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THE DYNAMIC EFFECTS OF AGE-RELATED STEREOTYPE THREAT ON EXPLICIT AND IMPLICIT MEMORY PERFORMANCE IN OLDER ADULTS

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While an awareness of age-related changes in memory may help older adults gain insight into their own cognitive abilities, it may also have a negative impact on memory performance through a mechanism of stereotype threat (ST). The consequence of ST is under-performance in abilities related to the stereotype. Here, we examined the degree to which explicit and implicit memory were affected by ST across a wide age-range. We found that explicit memory was affected by ST, but only in an Early Aging group (mean age 67.83), and not in a Later Aging group (mean age 84.59). Implicit memory was not affected in either the Early or Later Aging group. These results demonstrate that ST for age-related memory decline affects memory processes requiring controlled retrieval while sparing item encoding. Furthermore, this form of ST appears to dissipate as aging progresses. These results have implications for understanding psychological development across the span of aging.

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The population of older adults has increased substantially in the last two decades, as members of the "baby boom" generation enter this stage of life. With this increase in numbers, there is also increasing awareness of age-related memory decline in society in general. For example, the term "senior moment," referring to a brief memory lapse in an older adult, was chosen as emerging "Word of the Year" by *Webster's New World Dictionary* in 2000. This term has since become a widely used part of the vernacular. While an awareness of age-related changes in cognition may help older adults gain insights into their own cognitive abilities, this increasing awareness may also have a negative impact on memory performance in older adults through a mechanism of stereotype threat (ST). ST refers to the risk of either being reduced to, or confirming, a negative stereotype about the group to which one belongs (Steele & Aronson, 1995). The behavioral consequence of ST is under-performance in abilities related to the stereotype (Steele & Aronson, 1995). ST has been studied extensively in a laboratory setting, in a number of different populations, and the findings are ubiquitous. Effects of threats to intellectual ability have been found in highly educated African Americans (Steele & Aronson, 1995), women (Adams, Garcia, Purdie-Vaughs, & Steele, 2006; Spencer, Steele, & Quinn, 1999; Steele & Ambady, 2006), chess players (Maass, D'Ettole, & Cadinu, 2008), and, according to a growing literature, older adults when they are made aware of culturally held negative stereotypes associating memory loss and old age (Andreletti & Lachman, 2004; Barber & Mather, 2013a,b; 2014; Chasteen, Bhattacharyya, Horhota, Tam, & Hasher, 2005; Hess, Auman, Colcombe, & Rahhal, 2003; Hess & Hinson, 2006; Hess, Hinson, & Hodges, 2009).

A number of studies have investigated the effects of an age-related memory loss ST on memory performance in older adults (for a review, see Barber & Mather, 2014; Hess & Hinson, 2006). Typically, the stereotype is made explicit by stating to participants that memory has been shown to decline with age and that the study will be investigating this phenomenon. However in other studies, the age-related memory decline stereotype is activated indirectly by presenting words related to the stereotype (e.g., dementia) in an unrelated task before the memory test. Results from both types of ST manipulations reveal that evoking a negative stereotype about age-related memory decline causes older adults' memory performance to covary with degree of activation of the negative aging stereotype, while younger adults' memory performance remains unaffected by the threat manipulation (Hess, Auman, Colcombe, & Rahhal, 2003). This result holds for both the free recall of material (Chasteen, Bhattacharyya, Horhota, Tam, & Hasher, 2005; Hess, Auman, Colcombe, & Rahhal, 2003; Levy, 1996), recognition (Chasteen, Bhattacharyya, Horhota, Tam, & Hasher, 2005; Rahhal, Hasher, & Colcombe, 2001), and false memory suggestibility (Thomas & Dubois, 2011).

Past studies exploring ST effects on older adults' memory abilities have relied almost exclusively on explicit memory measures (but see Mazerolle, Régner, Morisset, Rigalleau, & Huguet, 2012, for a recent study on automatic and controlled memory operations and aging). Explicit memory constitutes the conscious, and usually intentional recollection of prior events and their contextual details; for instance, memories including those elicited by questions such as "what happened to you an hour ago?" or "what were the items on the list you read?" Explicit memory has been linked to the medial temporal lobe, particularly the hippocampus, a brain structure that has also been shown to undergo significant structural and biological changes in old age (Petersen, Jack, Xu, Waring, O'Brien, Smith et al., 2000; Squire, 1992). This form of memory has been dissociated from implicit memory (Graf & Schacter, 1985), the kind of memory that does not require specific conscious recollection of the event. Implicit memory involves the facilitation of performance due to information that was encountered previously, even if there was no conscious attempt or intention to remember the information. Implicit memory, as opposed to explicit memory, produces decreases in activation in different brain areas, including bilateral occipital, inferior temporal, and prefrontal regions (Richardson-Klavehn, Duezel, Henson, & Schott, 2005). Thus, while explicit memory is generally thought to decline in old age, implicit memory may be relatively preserved (see Zacks & Hasher, 2006). ST is generally thought to inhibit performance by reducing executive resources needed to complete the cognitive task at hand (Schmader & Johns, 2003). Schmader, Johns, and Forbes (2008) reported that female college students under threat spontaneously used emotion regulation strategies to control the anxiety elicited by the threat, which lead to a depletion of the executive resources needed to perform the cognitive tasks at hand, resulting in impaired performance. There is substantial evidence that explicit tests differ from implicit ones as they require more controlled, often conceptual, and attention-demanding executive resources that are thought to be impaired with age, and may mechanistically underlie ST effects, whereas implicit tests require automatic processes that are relatively preserved in older adults when compared to younger adults (e.g., Geraci, 2006; Light, Prull, La Voie, & Healy, 2000). Indeed, numerous studies have shown that implicit memory is largely intact in older adults despite the fact that explicit memory is compromised (Gopie, Craik, & Hasher, 2011; Light & Singh, 1987; Mazerolle, Régner, Morisset, Rigalleau, & Huguet, 2012). Given this, if ST in older adults primarily affects conscious memory retrieval processes, resources that are depleted by ST, it may impair explicit measures of memory but spare implicit measures of memory (see also Mazerolle, Régner, Morisset, Rigalleau, & Huguet, 2012). On the other hand, if ST associated with age-related memory decline affects general attention to studied material, or affects general encoding of or access to this material, it may impact implicit measures of memory as well as explicit measures. In the present study, we extended previous findings by testing older adults' implicit memory (using a word stem completion task) and explicit memory (using a cued-recall measure) after they received either an explicit ST manipulation or a neutral manipulation that did not evoke an age-related memory-decline stereotype.

One important factor in studying age-related ST is the likely heterogeneity across the age-range of adults identifying as "older." Individuals in their 50s and 60s may have different attitudes toward age-related stereotypes than older individuals. Indeed, Hess and Hinson (2006) found differences in age-related ST across the age range in older adults. Given this likely heterogeneity, we also set out to assess the effects of ST on implicit and explicit memory across a wide age-range of older adults to allow us to examine possible differences.

METHODS

PARTICIPANTS

Originally, 46 people were recruited to the study, and later the sample size was increased to 71 (18 men, 53 women) to attain a sample size comparable to other studies and to have sufficient power to detect the key interactions. Participants were between 53 and 98 years old (average = 74.68; *SD* = 9.97), with a reported 14.09 (*SD* = 3.17) years of education and reported subjective overall health rating of 6.83 (*SD* = 1.96) out of 10, where 10 was perfect health (one participant failed to report education or health). Nine additional participants were tested, but because they were either missing an instruction page in their booklet (*n* = 7), indicated having a neurological disorder (*n* = 1), or were too young (49 years old, *n* = 1), their data were not scored. The participants were recruited from local senior community centers or random market mailing in the Los Angeles and New York City areas, and testing occurred in local senior centers or in a classroom at the Taub Institute in New York City. Participants were randomly assigned to a memory threat condition (*N* = 37) or a no threat, control condition (*N* = 34). Memory (implicit and explicit) was manipulated within-subjects, while Threat Condition (memory threat and no threat) was manipulated between-subjects. A power analysis revealed that these *N*s were adequate to detect large effect sizes in two-tailed comparisons (Cohen's *d* > .7) with a .8 probability.

MATERIALS

All materials were presented in a paper booklet. Two test book-versions were created, each containing 39 total words/word stems (described below in detail), randomly assigned to be in the implicit old, implicit baseline, and explicit tests. The first page of this booklet presented either a memory threat prime or a no threat control prime. The memory threat prime read: *Many studies have shown that memory gets worse with age. We are interested in testing whether this is true. After you finish completing this booklet, we will give you a short story to read, and we will test your memory for details from this story. But first, we would like you to do some other tasks. Please complete the booklet from front to back (don't flip back or forwards within the booklet), without talking to you neighbors. If you have any questions, please raise your hand and the experimenter will come help you. How old are you?* While the no threat control read: *Please complete the booklet from front to back (don't flip back or forwards within the booklet), without talking to you neighbors. If you have any questions, please raise your hand and the experimenter will come help you.*

After receiving the prime, participants were instructed to provide pleasantness ratings using a 5-level Likert item scale for 26 words. Once they had provided these ratings, which served as the encoding phase of the experiment, the implicit word stem completion task and then the explicit cued-recall tasks were administered, in this fixed order. These memory tasks were modeled directly after Graf, Squire, and Mandler's (1984) seminal work showing a dissociation between the implicit and explicit memory systems in amnesia patients. The implicit memory task instruction read: *Each of the cues on the next page is the beginning of an English word. Please write a few letters to make each into a word. For example, you might see* APP___*. You could make this into* APPLE*. You can write any English word—but please write the first word that comes to mind.* This was followed on the next page by 29 word stems (the first three were not scored and included to eliminate any recency effects), while the remaining 26 word stems, presented in a random order, consisted of 13 word stems from the encoded list (implicit old) and 13 new stems (implicit baseline). This task constituted the implicit memory test. The difference in proportion of stems correctly completed between the implicit old and implicit baseline constituted the implicit memory measure, also sometimes referred to as a "priming score." Participants then received the explicit memory task instruction, presented on the next page: *Each of the cues on the next page is the beginning of one of the words that you made a like/dislike judgment about earlier. Please try to complete the fragment with a word from this list. You can use the cue to help you remember what the word was. Please don't look back at the list*. This was followed on the next page by the presentation, in a random order, of the remaining 13 stems from the previously encoded list. The proportion of correctly completed stems in the cued-recall phase constituted the explicit memory measure. The experiment was self-paced and there was no delay between encoding and test.

WORDS

A total of 39 words and their three-letter word stems were chosen from Graf and Williams's (1987) normed pool for use in the study. The average number of times that the target word that we chose was given as a first-completion in Graf and Williams's (1987) study was 6.76%, and ranged from 1%–27%. The word we chose for each stem was never the 1st or 2nd most common completion given by the participants in Graf and Williams's (1987) study. Words were also separately normed on 12 college students (prior to the current study) to ensure that there was neither a floor nor a ceiling effect of priming, and that approximately 50% of the words could be explicitly recalled in the cued-recall task.

RESULTS

Overall, the completion rate for tested items in both the implicit and explicit tasks was high: participants provided an answer 93.25% of the time. Priming was also successful: the difference in proportion of correct completions of old versus baseline implicit word stems was significant, $t(1, 70) = 5.71$, $p < .001$, such that the proportion correctly completed old word stems was higher than the proportion of correctly completed baseline word stems.

We began by investigating the overall effects of ST on implicit and explicit memory. An ANOVA with Threat Condition (memory threat vs. no threat) as a between-subjects factor and Memory (implicit: proportion old – proportion baseline correctly completed stems vs. explicit: proportion correctly completed cued-recall stems) as a within-subjects factor revealed a significant effect of Memory, $F(1, 69) = 7.77$. $p = .007$, $\eta^2_p = 0.10$. A follow-up paired samples *t*-test revealed that explicit had a higher completion proportion than implicit, $t(70) = 2.69$, $p = 0.009$ (95% CI: 0.02–0.12). Neither the main effect of Threat Condition, $F(1, 69) = 0.29$, nor the Memory × Threat Condition interaction, $F(1, 69) = 2.65$, were significant.

More recently, it has been suggested that age-related memory loss ST varies across the age-range of older adults. Given that the phase of life corresponding to "old age" comprises multiple decades, it is likely that attitudes regarding cognitive decline may be most pronounced as they begin to form in early old age. Hess and Hinson (2006) found that the oldest of their participants were not susceptible to explicit memory-related ST, while there were marginal effects in the younger of the older adults tested. In that study, middle-aged participants actually showed better explicit memory performance with exposure to the age-related memory loss ST, suggesting that in these participants, the contrast between themselves and the older adult stereotype is very salient. Hess, Hinson, and Hodges (2009) found that age-related memory loss ST only impaired explicit memory performance in early aging. These results suggest that aging ST may be most detrimental to individuals at the beginning of old age; the stereotype may be more salient to individuals transitioning to this life stage than to individuals who have become more accustomed to self-identifying as an older adult. At the onset of old age, a person may be more concerned about fulfilling negative stereotypes associated with old age, and thus may be more susceptible to exhibiting deleterious effects when threatened. While individuals may still be aware of these stereotypes as they continue to age, the stereotypes may become less salient and threatening (Hess, Hinson, & Hodges, 2009).

Following previous studies (Hess & Hinson, 2006; Hess, Hinson, & Hodges, 2009; McLaughlin, Connell, Heeringa, Li, & Roberts, 2010), we divided older adult participants into an Early Aging group (< 75years old, mean age 67.8) and a Later Aging group (≥ 75 years old, mean age 84.6). This division corresponded to a median split based on the age of the participants. Previous literature has also used a cutoff of 75 to designate early and later stages of aging (e.g., McLaughlin et al., 2010). There were no significant differences between participants in the Early and Later Aging groups in level of education or health score (*p*s > 0.50).

As is illustrated in Figure 1, an ANOVA with Threat Condition and Age Group (Early vs. Later Aging) as between-subjects factors, and Memory as a within-subjects factor revealed a significant main effect of Memory, $F(1, 67) = 5.62$, $p = 0.02$, $\eta^2_p = .08$ (95% CI = 0.009–0.109), such that explicit had a higher completion proportion than implicit, and a significant three way interaction between Memory × Age Group × Threat Condition, $F(1, 67) = 6.37$, $p = 0.01$, $\eta^2_p = 0.09$. The main effects of Threat Condition, $F(1, 67) = 0.24$, and Age Group, $F(1, 67) = .001$, were not signifi-

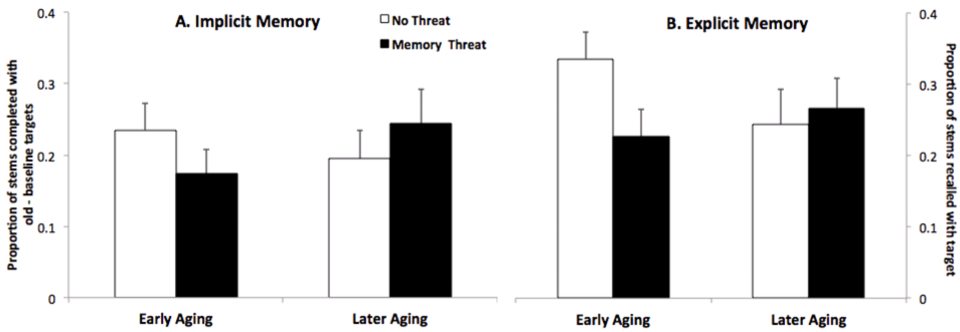

FIGURE 1. Implicit memory (as measured by the proportion of correct word stem completion for old – baseline targets) and explicit memory (as measured by the proportion of correct cued-recall stem completion) performance for Early and Later Aging groups as a function of threat manipulation. Error bars represents standard error of the mean.

cant, nor were any of the two-way interactions: Memory × Threat Condition, $F(1, 67) = 1.5$; Memory × Age Group, $F(1, 67) = 0.84$; Threat Condition × Age Group, $F(1, 67) = 0.01$.[1]

An ANOVA restricted to the Early Aging group revealed a significant main effect of Memory, $F(1, 40) = 8.33$, $p = 0.006$, $\eta^2_p = 0.17$, and a significant interaction between Memory × Threat Condition, $F(1, 40) = 9.97$, $p = .003$, $\eta^2_p = 0.2$. The main effect of Threat Condition was not significant, $F(1, 40) = 0.22$. The analogous ANOVA with the Later Aging group revealed no significant effects: Memory, $F(1, 27) = 0.69$; Threat Condition, $F(1, 27) = 0.07$; Memory × Threat Condition, $F(1, 27) = 0.69$.

Follow up *t*-tests revealed that explicit memory was significantly reduced in the threat condition as compared to the no threat condition for the Early Aging group, $t(40) = 2.21$, $p = 0.035$ (CI = -0.21–0.007). Implicit memory did not differ between the threat and no threat conditions, $t(40) = 0.17$. These results allay any potential concerns about the use of explicit strategies in the implicit test: the implicit measure is unlikely to be "contaminated" by explicit strategies, as it shows a different pattern of results (no effect of threat) than does the explicit cued-recall measure (which does show an effect of ST). These results indicate that the participants in the Early Aging group, unlike those participants in the Later Aging group, showed impaired explicit memory performance following exposure to the age-related ST. Across the Age Groups, implicit memory was unaffected by ST. These findings support the idea that sensitivity to the ST of age-related memory decline is primarily restricted to early aging.

1. To ensure that the significant three-way interaction was not an artifact due to the dichotomization of age, we also conducted a general linear model to test the interaction using Age as a continuous variable. The interaction between Age and Threat Condition significantly predicted the difference between explicit and implicit memory performance, $t(67) = 2.60$, $p < 0.05$. These findings indicate that the critical three-way interaction holds even when we treat age as a continuous variable.

DISCUSSION

In the present study, activating the stereotype that memory declines with age did not affect implicit memory but did reduce explicit memory early in aging, but not later in aging. These results suggest that ST in older adults does not have a general effect on attention or processing the studied words at a lexical level. Rather, the threat appeared to have targeted explicit memory processes such as the deliberate retrieval of contextually specific events early, but not later, in aging. The fact that ST only affected explicit memory performance, and not implicit memory performance, narrows that locus of action of ST to conscious retrieval as on the explicit memory test. Our results indicate that ST in older adults does not impair general encoding processes because word stem completion priming was not affected by this manipulation.

Our findings extend the results of a several related bodies of literature. Light and Singh (1987) tested older and younger adults on either explicit or implicit memory, the only difference in the test coming in the memory-test instruction: in the explicit case, participants were told "to use the word stems to help them remember the correct word from the previously studied list" and in the implicit case were told to "complete each stem with the first word that came to mind." They found significant age differences on the explicit test, but not the implicit test. These results are similar to ours, except that we provided an additional ST manipulation, and we manipulated explicit and implicit memory within subjects, rather than between subjects.

Rahhal, Hasher, and Colcombe (2001) assessed whether testing instructions affected explicit memory performance for older and younger adults. In two experiments, participants were given instructions before a memory test that either highlighted the word "memory" or did not contain the word "memory." They found that explicit memory was affected negatively when older adults were tested under conditions in which language emphasizing the memorial component of the task was used as opposed to in conditions where memory was not directly referenced.

Thomas and Dubois (2011) examined the effects of ST on false memory suggestibility using a procedure similar to ours in which ST was manipulated using a paragraph describing research showing age-related declines in memory after encoding, but prior to retrieval. They found that ST increased older adults' false alarm rates (i.e., erroneously identifying new words that were categorically related to the old word, as old), indicating an impairment in the ability to effectively use individuating, item-specific information (that depends highly on explicit memory) rather than relational processing (referring to gist or categorical processing that may have a lower explicit memory demand) under ST conditions.

Our results fit nicely with the findings of these studies. However, they diverge in a critical way: the "older" adults in these studies corresponded in age to our Early Aging group only, and not to a Later Aging group. The age range in Light and Singh (1987) was 60–76 (mean age 67.7) in Study 1, and 62–78 (mean age 68.3) in Study 2. In Rahhal, Hasher, and Colcombe (2001) the age range was 61–75 (mean age 69.38) in Study 1 and 60–74 (mean age 67.8; Study 2), and in Thomas and Dubois (2011), the range was 60–74 years (mean age 69.8). Thus, these studies did not assess whether the effects of age-related ST change across the age range of older adults.

The finding of ST effects in the Early Aging group, but not later in the Later Aging group, raises interesting questions as to possible differences that emerge across the age-range of older adults. Our results are consistent with the work of Hess and Hinson (2006), and Hess, Hinson, and Hodges (2009), in which the oldest participants did not exhibit evidence of age-related ST. The present results add to this literature in that they demonstrate no effect of ST in the oldest group even under strong ST conditions that result in significant reduction in memory performance early in aging. Perhaps the most likely explanation for the differential effect of ST in early and later aging is that the results are due to differences in self-perception during aging. Participants in the Later Aging group are no longer susceptible to ST of memory loss with age, while those in the Early Aging group are because they are part of fundamentally different groups. It is possible that later in aging, individuals feel that they have already fulfilled the negative stereotype of memory loss, and have habituated to this fact and no longer find it threatening. Earlier in aging, however, individuals may not fully identify with an older age group, and the ST of memory loss in old age is very salient and threatening, which explains the finding of impaired explicit memory performance.

Participants in our study were recruited from community-based centers, and an attempt was made to test a large age-range in order to investigate the effects of ST in different cohorts of older adults. However, given the relatively small sample size in the current study, which did not allow for much test power of small effects, follow-up with a larger sample size would help to determine the precise nature of ST effects across the lifespan. Further, the current stereotype threat instruction was relatively unspecific as to the type of memory being tested. Previous research has shown that ST affects performance on tests directly related to the threatened ability (see Abrams, Eller, & Bryant, 2006; Desrichard & Kopetz, 2005). It is possible that the lack of an effect of ST on implicit memory stems from the fact the participants did not view the implicit memory test as diagnosic of memorial ability. However, it has also been shown that simply informing older adults that younger adults' performance on cognitive tasks will be examined in parallel to their own is adequate to impair memory performance, and thus ST in older adults can be induced without directly mentioning memory decline at all (Mazerolle, Régner, Morisset, Rigalleau, & Huguet, 2012). We suggest that the present results indicate that age-related ST impairs conscious retrieval from memory; because stem completion in the implicit test did not require conscious retrieval from memory, it was not impaired. However, future research could examine the influence of targeted ST activations (e.g., more strongly worded statements of declining memory—such as the potential onset of Alzheimer's disease or forgetting things—vs. difficulties in learning new procedures) on explicit versus implicit memory performance. On the other hand, since age-related ST may be affecting performance to some extent even when it is not explicitly cued, it would also be interesting to investigate whether older adults would benefit from a stereotype boost, in which presenting information that contradicts negative stereotypes of cognitive aging or emphasizes positive effects of aging on cognition—such as knowledge and wisdom—leads to improved memory performance.

One strength of the current study is that we measured the effects of ST in a group of older adults who had not regularly participated in memory studies and who may therefore be more representative of how most older adults behave in the wild. Our results demonstrate that age-related ST effects can be very robust and apparent even when participants are not tested in a laboratory environment, and are particularly striking given that ST was induced through a brief statement about age-related memory decline. Cued-recall in the Early Aging group was reduced by nearly 30%, and was numerically lower than the performance of the much older Later Aging group in the memory threat condition.

These findings have important implications for theories regarding age-group specific ST, and ways to improve memory in old age. Our results demonstrate that at the onset of advanced age, older adults may be particularly sensitive to stereotypes about cognitive aging, and these concerns have the potential to impact performance in daily life. Training methods designed to enhance memory performance in this group should take this into account. These individuals may also tend to feel older, and identify more with aging after poor performance on explicit tests of memory (Geraci & Miller, 2013; Hughes, Geraci, & De Forrest, 2013), but this may not occur with implicit memory tests. Unlike inclusion in a gender or racial group, one must transition to one's identity as an older adult, and this transition phase may be particularly vulnerable to negative effects of aging stereotypes on measures of explicit, but not implicit, memory.

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