specific conditions. That is, prediction accuracy was above chance for all groups when predicting performance for unrelated and FA pairs. Interestingly, Experiment 2 also confirmed that intrinsic cues can be inappropriately used in making JOL predictions resulting in over-confidence and inaccurate predictions, and that the level of ineffective use varied as a function of both normal and pathological aging. Specifically, younger adults demonstrated above-chance prediction accuracy for BA pairs, whereas non-demented older adults demonstrated chance level prediction accuracy, and people with DAT were significantly worse than chance. These results suggest that younger adults were better able to take the perspective of "test-taker" when making predictions of future retrievability as compared to older adults. These results also confirm the hypothesis that both non-demented older adults and people with DAT are sensitive to intrinsic factors, and in some circumstances, can use those factors to effectively predict what they will and will not remember.

Experiment 3

Results from Experiments 1 and 2 suggested intact metamemorial monitoring processes in both older adults and people with DAT. Within the context of an episodic JOL task, both groups of participants demonstrated above chance prediction accuracy. These results also clearly suggest that neither normal nor pathological aging impaired the extraction and use of intrinsic cues on JOLs. However, the results of the first two experiments do suggest that the effective use of intrinsic cues changes as a function of both normal and pathological aging. This phenomenon will be explored further in the General Discussion.

Experiment 3 investigated whether non-demented older adults and people with DAT could also effectively use extrinsic cues when making JOL predictions. Research examining the influence of extrinsic cues on JOLs in older adults is limited. That said, a number of studies have demonstrated that extrinsic cues do influence younger adult JOL predictions, but only when the influence of intrinsic factors are limited. For example, Koriat (1997) demonstrated that extrinsic factors, such as repeated presentation, exerted some influence over JOLs; however that influence was disproportionate to the influence that repeated presentation had on recall. These findings suggest that individuals rely more heavily on intrinsic as opposed to extrinsic cues. Further, Castel (2008) demonstrated in younger adults that JOLs were not sensitive to serial position information or repeated presentation (Experiment 1), an extrinsic factor. Koriat (1997) suggested that intrinsic properties often take priority over extrinsic cues when making JOLs, because those properties are easily accessible. In fact, the tendency to discount extrinsic cues has been found in several studies (e.g. Dunlosky & Nelson, 1994; Koriat, Bjork, Sheffer, & Bar, 2004; Zechmeister & Shaughnessy, 1980). However, when the accessibility of the intrinsic properties was minimized and extrinsic information was emphasized, Castel found that extrinsic factors did influence JOLs (Experiment 3 and 4). Specifically, Castel had participants make JOL predictions *prior* to word presentation. Thus, JOLs were made based primarily on serial position (an extrinsic cue). Under these conditions, participants modulated average JOLs based on position of a word in the list.

In the present study we investigated whether older adults and people with DAT would demonstrate metacognitive sensitivity to extrinsic cues when intrinsic factors were minimized. Participants were presented with cue-target pairs; however for one-third of the pairs, the cue was a category label for an exemplar that served as the target; for the second third, the cue was a word that rhymed with the target, and for the last third, the cue was simply the first two letters of the target. By having participants study category, rhyming, or partial target cues along with the target, we established a levels-of-processing encoding orientation. At the object level, we expected that the deepest level of processing (categorical) would result in the best memory performance across all groups of participants.

The question of interest is whether the deepest level of processing would also result in the greatest average JOL magnitude across participants.

Method

Participants—A new group of twenty-seven younger adults (ages 18 – 24) and a new group of 55 older adults (ages 65 – 85) successfully completed Experiment 3. The same recruitment and screening procedures used in the previous experiments were used in Experiment 3. The two groups of older participants did not statistically differ in years of education, $t<1$. A more detailed description of demographic information can be found in Table 1. This experiment received institution review board approval from Washington University in St. Louis, and written informed consent was obtained for each participant.

Materials and Procedure—A list of 45 cue-target pairs was compiled. One third consisted of a category cues paired with exemplars of the category (e.g. “vegetable-carrot”). One third of the pairs consisted of words that rhymed (e.g. hurt-dirt), and one third consisted of the first two letters of the target as the cue (e.g. ba-balloon). The procedure of Experiment 3 was similar to the previous experiments. That is, during this study phase, participants were presented with cue-target pair to study. Participants were instructed to study each pair so that they later would be able to recall the second word in each pair when the cue was presented. Participants were given 4 s for study. After study of each pair, participants rated on a scale from 0 to 10 how likely they will be to later recall the second word of the pair when prompted with the first. A short (1 minute) break followed study to eliminate recency effects. A cued-recall test followed. During the cued recall test the cue was presented one after the other for up to 8 s each. Participants were instructed to say the target aloud within the 8 s allotted. Order of presentation of the items was randomly determined for each participant in the study and cued-recall phases. No feedback was given.

Results and Discussion

Recall and JOLs—The same procedure used for deriving average cued recall proportions in the previous two experiments, was again employed in Experiment 3. A 3 (Cue Type: letter, rhyme, category) × 3 (Group: younger, old CDR = 0, old CDR = 0.5) mixed design ANOVA performed on average cued recall scores found a main effect of Cue Type, $F(2, 158) = 159.35$, $p < .001$, and a main effect of Group, $F(2, 79) = 72.19$. $p < .001$. Cued recall performance was poorest when the first two letters were used as a cue ($M = .24$) and best when a categorical cue was used ($M = .67$). Planned comparisons employing a Bonferroni correction ($p < .025$) revealed that cued recall associated with letter cues was significantly worse than that associated with rhyming cues, $t(81) = 9.06$, $d = 1.10$. Cued recall associated with rhyming cues was also significantly worse than that associated with categorical cues, $t(81) = 7.72$, $d = .60$. In addition, younger adults ($M = .69$) yielded the best cued recall performance, followed by non-demented older adults ($M = .50$) and then by older adults with DAT ($M = .24$). The difference between younger and non-demented older adults was significant, $t(56) = 5.50$, $d = 1.59$. The difference between non-demented older adults and people with DAT was also significant, $t(53) = 6.95$, $d = 1.92$. Finally the interaction between Association and Group was significant, $F(4, 158) = 8.65$, $p < .01$. All groups of participants demonstrated changes in performance as a function of extrinsic cue. However, younger and non-demented older adults demonstrated a steeper rise in performance between the letter and rhyming cue conditions as compared to people with DAT.

As with average cued recall responses, we performed a 3 (Cue Type: letter, rhyme, category) × 3 (Group: younger, old CDR = 0, old CDR = 0.5) mixed design ANOVA on average JOLs. The only significant effect was a main effect of Cue Type, $F(2, 158) = 52.31$, $p < .001$. Average JOLs were lowest in the letter condition ($M = 4.4$) and highest in the category condition ($M = 5.6$). Planned comparisons reveal that JOLs associated with the letter condition were significantly lower than those associated with rhyming condition, $t(81) = 5.08$, $d = 0.35$. In addition JOLs associated with the rhyme condition were significantly lower than those associated with the category condition, $t(81) = 6.08$, $d = .52$.

Resolution: As with previous experiments we computed *G* correlations to examine prediction accuracy, or resolution. A 3 (Cue Type: letter, rhyme, category) × 3 (Group: young, CDR=0, CDR=0.5) ANOVA performed on average scores found a main effect of Cue Type, $F(2, (158) = 6.40$, $p < .001$. Resolution was best when participants were cued with the first two letters of a pair ($M = .34$) than with a rhyming word ($M = .07$) or with a category cue ($M = .13$), [letter-rhyme: $t(81) = 3.53$, $d = .79$; letter-meaning: $t(81) = 2.81$, $d = .55$; rhyme-meaning: $t(81) = 1.2$, $p > 0.1$]. In addition, the interaction between Cue Type and Group was significant, $F(4, 158) = 2.69$, $p < .05$. Unlike younger adults, both non-demented older adults and CDR=0.5 older adults demonstrated above chance prediction accuracy in the 'first two letter' condition, [older: $t(30) = 6.27$, $d = .87$; CDR=0.5: $t(23) = 4.23$, $d = .69$]. If fact, younger adults did not demonstrate above chance prediction accuracy in any of the conditions. Importantly, prediction accuracy was above chance only for non-demented older adults and people with DAT in the letter condition.

General Discussion

The present study investigated the separate influences of intrinsic and extrinsic factors on JOL magnitude and prediction accuracy in young and non-demented older adults and people with early stage DAT. We found that older adults and people with DAT demonstrated changes in JOL magnitude and prediction accuracy as a function of word pair association, an intrinsic factor. In addition, we found that JOL predictions were also affected by encoding orientation, an extrinsic factor. Broadly, these results suggest that non-demented older adults and people in early stages DAT can use specific cues to monitor their learning. However, both aging and dementia affected how well specific cues were used to predict learning. As one example, in Experiment 2 the DAT group used the intrinsic cue of backward associative strength incorrectly, resulting in inflated JOLs and deficits in monitor resolution. Although easily biased, the results from the three experiments demonstrated that people in early stages of DAT can use intrinsic and extrinsic cues to some extent to predict learning and later memory performance. These results also demonstrated the limitations in monitoring effectiveness in young adults, non-demented older adults and people with DAT.

The finding that older adults showed no age-related deficit in JOL resolution is consistent with previous research (e.g., Hertzog, et al., 2002; Robinson, Hertzog & Dunlosky, 2006). The important contribution of the present study is the finding of good resolution in people with very mild DAT. Further, our results suggest that good resolution in this group is related to the effective use of intrinsic cues when making item-by-item predictions. The present study adds to the body of research that has examined the relationship between JOLs and memory performance in people with DAT (cf., Cosentino, et al., 2007; Moulin et al., 2000a; Moulin, Perfect, & Jones, 2000b). In addition, the present study is useful in resolving some of the conflict that appears in this literature. That is, we attempted to answer the question of whether people with DAT demonstrate a metamemorial deficit. The answer is – it depends. We suggest that heterogeneity in the cognitive profile of the DAT population, differences in metamemorial tasks, differences in metamemorial measurement, and small sample sizes all contribute to this conflict in the literature. In the present study, we evaluated relatively large groups of participants and collected numerous observations for each condition within each experiment in order to increase the stability of *G* and establish a consistent pattern of DAT resolution performance. In addition, we evaluated participants categorized with a clinical dementia rating of 0.5. Finally, we investigated the systematic influence of specific cues proposed to affect JOL predictions. Under these conditions we found that people with very mild DAT were able to make accurate predictions. These results suggest that this group of individuals is able to rely on intrinsic and extrinsic cues to make JOLs. These results also suggest that people with DAT demonstrate an inappropriate over-reliance on intrinsic cues (Experiment 2).

It is important to acknowledge that the pattern of metamemory performance demonstrated in this study may not occur in people categorized with a dementia rating greater than 1.0. That being said, with large samples, and sizeable numbers of observations per participant, we found a stable and replicable relationship between JOLs and memory in people with very mild DAT. This group of participants effectively used specific intrinsic cues to make metacognitive monitoring decisions. The only exception to this pattern was the BA condition, in which a negative *G* correlation was observed in the early stage DAT individuals. The condition also resulted in poor resolution in non-demented older adults.

Two Bases for Metacognitive Judgments: Theories and Mnemonics

Intrinsic cues are useful because they are easily extracted from to-be-remember stimuli, and participants can use a priori knowledge developed through years of experience to generate predictions of memorability. In cases where a priori knowledge drives JOLs, participants are likely using theory-based processes to make predictions (Koriat, Bjork, Sheffer, & Bar, 2004). Theory-based JOLs rely on the deliberate application of metacognitive beliefs or theories about one's competence and skills (Dunning, Johnson, Ehrlinger, & Kruger, 2003; Perfect, 2004) and about the way in which various factors can affect memory performance (see Dunlosky & Nelson, 1994; Mazzoni & Kirsch, 2002). In the present experiments, average JOLs increased between unrelated and strongly related word pairs, and between shallow and deep encoding, presumably, because participants were able to bring a priori knowledge about word-pair associations and type of encoding to bear when making predictions.

In some respect, the finding that people with DAT were able to use a priori knowledge to guide metamemorial monitoring is not a complete surprise. Previous research has demonstrated that people with DAT were able to adjust their predictions based on task demands. For example, McGlynn and Kaszniak (1991) found that participants with DAT reduced predictions of recallability for delayed tests as compared to immediate tests. Moulin (2002) found that people with DAT made higher predictions for recognition as compared to recall tasks. In the present study, we found that people with DAT adjusted their predictions based on associations between cue-target pairs, and based on the conditions of learning.

Importantly, the ability to adjust monitoring as a function of general knowledge about memory is a necessary and vital component of prediction accuracy, but it is not the only factor. Using general knowledge about classes of studied material or conditions of learning does not necessarily require individuals to be aware of how their own memory operates. It also does not require individuals use self-generated cues associated with a specific episode. Numerous studies have suggested that people with DAT manifest an unawareness of deficit or anosognosia (i.e., Lopez, Becker, Somak & DeKosky 1994). Further, studies have demonstrates that people with DAT show metamemorial monitoring deficits when prediction tasks require participants to recollect partial information indicative of future recognition (for review see Souchay, 2007). The present study demonstrated that people with early DAT were able to use information integrated into their semantic network to guide monitoring decisions; however deficits in monitoring emerged when these individuals were required to flexibly apply information about their own memory and how their memory might work within specific contexts.

Deficits in monitoring also emerged in non-demented older adults. When presented with pairs high in backward associative strength, poor resolution was found in all groups of older adults. These participants were not able to discount the strong association between the cue and the target and base their prediction solely on the learning of the episode. The influence of the BA relationship was so powerful, that participants with DAT demonstrated a significant negative relationship, as measured by G, between JOLs and memory performance. Younger adults, on the other hand, demonstrated good resolution across all pair types in the first two experiments. Unlike the older adults, younger adults were able to discount the unhelpful a priori relationship inherent in BA pairs.

While the a priori relationship associated with BA word pairs did not negatively impact younger adult resolution, younger adults, and all groups of older adults did demonstrate what Koriat and Bjork (2005) termed the *foresight bias*, or an illusion of competence. That is, while memory performance was better for FA as compared to BA word pairs, average JOLs were statistically identical between these two classes of stimuli, across all groups of participants. These results suggest that even younger adults have difficulty assessing retrieval conditions when making JOLs (cf., Castel et al., 2007; Kelley & Jacoby, 1996; Koriat & Bjork, 2005). When presented with highly associated pairs, the theory that strong relationships are useful for later memory has a greater influence on metamemory predictions, than expectations regarding the conditions at retrieval. The inappropriate discounting of retrieval conditions disrupted JOL discrimination in all groups of older adults; however, young adults demonstrated the ability to discriminate between pairs that would and would not be remembered. These findings suggest that younger adults may have been able to use additional mnemonic and/or idiosyncratic cues when discriminating between pairs; however, globally, backward association inappropriately inflated average JOLs.

Theory-based processing adequately accounts for changes in average JOL ratings among different levels of pair association and different encoding conditions; however, it does not account for discrimination accuracy. In Experiment 1, all groups of participants demonstrated good resolution across all classes of pairs. According to Koriat (1997), intrinsic and extrinsic cues may influence JOLs directly through the application of a rule or theory, or indirectly, through their effects on a third cue – mnemonic cues. Mnemonic cues potentially signal to the participant the extent to which items have been learned and can be recalled in the future. A variety of intrinsic cues have been shown to affect JOLs indirectly through ease of processing, a mnemonic cue. For example, research has demonstrated that concreteness-abstractness of words influence JOLs by influencing the ease with which those words are processed (Begg et al., 1989). Participants may have been able to effectively use a mnemonic cue, such as ease of processing to make accurate JOL predictions. Certain pairs may have been easier to process than others, and that ease of processing may have been influenced by intrinsic cues such as association strength, or other idiosyncratic factors, such as individual experience and/or association with specific pairs.

The Continuum between Intrinsic and Extrinsic Cues

The metacognitive literature is rich with situations in which participants discounted extrinsic cues when making predictions of future memorability (Dunlosky & Nelson, 1994; Koriat et al., 2004; Zechmeister & Shaughnessy, 1980); however, in a recent study, Castel (2008) demonstrated that young participants were able to effectively use the extrinsic cue of serial position when other information in which to base JOLs was lacking. Similarly, Dunlosky and Matvey (2001) demonstrated primacy effects on JOLs and Dunlosky, Hunt and Clark (2000) demonstrated isolation effects on JOLs. Both are effects of extrinsic cues. In the present study, we found that average JOLs followed a similar pattern as average cued recall performance. That is, JOLs were highest when participants studied a category-target pairing as compared to the first two letters-target pairing. This modulation in JOLs based on the level of the cue suggests that participants relied on theory-based analytical processing. That is, all participants used a priori knowledge when predicting later memory performance. Importantly, older adults and participants with DAT applied this theory similarly to younger adults, with some modest level of effectiveness.

While all groups demonstrated changes in average JOLs that paralleled changes in memory performance, prediction accuracy, as measured by *G*, was only found for one cue type and only for older and DAT participants. This is the first study to examine resolution in these groups with this kind of extrinsic manipulation. As such, we choose not to posit an explanation for these findings until they have been replicated in future studies. What does seem to be reliable in the present study is that extrinsic cues had a modest effect on average JOLs. Why might extrinsic cues influence JOLs in some situations and not in others? One explanation is that extrinsic cues are discounted in the presence of more salient intrinsic cues (Koriat, 1997). Alternatively, studies may blur the line between what can be considered an intrinsic as compared to an extrinsic cue. For example, Castel (2008) explicitly provided serial position information and found an effect on JOLs. However, by explicitly providing that information, participants may have made identifiable associations between order and item, resulting in order becoming a property of the item, rather than information external to the item. In the present experiment, participants did not engage in a standard levels-of-processing manipulation. Rather, participants studied cue-target pairs designed to influence recall based on level-of-processing principles. In our case, we may have also inadvertently blurred the line between intrinsic and extrinsic cues, resulting in the modest effects found in Experiment 3. That being said, studies have demonstrated that non-demented older adults possess prior knowledge of the effect of different conditions of learning, extrinsic cues, on memory performance. Further, non-demented older adults have been shown to update knowledge regarding conditions of learning based on their performance throughout the course of the experiment (Bieman-Copland & Charness, 1994). That is, non-demented older adults acquired a theory about the conditions of learning during a given experiment, and changed metamemorial predictions based on that theory. The present results, coupled with prior findings in non-demented older adults suggest that when intrinsic cues are minimized, non-demented older adults and people with early stage DAT can use a priori knowledge about the conditions of learning to guide metamemorial predictions, though the effect on monitoring performance is modest at best.

Conclusions

Unequivocally, non-demented older adults and people with early stage DAT make JOLs based on available cues. Whether cues are intrinsic or extrinsic is not fundamental to the important finding that people with DAT can demonstrate metacognitive monitoring accuracy. Consistent with Koriat (1997) and Koriat et al. (2004) we hypothesized that the effects of intrinsic and extrinsic cues on JOL resolution accuracy was based on their a priori theories about memory. Age- and dementia-related decline seem to only modestly impact participants use of a priori knowledge. In addition, these experiments suggest that a priori beliefs about memory do not change as a function of either normal or pathological aging. Older adults and people with DAT believe that memory will be better for strongly related as compared to unrelated words. Similarly, they believe that memory will better when they are given a categorical cue as compared to a surface level cue. They know generally how memory works and they can use that information to monitor on-line learning. This is not to say that there are no age- or dementia-related changes in monitoring effectiveness. This study also demonstrated boundaries in monitoring effectiveness in both non-demented and demented older adults. For example, this is the first study that has demonstrated chance level *G* correlations in non-demented older adults, as well as the first to demonstrate an inverse relationship between JOLs and memory in demented adults. There are boundaries to the effective application of a priori knowledge to metamemory predictions. Those boundaries change as a function of both normal and pathological aging.

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Table 1

Demographic Information for all Experiments.

	Male	Female	Age	Yrs. Ed
Experiment 1				
Young	15	12	19.2 (1.3)	14.3 (1.4)
Old	11	20	72.3 (5.6)	15.1 (2.5)
CDR 0.5	12	12	74.1 (4.3)	14.8 (2.7)
Experiment 2				
Young	10	16	19.7 (1.2)	13.9 (1.5)
Old	25	33	78.2 (9.5)	14.5 (2.7)
CDR 0.5	16	15	72.3 (5.1)	13.6 (3.7)
Experiment 3				
Young	12	15	19.5 (2.1)	13.5 (1.1)
Old	13	18	73.4 (5.9)	14.2 (3.1)
CDR 0.5	14	10	75.0 (4.6)	14.7 (3.6)

Yrs. Ed = Years of education.

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Table 2

Experiment 1 Cued Recall, JOLs, and Gamma Correlation Coefficients (Means and SD)

	Unrelated	**Weak**	**High**
Younger	M (SD)	M (SD)	M (SD)
JOLs	5.2 (1.0)	5.9 (0.9)	6.1 (1.1)
Cued Recall	.39 (.23)	.76 (.18)	.79 (.17)
G	.32 (.38)	.30 (.48)	.35 (.46)
CDR 0			
JOLs	4.8 (1.5)	6.2 (1.5)	6.7 (1.5)
Cued Recall	.32 (.18)	.52 (.19)	.60 (.25)
G	.45 (.48)	.29 (.48)	.32 (.40)
CDR 0.5			
JOLs	4.6 (1.5)	5.9 (1.2)	6.7 (1.6)
Cued Recall	.25 (.19)	.36 (.19)	.37 (.23)
G	.50 (.36)	.27 (.56)	.42 (.46)

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Table 3

Experiment 2 Cued Recall, JOLs, and Gamma Correlation Coefficients (Means and SD)

	Unrelated	**Foward**	**Backward**
Younger	M (SD)	M (SD)	M (SD)
JOLs	4.6 (1.3)	5.9 (1.0)	6.0 (1.0)
Cued Recall	.40 (.12)	.83 (.15)	.74 (.18)
G	.46 (.24)	.32 (.57)	.35 (21)
CDR 0			
JOLs	4.2 (1.9)	5.5 (2.0)	5.4 (2.1)
Cued Recall	.35 (.21)	.64 (.19)	.47 (.20)
G	.33 (.41)	.28 (.41)	.06 (.62)
CDR 0.5			
JOLs	4.1 (2.1)	5.5 (2.2)	5.6 (2.1)
Cued Recall	.22 (.17)	.47 (.21)	.37 (.18)
G	.26 (51)	.33 (.56)	−.39 (.48)

Table 4

Experiment 3 Cued Recall, JOLs, and Gamma Correlation Coefficients (Means and SD)

	Letter	**Rhyme**	**Meaning**
Young	M (SD)	M (SD)	M (SD)
JOLs	4.5 (1.4)	5.2 (1.3)	5.7 (1.1)
Cued Recall	.37 (.21)	.79 (.15)	.90 (.12)
G	.06 (.40)	.14 (.47)	.08 (.40)
CDR=0 Old			
JOLs	4.6 (1.8)	5.2 (1.6)	6.0 (1.4)
Cued Recall	.25 (.19)	.53 (.16)	.74 (.19)
G	.48 (.43)	.11 (.53)	.15 (.41)
CDR=0.5 Old			
JOLs	4.2 (1.3)	4.5 (1.1)	5.2 (1.3)
Cued Recall	.12 (.12)	.20 (.20)	.40 (.25)
G	.48 (.55)	−0.02 (.39)	.14 (.74)