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Mood, motivation, and misinformation: Aging and affective state influences on memory

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Abstract

Normative age differences in memory have typically been attributed to declines in basic cognitive and cortical mechanisms. The present study examined the degree to which dominant everyday affect might also be associated with age-related memory errors using the misinformation paradigm. Younger and older adults viewed a positive and a negative event, and then were exposed to misinformation about each event. Older adults exhibited a higher likelihood than young adults of falsely identifying misinformation as having occurred in the events. Consistent with expectations, strength of the misinformation effect was positively associated with dominant mood, and controlling for mood eliminated any age effects. Also, motivation to engage in complex cognitive activity was negatively associated with susceptibility to misinformation, and susceptibility was stronger for negative than for positive events. We argue that motivational processes underlie all of the observed effects, and that such processes are useful in understanding age differences in memory performance.

Keywords

Aging; Memory; Misinformation; Affect; Emotion

Aging is associated with normative changes in a host of cognitive abilities. Declining memory skills are perhaps the most obvious and most studied changes that occur in later life, with age differences being most evident in situations involving episodic memory (see Hoyer & Verhaeghen, 2006). These age effects are thought to be linked to normative changes in cortical structures associated with the binding of memories to time and place (hippocampus) and to executive functions associated with the monitoring and control of memory strategies (prefrontal cortex) (see Park & Reuter-Lorenz, 2009). Changes in binding and control operations affect the specificity of memories, which results in older adults remembering less than younger adults due to the more general nature of their memories and the scarcity of contextual cues necessary for retrieving information about specific events. These processes are also thought to account for observations that aging is associated with increased probability of recalling or incorporating false information into event representations. For example, relative to younger adults, older adults often produce more false memories when tested using the Deese–Roediger–McDermott (DRM; Roediger & McDermott, 1995) procedure (e.g., Norman & Schacter, 1997) and, when tested using the misinformation paradigm (e.g., Loftus, Miller, & Burns, 1978), are more likely to incorporate the misinformation into their memory representations (e.g., Cohen & Faulkner,

1989; Marche, Jordan, & Owre, 2002). Such memory errors may result from less contextual information being available to distinguish between semantically similar or relevant events that did and did not occur or poorer monitoring of source information, and some researchers have associated these age-related memory errors with neuropsychological factors (e.g., McCabe, Roediger, McDaniel, & Balota, 2009; Roediger & Geraci, 2007).

Almost all of the work investigating age differences in false memory and misinformation effects has focused on cognitive or neuropsychological factors as explanatory mechanisms. An interesting, but unexplored notion is that these effects may not just represent cognitive deficits, but may be ancillary outcomes of normative changes in adaptive mechanisms associated with affective functions in later life. In research with young adults, several researchers have shown that the aforementioned types of memory errors are influenced by mood. For example, using the DRM procedure, Storbeck and Clore (2005, 2011) have found that young adults exhibit higher levels of false memories when in a positive mood than when in a negative mood. Similarly, Forgas, Laham, and Vargas (2005) found that positive moods were associated with greater susceptibility to misinformation than were negative moods. These effects have been attributed to differences in the nature of processing associated with positive and negative affect (see Fiedler, 2001). Specifically, negative moods tend to be associated with item-specific, detail-oriented processing, which in turn have been associated with lower rates of false memories and a decreased probability of incorporating false information into an event representation (e.g., McCabe, Presmanes, Robertson, & Smith, 2004; Mitchell, Johnson, & Mather, 2003). In contrast, positive moods are typically associated with more general schematic and relational processing. This may increase the semantic activation associated with false memories in the DRM paradigm (Roediger, Balota, & Watson, 2001) and decrease the contextual information necessary for successfully discriminating misinformation from true event information.

From a motivational perspective, the different forms of processing associated with positive and negative moods may be thought of as reflecting goal-based processes. For example, Fiedler (2001) has argued that positive and negative moods are associated with appetitive and aversive settings, which in turn are associated with specific behaviors that can be considered adaptive responses to these settings. Specifically, aversive settings lead to stimulus-driven behavior focused on attending to significant stimuli in the environment and avoiding potentially consequential errors. In contrast, appetitive settings lead to less-focused, more explorative behavior involving activation of knowledge structures to organize information. Thus, this motivational perspective can be used to understand the just-described affective influences on memory errors.

This perspective leads to a potentially interesting view with respect to the sources of aging-associated memory errors. Whereas it would be foolhardy to ignore the all-too-real negative influences associated with age-related cortical changes on performance, it may also be likely that affective factors influence memory. Indeed, there is a growing body of research that suggests that normative goal states associated with affect and other factors may partially account for age differences in memory performance (for reviews, see Hess & Emery, in press; Mather & Carstensen, 2005). A relatively unexplored topic, however, is the relationship between normative age differences in affective states and memory performance.

A frequently observed finding in studies of adult development is that dominant affective states become more positive through adulthood, at least until relatively late in life (e.g., Carstensen, Pasupathi, Mayr, & Nesselroade, 2000; Mroczek, & Kolarz, 1998; Windsor & Anstey, 2010). Although the mechanisms underlying this trend are still in question, it has been hypothesized to reflect adaptive shifts in functioning associated with either (a) changes in future time perspective and a concomitant focus on promoting positive affect (Carstensen,

Isaacowitz, & Charles, 1999), or (b) reductions in negative affective responses associated with decreased cognitive resources (Labouvie-Vief, Grühn, & Studer, 2010). Of interest in the present study was whether these adaptive changes in affective states might help account for age differences in susceptibility to misinformation. Given that (a) the differences in the strength of the misinformation effect observed between young adults in positive vs. negative mood states are similar to those observed between old and younger adults, and that (b) older adults exhibit higher levels of positive affect than younger adults, it is reasonable to hypothesize that age differences in dominant affect partially account for observed age differences in the misinformation effect. We tested this hypothesis by determining whether age differences in dominant affective states accounted for age differences in the misinformation effect.

We also investigated affective influences on misinformation by examining the degree to which susceptibility to misinformation is influenced by the valence of the target event. Porter and co-workers (Porter, Bellhouse, McDougall, ten Brinke, & Wilson, 2010; Porter, Spencer, & Birt, 2003; Porter, Taylor, & ten Brinke, 2008) have found that negative events are more vulnerable to the introduction of misinformation than are positive events. They propose that this may reflect an adaptive response on the part of individuals experiencing such events to maximize the incorporation of relevant information in order to learn from and prepare for similar aversive events in the future. This vulnerability to misinformation may also reflect the fact that the representations of negative events are often less coherent than those of positive events (e.g., Bohanek, Fivush, & Walker, 2005). In addition to replicating this finding, we were interested in whether participant age might moderate this effect. We had no strong basis for making a specific prediction, but findings that older adults have poorer memory for negative events than do young people (e.g., Charles, Mather, & Carstensen, 2003) could be interpreted to mean that the representations of such events decrease in coherence with age. This might result in event valence having a greater impact on susceptibility to misinformation in older as opposed to younger adults.

Another goal of the present study was to investigate more general motivational influences on the misinformation effect based in preferences for complex vs. simple forms of cognitive activity. We assessed such preferences using two related scales that assessed intrinsic motivation. The first, Personal Need for Structure (PNS; Neuberg & Newsom, 1993), is a dispositional motive reflecting the need to cognitively structure one's world (Neuberg & Newsom, 1993). Individuals who are high in PNS display a preference for simple, well-defined structures for understanding the world, and often use internal knowledge structures (e.g., stereotypes) to reduce ambiguity and simplify representations (e.g., Moskowitz, 1993; Neuberg & Newsom, 1993; Vess, Routledge, Landau, & Arndt, 2009). In contrast, Need for Cognition (NFC; Cacioppo, Petty, Feinstein, & Jarvis, 1996) is a relatively stable intrinsic motivational factor reflecting enjoyment associated with engaging in cognitively demanding activities. It has been found to be associated with engagement in complex thought and the creation of more complex memory representations (see Cacioppo et al. for review). These two variables are negatively correlated, with shared variance assumed to reflect preference for simple vs. complex processing. Following earlier work (Hess, Emery, & Neupert, 2011), we created a composite variable representing this shared variance and hypothesized that preferences for less complex processing would be associated with greater susceptibility to misinformation as individuals create less elaborate memory representations and use internally activated knowledge to structure events.

Age in adulthood has not been shown to be systematically related to either of these variables (e.g., Hess et al., 2011). Thus, it was not anticipated that intrinsic motivation would account for significant age-related variance. We were interested, however, in whether age might moderate the impact of motivation on performance. For example, Hess, Waters, and Bolstad

(2000) found PNS to moderate older adults', but not younger adults', performance on a social judgment task. It has been hypothesized that declines in health and other resource variables supportive of cognitive functioning in later life are more strongly linked to motivation than at other points in the lifespan, perhaps accounting for these moderating effects (Hess et al., 2011). This linkage with motivation is thought to reflect an adaptive response on the part of older adults as they seek to conserve limited resources (Hess & Emery, in press). Thus, the hypothesized linkage between susceptibility to misinformation and motivation to engage in complex processing might increase in strength with age, reflecting these adaptive changes in motivational processes. In the present study, we tested this notion by examining whether age moderated the impact of intrinsic motivation to engage in simple vs. complex thought on susceptibility to misinformation.

METHODS

Participants

The sample consisted of 96 older adults (57–83 years old; 48 women) and 96 younger adults (17–29 years old; 48 women). Older adults were recruited from the Raleigh, NC, community through newspaper and internet advertisements, and they received an honorarium of \$30 for participation. Younger adults were recruited from Introductory Psychology classes, and they satisfied a course option with their participation. Participant characteristics are presented in Table 1. As can be seen, the pattern of age differences is consistent with existing knowledge.

Our original experimental design involved a mood induction procedure in which half of the participants in each age group were assigned to either a positive or negative mood condition, whereas the other half formed a no-induction control group. Our mood manipulation involved viewing a positive or negative 10-min film clip, and the manipulation was generally successful. We did not find, however, that the induction influenced memory. Thus, to simplify presentation of the study, we only include general procedural details associated with this manipulation and we exclude consideration of induction-related details from the results.

Materials

Event Presentations—A series of slides visually depicting each of four different target events was created. To attempt to equate the content and visual details across event valence as much as possible, we created a positive and negative version in each of two contexts. One context involved a woman stepping out of her office, with the negative version depicting a man coming in and stealing money out of her purse while she was gone and the positive version showing the same man leaving a card with money in it on the woman's desk as a surprise birthday gift. The other pair of events occurred outside and involved a woman who had locked her bicycle in a bike rack. In the negative version, a man later steals the bicycle, whereas in the positive version, a man comes and replaces the old bicycle with a newer one as a surprise gift. Each participant viewed one positive event from one context and the negative event from the other context, with the number of positive and negative events viewed from each context equated across age groups and conditions. The slide presentations were pilot-tested to ensure both that participants viewed the events as either positive or negative events and that the actions and information presented in each event were clearly discriminable. The resulting events consisted of 54 to 58 slides presented at a 4 s rate on a computer monitor.

Misinformation Exposure: For each event, eight different pieces of misinformation were identified involving either a substitution of a new object or action for one that had appeared in the slides or the introduction of a new object or action. Eight open-ended questions about

each event were then created to introduce this misinformation. Each question asked about a valid aspect of the event (e.g., ‘Where was the vase located in the room?’), but also allowed the incorporation of additional misinformation (e.g., ‘Where was the vase *of lilies* located in the room?’; the vase actually contained roses). For each event, the questions were divided into two sets of four questions each. Half of the participants viewing each event were presented with the standard versions (i.e., containing no misinformation) of the first set of questions and the misinformation versions of the second set, whereas the opposite was true for the other half of the sample. Note that the same questions were used for the positive and negative versions of each event within contexts, thus controlling for content of the memory tests.

Recognition Test: An 18-item recognition test was created for each event. Six items (*event targets*) presented information actually contained in the event and four items (*event distractors*) presented information that was neither contained in the event nor in the misinformation questions. The remaining eight items tested for the misinformation that could be presented through the eight misinformation exposure questions. Of these questions, each participant had been exposed to the misinformation presented in four of them earlier in the session (*misinformation targets*) whereas the misinformation presented in the other four was new (*misinformation distractors*). Participants provided a ‘yes’ or ‘no’ recognition response for each item, and then rated how confident they were that their answer was correct on a 5-point scale (1 = *not at all*, 5 = *very confident*).

Mood Measures—The Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) consists of 10 positive (e.g., enthusiastic) and 10 negative adjectives (e.g., irritable), and was used to assess mood over the prior 30 days and then again at the beginning of the test session as a current mood index.

Participants were also asked to rate how interested, happy, focused, unhappy, calm, involved, tense, and bored they were on an 8-point Likert scale (1 = *not at all*, 8 = *very much*) at three different points during the session. These ratings were used in conjunction with the experimental mood manipulation, and thus are not described further.

Motivation Measures: The 11-item Personal Need for Structure Scale (PNS; Neuberg & Newsom, 1993) and the 18-item Need for Cognition Scale (NFC; Cacioppo, Petty, & Kao, 1984) were used to assess motivation.

Ability Measures: Participants completed several tests to assess basic cognitive abilities. Working memory processes were assessed using an Operation Span task. In this task, participants were shown a series of equation–word pairs [e.g., Is $(2 + 5) \times 3 = 21$? CHIMNEY]. As soon as each equation was presented, they solved the equation, indicating whether it was correct or incorrect, and then said the word aloud. At the end of a set of 2 to 5 equation–word pairs, participants recalled the words. The dependent measure is the number of words recalled.

The Stroop task was used to assess inhibitory skills. Participants were presented with a series of X's shown in 4 different colors, or color names shown in 4 different colors (most of these trials are incongruent), and they were instructed to say what color the X's or color names presented in on the screen are. The dependent measure is the reaction time for incongruent trials minus the reaction time for X's. Thus, larger numbers indicate greater difficulty with inhibition.

The ability to shift between tasks was assessed using the Plus-Minus task. Participants were presented with a sheet containing three columns with a two-digit number at the top of each.

They were instructed to add 3 to each number in the first column, subtract 3 from each number in the second column, and alternate between adding and subtracting 3 from the numbers in the third column. The dependent measure for this task is the time taken to complete the third column divided by the mean time taken to complete the first two columns.

Processing speed and verbal ability were assessed using the Digit-Symbol Substitution and Vocabulary Subtests from the Wechsler Adult Intelligence Scale-III (WAIS-III; Wechsler, 1997).

Personality: The 60-item NEO Five Factor Inventory (Costa & McCrae, 2003) was used to obtain a measure of neuroticism.

Health: The SF-36 Health Survey (Ware, 1993) was used to assess self-rated health. The Geriatric Depression Scale (GDS; Sheikh & Yesavage, 1986) was also administered to further assess negative affect.

Procedure—Participants were tested individually. Prior to testing, they were sent and completed a background questionnaire, the SF-36, PNS, NFC, and GDS scales, and the 30-day PANAS. At the testing session, participants signed their informed consent form and then completed the PANAS to assess how they were currently feeling. Next, they were asked to watch the slide show presentations of the positive and negative events. Presentation order of the two events was counterbalanced across participants. In introducing the event presentations, they were asked to ‘pay close attention’ because they would be asked questions about the events later in the session, and that they should ‘look at these events as if [they] had unexpectedly observed them in everyday life’. Afterward, participants were asked to briefly summarize the scenarios they just viewed on a piece of paper to ensure that they had understood the events correctly. All participants characterized the events in accordance with the intended valence. Participants then made their first mood rating. They were asked to rate how they were feeling right now, making sure ‘not to think too much about how [they were] feeling since we [were] interested in relatively spontaneous reactions’. This was followed by a 15–20-min period in which participants completed the Plus-Minus task and the WAIS III Vocabulary test.

Next, participants in the control condition completed the NEO while those in the positive and negative mood conditions watched the appropriate mood induction video clips. In introducing the video, participants were told that the purpose of the clip was to get their ‘impression or reaction to this video’, and that we wanted them to ‘watch the video clip naturally, as if watching it in the comfort of [their] own home’. Immediately following the video clip or NEO, all participants were presented with the misinformation exposure test consisting of eight questions – four of which had misinformation embedded in them – for each event. As a manipulation check, participants made their second mood rating to see if the video clip had induced the appropriate change in mood.

After a delay of 15–20 min in which participants completed the Operation Span, Stroop, and Digit-Symbol Substitution tasks, participants were given the 18-item recognition test for each event using the same order in which the events were initially viewed. They subsequently made their third and final mood ratings. To remove any undesirable effects from the mood induction, participants in the negative condition watched a neutral video. Those in the control condition were debriefed and thanked for their participation, while those in the positive and negative conditions completed the NEO Personality Inventory before being debriefed and thanked for their participation.

RESULTS

Affective and Motivational Measures

Mood—To determine whether the anticipated normative age differences in affective characteristics existed in our sample, we examined several different measures that tapped into such characteristics. First, we conducted a $3 \times 2 \times 2$ (Age Group $\times$ Time [30-day vs. current] $\times$ Valence [positive vs. negative]) ANOVA on PANAS scores. Positive mood scores ($\alpha = .88$) were higher than negative mood scores ($\alpha = .88$), $F(1,186) = 1138.73$, $p < .001$, $\eta_p^2 = .86$, with this effect being moderated by age, $F(1,186) = 30.10$, $p < .001$, $\eta_p^2 = .14$. Consistent with expectations, older adults reported higher positive affect ($M = 3.5$) and lower negative affect ($M = 1.3$) than did younger adults (M s = 3.2 and 1.7, respectively). We also observed a significant Time $\times$ Valence interaction, $F(1,186) = 27.83$, $p < .001$, $\eta_p^2 = .13$, due to negative affect being greater for the 30-day than for the current assessment (M s = 1.8 vs. 1.2); positive affect did not change as much across assessment periods (M s = 3.5 vs. 3.2, respectively).

We next examined scores on several additional measures that reflect affective functioning. Relative to younger adults, older adults had lower scores on the GDS ($\alpha = .94$), $t(190) = 3.63$, $p < .001$, and NEO Neuroticism scale ($\alpha = .88$), $t(190) = 5.39$, $p < .001$, but higher SF-36 Mental Health scores ($\alpha = .90$), $t(190) = 6.68$, $p < .001$ (see Table 1).

Taken together, these results are in line with expectations regarding normative age differences in dominant affective states. To obtain a general measure of dominant affect for use in later analyses, we conducted a principal components analysis on the following: (a) positive and negative scores from the 30-day PANAS; (b) SF-36 mental health index; (c) GDS score; and (d) NEO neuroticism score. The resulting component accounted for 64.4% of the overall variance and, as can be seen in Table 2, reflected degree of negative affect. Comparisons of component scores revealed the expected differences between age groups, with younger adults having significantly higher levels of negative affect ($M = 0.41$, $SD = 1.10$) than older adults ($M = -0.41$, $SD = 0.67$), $t(190) = 6.22$, $p < .001$.¹

Motivation—We next examined our two trait-level variables relating to the motivation to engage in simplistic vs. complex processing. There were no age differences observed on the PNS scale ($\alpha = .85$), $t(190) = 1.02$, $p = .30$, but – unexpectedly – older adults had higher NFC scores ($\alpha = .89$) than younger adults, $t(190) = 3.07$, $p = .002$ (Table 1). This latter result may reflect the somewhat advantaged nature of our older adult sample. Consistent with our previous work (Hess et al., 2011), we performed a principal components analysis on these two scores in order to obtain a general score for use in later analyses. A single component was extracted that accounted for 65.1% of the total variance, with higher scores being associated with greater motivation to engage in complex thought. The two age groups did not differ on the obtained scores, $t(190) = 1.23$, $p = .22$.²

¹Concerns could be raised that mood alterations associated with our experimental induction might have complicated the use of this mood measure in our subsequent analyses as a measure of dominant mood reflective of age differences in such mood. Note, however, that in spite of participants reporting their mood to be affected by the induction, older adults as a group exhibited more positive moods than younger adults in all conditions across all measurement points. In addition, the mean change in mood for the two induction conditions was only 0.45 points on a scale of 1 to 8. Although reliable, the change was relatively small. These two factors together suggest that the confounding influence of the mood induction should be minimal.

²Although PNS and NFC do contain some construct overlap, they also focus on somewhat different processes. It may also be the case that these more unique processes may moderate the impact of each other. For example, a tendency toward cognitive structuring might be amplified in individuals who are high in NFC. (We thank an anonymous reviewer for pointing this out.) Including NFC and PNS as separate variables in our analyses, however, did not reveal such moderating effects, and each individually was associated with the misinformation effect (a negative association for NFC, and a positive association for PNS). However, the composite variable exhibited a stronger association, suggesting that the shared construct space was accounting for the observed effects.

Memory—We next examined memory performance. Given that age effects in susceptibility to misinformation appear to be partially related to subjective experiences of memory (e.g., Saunders & Jess, 2010), we multiplied the confidence rating assigned to each item by +1 if it received a positive recognition response and by -1 if it received a negative response. This provided us with a more sensitive measure of memory, resulting in scores ranging from -5 (high confidence that the item is new) to +5 (high confidence that the item was old). These scores were then used to examine both overall memory and susceptibility to misinformation. Mean scores are presented in Table 3. In all memory analyses, we controlled for ability using a principal components composite of digit-symbol substitution, plus-minus, and operation span scores. This was done to minimize effects on performance due to ability and focus more on affective and motivational influences. (Due to testing error, data on the Stroop task was missing for 16 participants. Thus, this test was not used in construction of the summary ability measure.) For both correct recognition and misinformation responses, we also investigated whether presentation order of the positive and negative events or the context (bike vs. office) of the events had an impact on performance. No systematic effects were observed due to either variable, and thus they were excluded from further examination.

Corrected Recognition: To gauge overall accuracy, we calculated corrected recognition scores by subtracting the mean memory score for event distractor items from the mean memory score for event target items, and then submitted these scores to a 2×2 (Age Group $\times$ Scene Valence) ANCOVA, with the last factor being within participants. No significant differences were observed between young ($M = 5.4$, $SD = 1.4$) and older adults ($M = 5.1$, $SD = 1.6$), $F < 1$. The Age $\times$ Scene Valence interaction approached significance, $F(1,189) = 3.30$, $p = .07$, $\eta_p^2 = .02$. This reflected the fact that older adults had somewhat better memory ($p = .11$) for the negative than for the positive scene ($M_s = 5.4$ vs. 4.8), whereas younger adults exhibited little difference between the two ($M_s = 5.5$ vs. 5.4). In addition, the age difference for positive scenes was marginally significant ($p = .08$), whereas the age difference for negative scenes was not ($p = .43$). Importantly for present purposes, the absence of an age main effect simplifies interpretation of any misinformation effects by eliminating overall scene memory as a possible contributor to any observed age differences.

Misinformation Effects: Our primary analyses focused on the misinformation effect, which was represented by contrasting responses to the items in the misinformation set to which participants were exposed (i.e., misinformation targets) with responses to the items in the set to which they were not exposed (i.e., misinformation distractors). Since there were two sets of potential misinformation items for each scene, our ability to detect a misinformation effect depended on similar base-rate responses (i.e., false positives) to items across sets when they served as distractors. To this end, we compared base-rate responding across items and found a fair amount of variation in response rates (-0.3 to -4.5). Thus, to control for these differences, the sample base-rate for each item was subtracted from each participant's response to that item, regardless of whether the item had been a target or distractor. This, in essence, reduced the mean sample response rate across all distractors to 0, with the resulting responses to targets representing deviations from this base-rate. To ensure that individual test items were actually sensitive to exposure to misinformation, we then compared responses of participants who were exposed to the misinformation in the item to those who were not. This resulted in the elimination of 3 of the 16 items across the two events from further consideration given the absence of significant differences in mean response rates when the item served as a misinformation target vs. distractor.

We then performed a $2 \times 2 \times 2$ (Age Group $\times$ Scene Valence $\times$ Item Type) ANCOVA on mean responses to the remaining misinformation test items, with the last two factors within participants. A significant misinformation effect was observed, $F(1,189) = 207.19$, $p < .001$, $\eta_p^2 = .52$, with responses to targets being greater than to distractors ($M_s = 1.96$ vs. 0.00). A

significant Age Group $\times$ Item interaction was also obtained, $F(1,189) = 5.04, p = .03, \eta_p^2 = .03$, reflecting the fact that the difference between target and distractor items (i.e., the misinformation effect) was greater for older adults (2.30) than for younger adults (1.62) (see Figure 1). Consistent with previous research (e.g., Porter et al., 2003), a stronger misinformation effect was observed for negative scenarios than for positive ones (2.31 vs. 1.61), $F(1,189) = 5.50, p = .02, \eta_p^2 = .03$. Age did not moderate this effect ($F < 1$).

Affective Influences on Misinformation: Consistent with our hypothesis, we investigated whether age differences in dominant affect might account for the observed age effects in the misinformation effect. As expected, negative affect scores and misinformation scores (i.e., mean response to misinformation targets minus mean response to misinformation distractors) were negatively correlated ($r = -.19, p = .01$), and entering negative affect as a covariate in our primary analyses reduced the previously observed Age $\times$ Item interaction to nonsignificance, $F(1,184) = 1.40, p = .24, \eta_p^2 = .01$. We subsequently conducted a series of regression analyses to more formally test whether affect accounted for the observed age differences in the misinformation effect. In the initial step, age (controlling for ability) was found to be a significant predictor of both negative affect, $\beta = -0.48, p < .001$, and the misinformation effect, $\beta = 0.19, p = .02$. Subsequently controlling for negative affect reduced the relationship between age and the misinformation effect to nonsignificance, $\beta = 0.12, p = .17$, and the addition of age to the equation containing negative affect and ability did not result in a significant increment in prediction. In other words, age differences in dominant affect accounted for the observed age differences in susceptibility to misinformation.

Motivational Influences on Misinformation: Given the absence of a significant relationship between age and our measure of motivation, it did not make sense to examine motivation as a mediating variable. Instead, we chose to examine potential moderating influences by including it as a continuous predictor variable in our analysis of responses to our misinformation items. When this was done, we obtained a significant interaction between motivation and item, $F(1,187) = 6.01, p = .01, \eta_p^2 = .03$. Comparisons of the item effect at 1 *SD* above and below the sample mean on the motivation variable revealed a stronger misinformation effect (i.e., difference score) for those low in motivation (2.59), $F(1,187) = 142.09, p < .001, \eta_p^2 = .43$, than for those high in motivation (2.07), $F(1,187) = 71.91, p < .001, \eta_p^2 = .28$. Age did not, however, moderate the impact of motivation on performance ($p = .61$).

Motivation and negative affect were negatively correlated ($r = -.31, p < .001$), perhaps suggesting some common influence on susceptibility to misinformation. When we performed a series of stepwise regression analyses that included both motivation and negative affect, however, we found that each accounted for significant variance in the misinformation effect, with their effects relatively independent of each other. In fact, these two variables acted as suppressors, with the strength of their effects when each was included in the regression equation alone (negative affect: $\beta = 0.20, p = .01$; motivation: $\beta = -0.16, p = .03$) increasing when included in the equation with the other variable (negative affect: $\beta = -0.27, p < .001$; motivation: $\beta = -0.25, p = .001$). In addition, only negative affect negated the impact of age on the misinformation effect, further suggesting that these two factors are operating independently.

DISCUSSION

A traditional approach to examining aging effects on memory has been to determine the extent to which age-related variance in performance can be accounted for by normative changes in basic cognitive mechanisms (e.g., working memory, executive function) or

cortical structures (e.g., hippocampus, prefrontal cortex). Although such factors are undoubtedly important in accounting for observed age effects, they are not the only mechanisms that both affect memory and exhibit normative change across adulthood. In the present study, we sought to determine whether normative changes in affective mechanisms might also be implicated in determining age differences in qualitative aspects of memory performance. Specifically, we investigated whether commonly observed age differences in memory errors – in the form of susceptibility to misinformation – might be influenced by age-related variation in dominant affect. Although older adults' susceptibility to misinformation has been attributed to, for example, neuropsychological factors (e.g., Roediger & Geraci, 2007), there is also evidence that susceptibility is positively associated with mood states (e.g., Forgas et al., 2005). Given that aging is associated with a shift toward more positive everyday mood states (e.g., Mroczek, & Kolarz, 1998), we hypothesized that dominant affective states might account for observed age differences in susceptibility to misinformation.

Our results were generally consistent with our expectations. We replicated the oft-observed increase in the misinformation effect with increasing age, and also observed that age differences in dominant affect were in the expected direction. That is, based on a variety of measures, older adults exhibited more positive affect than did younger adults. In line with expectations, we also found that dominant affect was positively associated with the misinformation effect and that controlling for dominant affect eliminated the observed age differences in this effect. Importantly, these effects were obtained (a) after controlling for individual differences in basic cognitive ability and (b) in the absence of age differences in memory for the event itself. Thus, without discounting the impact of basic cognitive mechanisms and overall memory, our results suggest that affect may also play an important role in determining age differences in susceptibility to misinformation.

An interesting question relates to the form of the age-related affective influence. One way to conceptualize the operative mechanisms is in terms of affect-driven motivation. Specifically, it has been argued that the characteristic ways of processing information associated with positive and negative mood states reflect responses to those mood states and associated attributions about the contexts in which they occur (e.g., Clore et al., 2001; Fiedler, 2001). For example, Fiedler (2001) proposed that positive and negative mood states are associated with appetitive and aversive settings, respectively. Further, each of these settings is associated with a general processing style that reflects an adaptive response to these settings. Thus, in negative moods, individuals engage in an accommodative style, incorporating bottom-up processing to accurately and carefully monitor the environment. Such processing is likely to result in a more detailed representation of an event, including contextual information that permits more accurate source monitoring. In contrast, positive moods are associated with less vigilance and greater use of assimilation. This latter mode of processing is more top-down, involving the use of internal structures to interpret events in the environment. This more general, heuristic processing may not only limit the amount of contextual detail in the memory representation, but also encourage incorporation of relevant but unrepresented information into the event representation. It may be that age differences in dominant affective states result in general differences in the manner in which younger and older adults process information, independent of changes in basic cognitive or cortical mechanisms.

Other researchers have posited a link between affect and age differences in memory, most notably within the context of socioemotional selectivity theory (SST; Carstensen et al., 1999; Mather & Carstensen, 2005). Within this perspective, there is a shift in memory for valenced information with age as older adults focus more on positive events and less on negative events in the service of emotion regulation processes aimed at maintaining positive

affect. The present perspective differs, however, in suggesting an age-based process based in more fundamental relationships involving mood and memory. Rather than suggesting that there is some positive benefit associated with an increase in susceptibility to misinformation in later life, we argue that this age trend is an unintended outcome of changes in affective processes that may be linked to adaptive or compensatory mechanisms. For example, the normative increase in positive mood with age in adulthood has been hypothesized to reflect the emotion-regulation processes proposed by SST, and thus the linkages suggested here may be based in these goal-based regulatory functions. The memory outcomes that we are proposing, however, reflect more of a by-product of mood rather than motivated representations designed to foster positive mood.

Obviously, further research would be necessary to support the proposed linkage between affect and age differences in memory, but other parallels between age effects and mood effects on memory exist in the literature. As noted earlier, both age and mood are positively associated with an increase in false memories within the DRM paradigm (e.g., Norman & Schacter, 1997; Storbeck & Clore, 2005). Aging is also associated with stronger schematic influences on memory (see Hess, 1990) and less verbatim and more interpretative recall of text (e.g., Adams, 1991), both of which are consistent with the assimilative processing associated with positive moods.

We also investigated the impact of scene valence on both memory and misinformation. Previous research has shown that negative scenes are more susceptible to misinformation than positive scenes, a result that we replicated here. The basis for this effect is still open to interpretation, and our study – unfortunately – does not help much in identifying possible explanatory mechanisms. Porter et al. (2010) proposed that negative event representations might be more open to incorporation of new, additional information – including misinformation – as individuals seek to fully understand such events to better deal with them in the future. An alternative perspective has to do with the possibility that positive and negative events are represented differently in memory. For example, Bohanek et al. (2005) found that representations for strongly negative events were less coherent than those of similarly arousing positive events. This lack of coherence may make them more vulnerable to misinformation.

With respect to age differences in responses to positive and negative scenes, it might be expected based on SST that, relative to young adults, older adults would have disproportionately poorer memory for negative scenes than for positive ones. This might imply less coherent representations for the former and disproportionately greater vulnerability to misinformation. Inconsistent with such expectations, we found that older adults had marginally better memory for negative than for positive scenes, whereas younger adults demonstrated no difference. There were no age differences, however, in impact of scene valence on misinformation.

Our final goal in the present research was to determine whether intrinsic motivation influenced susceptibility to misinformation. Motivation was assessed in terms of the degree to which individuals prefer engaging in complex vs. simple and structured processing, which was then examined in relationship to memory performance. We found that individuals who displayed high levels of intrinsic motivation were less likely to endorse misinformation items as being part of the original memory event than were those who were low in motivation. As far as we know, this relationship has not been reported before, but most likely can be understood in terms of the types of strategies that individuals varying in motivation are likely to employ and their impact on memory. Research has shown that individuals who are low in intrinsic motivation to engage in complex cognitive activity tend to spend less time processing information, engage in more schema-based processing, and

create relatively simple representations. In contrast, individuals with the opposite characteristics spend more time on task, process more details, and show less preference for simplistic representations (for reviews, see Cacioppo et al., 1996; Thompson, Naccarato, Parker, & Moskowitz, 2001). Thus, it is likely that those individuals exhibiting high levels of motivation to think complexly engage in the types of memory strategies that result in relatively specific and coherent event representations, thereby reducing the impact of misinformation. It may also be the case that, at test, they are more likely to carefully scrutinize the test items, resulting in greater source monitoring, which has been shown to be associated with the strength of the misinformation effect (e.g., Mitchell et al., 2003). Interestingly, although motivation was negatively correlated with degree of negative affect, the impact of the motivational and mood-related factors on performance were independent of each other. This suggests that intrinsic motivational states of the form assessed here are not necessarily linked to the motivational states hypothesized to be associated with affect. These results also emphasize the multifaceted nature of potential motivational influences on performance.

Age was unrelated to intrinsic motivation, and it did not moderate the impact of motivation on performance. Based on previous research (Hess et al., 2000; Hess, Germain, Rosenberg, Leclerc, & Hodges, 2005), we had predicted that motivation would be a stronger predictor of susceptibility to misinformation in older than in younger adults. As with our conceptualization regarding age, affect, and performance, this relationship was thought to reflect an unintended outcome of an adaptive process in old age (i.e., selective engagement; Hess & Emery, in press). The absence of such a relationship in the present study may reflect the relatively advantaged status of the older adult group. In the prior studies that found age-based moderation of motivation effects, there was a stronger linkage between resource variables (e.g., health, ability) and motivation in older adults. In the present study, there were no such age-based linkages, perhaps accounting for the absence of age effects.

In conclusion, our results are in line with a growing body of evidence indicating that age differences in memory performance are not just reflective of changes in the aging nervous system (e.g., neuronal loss) that affect basic cognitive mechanisms underlying performance. Consistent with a contextual perspective (Hess, 2005; Hess & Emery, in press), there is evidence that age differences in memory performance also reflect, among other things, responses to the social context (e.g., Hess, Auman, Colcombe, & Rahhal, 2003; Levy, 1996), efficiency of emotion regulation processes (Emery & Hess, 2011; Scheibe & Blanchard-Fields, 2009), social goals (Mather & Carstensen, 2005), and adaptive responses associated with conserving resources (e.g., Germain & Hess, 2007; Hess, Germain, Swaim, & Osowski, 2009). In the same way that we have attempted to conceptualize the mood-based effects observed in the present study in motivational terms, many of these findings can also be understood from a motivational perspective as older adults attempt to regulate their behavior in response to, for example, social threats, future time perspective, and changes in the resources supporting memory activity. We argue that such motivational processes not only provide a more complete understanding of memory functioning in later life, but also provide insight into adaptive functions associated with healthy aging.

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Figure 1.
Mean misinformation effects adjusted for ability covariate.

Table 1

Participant characteristics

Measure	<u>Young adults</u>		<u>Older adults</u>	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Age *	19.6	2.1	68.9	6.2
Years Education *	13.2	1.4	16.1	2.0
Physical Health	48.5	4.8	47.5	5.1
Mental Health *	47.1	11.0	56.0	6.6
GDS *	2.8	3.0	1.5	1.8
Neuroticism *	31.4	8.4	25.5	6.8
Plus-Minus	1.4	0.3	1.5	0.3
Operation Span	28.0	8.1	25.7	8.5
Stroop Interference *	140	65	198	87
Digit-Symbol Substitution *	81.3	11.3	63.5	12.2
Vocabulary *	47.3	7.8	54.0	8.4
Personal Need for Structure	3.6	0.9	3.7	0.9
Need for Cognition *	3.8	0.8	4.2	0.8
PANAS Positive Affect (30-day)	3.5	0.6	3.5	0.7
PANAS Negative Affect (30-day) *	2.1	0.7	1.5	0.5

* Age group difference significant at $p < .05$.

Table 2

Principal component analysis of affective measures

Measure	Loading
GDS	0.87
NEO Neuroticism	0.88
PANAS Negative Affect	0.80
PANAS Positive Affect	−0.54
SF36 Mental Health	−0.88

Table 3

Mean recognition responses

Measure	<u>Positive scene</u>		<u>Negative scene</u>	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
<i>Young adults</i>				
Event targets	2.3	1.3	2.5	1.3
Event distractors	−3.1	1.3	−3.0	1.5
Corrected recognition	5.4	1.9	5.5	2.1
Misinformation targets	1.9	2.4	2.2	2.5
Misinformation distractors	0.6	2.1	0.0	2.0
<i>Older adults</i>				
Event targets	1.6	1.5	2.1	1.4
Event distractors	−3.2	1.4	−3.3	1.6
Corrected recognition	4.8	2.0	5.4	2.2
Misinformation targets	1.8	2.6	2.0	2.5
Misinformation distractors	−0.1	2.3	−0.5	1.8

Note: Scores are not corrected for ability covariate used in analyses.