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Is Episodic Memory Performance More Vulnerable to Depressive Affect in Older Adulthood?

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Abstract

Aging researchers have been interested in examining how the association between depressive affect and memory function interacts with age, expecting that the effect of depressive symptoms on memory performance would be more pronounced in older adults than in younger adults. This study examined how age, depressive symptoms, frailty, and health factors separately and jointly influence episodic memory across the lifespan in two large, diverse samples: Sample 1 (N=1,204, aged 18–91) and Sample 2 (N=1,332, aged 17–92). For each sample, a hierarchical regression analysis entered: 1) age, depression, and their interaction, 2) demographic variables, 3) frailty and health variables, and 4) interaction terms between age and the predictors. Analyses from both samples showed that depressive symptoms negatively impacted episodic memory performance with the effect being more pronounced for older adults. Common individual difference covariates such as gender, level of education, and ethnicity were related to episodic memory performance. Health and frailty tended not to be associated with episodic memory. However, the main effect of depressive symptoms tended to remain significant over and above other predictors, while the interaction with age was weakened with the addition of individual difference variables. The unique contribution of this study is demonstrating that the relationship between depressive symptoms and episodic memory is moderated by age across relatively large non-clinical lifespan samples of adults. The findings indicate the importance of measuring and studying depressive symptoms during the course of aging in order to better understand the complex relationship between age, affect, physical functioning, and memory.

Keywords

aging; episodic memory; depression; chronic health; frailty

The relationship between depressive affective states and declines in episodic memory later in the lifespan have been well documented (Bierman, Comijs, Jonker, & Beekman, 2005; González, Bowen, & Fisher, 2008). In the current study, we use the traditional definition of episodic memory as memory for past experiences (Tulving, 2002), which has been widely measured by participants' ability to recall or recognize lists of items. However, the mechanisms proposed to underlie age-related decline in episodic memory are complex and include psychological, social, and physiological factors. The evidence appears to be converging on depressive symptoms as being strongly associated with a decline in cognition, and possibly with the onset of dementia, over and above other mental health factors, such as anxiety (e.g. Bierman et al., 2005; Airaksinen, Wahlin, Forsell, & Larsson, 2007; Bunce, Batterham, Mackinnon, & Christensen, 2012), or chronic illness conditions (e.g. Zahodne, Stern, & Manly, 2014). One possibility worth considering is that untreated depressive affect could serve much as chronic stress does in degrading physiological structures (e.g. Esterling, Kiecolt-Glaser, Bodnar, & Glaser, 1994; Segerstrom & Miller, 2004) and contributing to cognitive decline later in life (e.g. Peavy et al., 2009). Therefore, depressive affect should be included in a model of cognitive function with age as it may serve as a marker for decline associated with long-lasting damage to memory performance that is essential for daily living.

Aging researchers have been interested in examining how the association between depressive affect and memory function interacts with age, expecting that the effect of depressive symptoms on memory performance would be more pronounced in older adults than in younger adults (e.g. Allen, Kaut, Baena, Lien, & Ruthruff, 2011; Christensen, Griffiths, Mackinnon, & Jacomb, 1997). One way to conceptualize the interaction is to consider a possible relationship between cognitive abilities and depressive affect. Depressive affect and its sequelae such as ruminative thought (e.g. Nolen-Hoeksema, 2000) might draw attention away from an episodic memory task (e.g. a recall test for lists of items) while one performs the task. When cognitive capacity is near its peak in early adulthood (teens to twenties) (Park et al., 2002), a young adult's cognitive capacity could be adequate to compensate for depressive affect's effects on encoding, storage, and retrieval processes necessary for accurate performance. For instance, switching away from a ruminative thought might occur quickly enough to encode the next item in a list successfully. However, later in adulthood, when cognitive abilities have declined significantly, similar levels of depressive affect may compromise performance significantly. General slowing in speed of processing with age, and specifically, task-switching speed (e.g. Kray & Lindenberger, 2000), might mean that attention does not move quickly enough from a ruminative thought to the next item in the list and it would fail to be encoded.

In their meta-analytic review, Christensen et al. (1997) found evidence supporting the interaction of depressive symptoms with age in samples of depressed individuals. Allen et al. (2011) specifically posited that lower positive affective intensity (assessed by an

extraversion scale) combined with increased age and depressive mood, could be another possible explanation for the interaction between depressive symptoms and age on episodic memory. The age-related decline in affective intensity might lead older adults not to perceive or process their emotional reactions to stimuli with the same intensity as younger adults (i.e., not processing negative emotions and reporting being happier). Thus, it may result in weaker or fewer available cues at encoding, which impairs memory recall at a later time (Allen et al., 2011). In fact, individuals with depression have shown a reduced volume in brain regions associated with episodic memory, such as the medial temporal lobe (e.g. Von Gunten, Fox, Cipolotti, & Ron, 2000) and hippocampus (e.g. Sapolsky, 2000).

However, in contrast to a few studies supporting the existence of the interaction, a failure to find the age by depression interaction on memory performance has been frequently reported (e.g. Fossati, Coyette, Ergis, & Allilaire, 2002; La Rue, Swan, & Carmelli, 1995; Lyness, Eaton, & Schneider, 1994; Niederehe, 1986; Rohling & Scogin, 1993). Reasons for these inconsistent findings in previous studies include differences in “the definition of the severity of depression, selected tasks for studies, methods of testing for age effects, the influence of other cognitive impairments on memory performance and the heterogeneity of normal cognitive aging” (Fossati et al., 2002, p 262). It should also be noted that most of the previous studies have relied on relatively small samples of depressive patients, typically fewer than 50 – 60 depressive patients. Thus another potential reason for a failure to find the hypothesized interaction is that the effect size is small and requires much larger samples than used in prior studies. As noted by McClelland and Judd (1993), detecting interaction effects using regression with correlation data sets requires much larger samples than is the case for detecting interactions in experimental studies that typically use orthogonal comparison groups (e.g., depressive patients, same-age controls).

Considering the limitations of previous studies, we provide a strong test of the interaction hypothesis in this study by using two large life-span samples of adults. We also investigate how age moderation is associated with other social and health factors that have been regarded as critical factors in age-related decline in episodic memory.

Social Factors, Health, and Frailty on the Decline in Episodic Memory in Older Adults

Social factors, such as educational attainment, gender, and ethnicity have also been found in epidemiological and experimental studies to influence cognitive function, including memory, during the aging process (Gomes et al., 2013; Marinho et al., 2010; Small, Dixon, McArdle, & Grimm, 2012). Those who had achieved higher levels of education showed better performance on episodic memory and executive function tasks (Jefferson et al., 2011), suggesting that higher education might be a protective factor for age-related memory decline. Gender effects on episodic memory have been well documented, as women showed higher levels of episodic memory performance compared to their male counterparts (e.g. Herlitz, Nilsson, & Bäckman, 1997; Lachman, Agrigoroael, Tun, & Weaver, 2013; Meinz & Salthouse, 1998; van Hooren et al., 2007). Sachs-Ericsson and Blazer (2005) revealed that African American older adults are particularly vulnerable to cognitive decline and suffer

more often from physical ailments. Furthermore, this group has reported receiving fewer educational opportunities, which has also been shown as a risk factor for cognitive decline (Sachs-Ericsson & Blazer, 2005).

Older adults are more prone to suffer from chronic diseases and disorders, such as hypertension (Wells et al., 1989). Such chronic health conditions are also closely related to age-related decline in episodic memory. Particularly, chronic health conditions in older adults can be associated with neuronal loss in areas of the brain that are highly vulnerable to the aging processes and correlated with higher order function. Those brain regions include the caudate nucleus (Hannestad et al., 2006), which is associated with mood, movement, and motivation regulation, and the hippocampus (Head, Rodriguez, Kennedy, & Raz 2008), which is a region related to long-term memory encoding important for the consolidation of episodic memory. For instance, high blood pressure may damage the small blood vessels in the brain affecting oxygenation and the supply of nutrients to the brain tissue leading to neuronal loss in the critical regions described above (Wardlaw, Smith, & Dichgans, 2013). Earlier work (Fahlander et al., 2000) also found that cardiovascular symptoms related to the onset of heart failure predicted poor performance on episodic memory tasks. These findings suggest that persons with chronic health conditions would show a different pattern of memory performance over the lifespan due to a possible damage in the brain areas associated with mood regulation and memory.

Frailty is another chronic problem associated with aging that has been found to be consistently related to poor cognitive performance (Robertson, Savva, Coen, & Kenny, 2014). Frailty is a multidimensional construct including a wide range of physiological conditions that can leave an older adult in a vulnerable state (Fried, Ferrucci, Darer, Williamson, & Anderson, 2004). While frailty is difficult to define as it is often confused with disability (the need for assistance in activities of daily living); there is some agreement and growing evidence that frailty and disability should be thought of as separate constructs. For example, one prevalent symptom in older adults is the loss of muscle mass. The weakening of some muscle mass does not mean that one cannot carry out activities (disability), but that such activities may require increased effort, difficulty, and the concomitant vulnerability for injury. Some older adults may also believe that they do not have the physical resources to cope with daily living, which can lead to depressed moods. In fact, depressive symptoms and frailty are often comorbid conditions (St. John, Tyas, & Montgomery, 2013). Furthermore, people who are more frail than average often believe they are limited in their abilities and suffer from a higher number of chronic health conditions (Fried et al., 2004). Therefore, it can be important to take into account older adults' perceptions of their physical health and frailty when investigating the relationship between depressive symptoms and cognitive function.

Present Study

To summarize, there is inconsistency across studies for the presence of an interaction of age with depressive affect on memory performance, and a lack of evidence of the interaction in samples of non-clinical as opposed to clinical populations. Our major goal was thus to investigate the potential interaction effect of age and depressive affect on episodic memory

in non-clinical adults rather than in clinical patients, using cross-sectional data from two separate, and relatively large, adult lifespan samples. The current study also explored the joint relationships between age, depressive symptoms, episodic memory, and individual differences in comorbid physical health factors. The analysis was guided by three predictions based on the body of evidence discussed above which shows that depressive symptoms, physical frailty, ethnicity, lower levels of education, and poor health negatively impact memory performance.

First, we predict that age and depressive symptoms will interact, such that those individuals with more depressive symptoms will have a lower memory capacity and that the effect should be more pronounced for older adults. Our prediction of an interaction for age and depressive symptoms is based on the assumption that younger adults have a greater cognitive reserve to draw on when dealing with any effects of depressive symptoms. Second, it is expected that higher levels of education and female gender will protect episodic memory over and above depressive symptoms. Self-identified ethnicity will also be included in the model to assess if it would account for episodic memory performance after controlling for the other individual difference factors. Third, we predict that chronic health conditions and physical frailty, which are often related to depressive symptoms, will also be associated with a decline in episodic memory performance. Similar to the issue of depressive symptoms, we also predict that the frailty effect will be more pronounced for older adults who have more limited cognitive resources than younger adults.

Methods

Participants

Sample 1.—Participants were recruited from January 2000 thru November 2004 in three metropolitan areas of the Southeastern United States. The sample included 1,204 community-dwelling adults (454 males, 750 females) aged 18 to 91 ($M = 46.9$, $SD = 21.9$). The protocol was standard across all sites and local review boards in each area approved the protocol prior to data collection and recruitment. Potential participants were located through in-person contact, senior organizations, printed media, television, and radio advertising. Each interested person called in, and, after providing oral informed consent, was pre-screened for cognitive impairment over the telephone using the Short Portable Mental Status Questionnaire (Pfeiffer, 1975) and the Wechsler Memory Scale (Logical Memory subscale; age-adjusted criterion; Wechsler, 1997). The phone interview also had items to check for corrected hearing and vision, as well as proficiency in the English language. Eligible and interested participants then reported to the local study site where written informed consent took place. The eligible participants were also screened for psychic distress (a score of below 81 on the Brief Symptom Inventory [BSI]; Derogatis, 1994). Trained personnel administered a battery of measures in paper and pencil format. Participants who were not university students were paid a small stipend while university students received course credit as compensation. Details of the protocol have been published elsewhere (see Czaja et al., 2006).

Sample 2.—The second sample was recruited during July 2005 thru June 2009 in the same three metropolitan areas as described for sample 1. Care was taken to ensure that no person was included in both samples. Sample 2 included 1,332 persons (519 males, 813 females) aged 17 thru 92 ($M = 44.2$, $SD = 25.4$) years. The same protocol used in sample 1 was applied to sample 2 except for that the BSI was not used to screen for psychic distress. Both samples are described further in Tables 1 and 2.

Data from the United States Census Bureau (2010) shows that 72 percent of people identified as White, 13 percent as Black or African American, 6 percent as Other, 5 percent as Asian, 3 percent as Multi-Racial, 0.9 percent as American Indian and Alaska Native, and 0.2 percent as Native Hawaiian and Other Pacific Islander. In the 2010 Census, Hispanic origin was considered to be a separate concept from race and 16 percent of the total population identified as Hispanic in the Census. Efforts to include minority participants were largely successful in both samples and the proportion of minorities of older adults in particular appears representative of the U.S population in both samples.

Measures

Episodic Memory.—Participants completed the delayed and immediate California Verbal Learning Test (CVLT) designed by Delis and colleagues (1987) and the Meaningful Memory Measure developed by the Institute for Personality and Ability Testing (Hakstian & Cattell, 1982). The CVLT administration consisted of an oral presentation of a list of 16 words for five immediate-recall trials. Then, following an interpolated task lasting about 20-minutes, participants were given a delayed recall test. For the meaningful memory test, participants were given a list of 20 thing-description word pairs (e.g. roof – flat) to study. Following an interpolated task lasting about 20 minutes, participants were given the list of 20 thing words and asked to pick a synonym of the description word originally paired with each thing word from a list of 5 description words (e.g. roof – level, rough, sloping, leaky, sturdy). The CVLT is one of the most common episodic memory assessment measure used by clinical neuropsychologists (Woods et al., 2006). Czaja et al. (2006) showed that the CVLT and the Meaningful Memory test scores measured a very similar construct of memory. Specifically, high factor loadings from the Meaningful Memory test (.72) and the CVLT scores (.75, .72) was reported when a latent memory factor was generated based on those scores. In our samples, significant correlations between the both types of CVLT (immediate and delayed recall) and the Meaningful Memory test scores were found across Sample 1 ($r = .54$, $.47$) and Sample 2 ($r = .62$, $.58$). The composite score for episodic memory performance was the mean of the three standardized (z-scored) measures from the two (CVLT) measures (immediate, delayed recall scores) and the meaningful memory score. The measures chosen are widely used in the literature and have been shown to have good psychometric properties (Czaja et al., 2006).

Depressive Symptoms.—Participants completed the Center for Epidemiologic Studies —Depression (CES-D) Scale (Radloff, 1977). Scores on the CES-D range from 0 to 60 and a score of 16 or above indicates elevated depressive symptoms. Data from the National Institute of Mental Health (NIMH, 2014) shows that 9.3 percent of those aged 18–25 years experienced a major depressive episode compared to 7.2 percent for those aged 26–49 years

and 5.2 percent for those 50 years of age and older. As shown in Tables 1 and 2, our samples show a higher proportion of depressive affect (over 16 on the CES-D) than the national averages while replicating the national trend of older adults (60 – 92 years) generally showing lower levels of depressive affect than those in the middle (40 – 59 years) and younger (17 – 39 years) age groups.

Physical Frailty.—Participants completed the 10-item Physical Functioning Scale, selected self-report items from the Medical Outcomes Study 36 Item Short Form (SF-36), and an additional item modified from the Social Function Subscale (which asked how often health problems prevented them from doing things they wanted to do) that were administered by the research team. The remaining 10 items used the original SF-36 response choices from 1 (limited a lot) to 3 (not limited at all) to determine if health burdens limited their ability to complete physical activities like walking one block and climbing stairs, as well as difficulties completing activities of daily living such as bathing and dressing (Ware & Sherbourne, 1992). The score could range from 11 to 35 with lower scores indicating poor mobility and difficulty with activities of daily living, which has been previously described as frailty (St. John et al., 2013).

Perceived Health.—Participants also completed 3 modified items based on the SF-36 Health Perceptions Subscale in order to assess their general health and health for their age (poor to excellent) and satisfaction with their health (not at all satisfied to extremely satisfied) on a 5-point Likert-type scale (Czaja et al., 2006). The scale ranged from 3 to 9 with higher scores indicating better-perceived health.

Chronic Conditions.—Participants were presented a list of common chronic conditions including high blood pressure, asthma or bronchitis, diabetes, epilepsy, heart problems, rheumatoid arthritis, and stroke. They indicated (Yes/No) if they had ever been diagnosed with each condition. The range of possible scores was from 0 to 8 with lower scores indicating fewer chronic conditions. Correlations between these outcome measures and age are provided in Table 3.

Other Covariates.—Gender (coded as 0 for males and 1 for females), self-reported ethnicity and educational attainment (i.e., high school or college graduate) were also included in the analysis with each higher level of education achieved having a higher number. Those who had not completed high school were assigned an education category of one, and each level (e.g., some college, bachelor's degree) increased the category by one up to attainment level six, or the level of a doctoral degree.

Analytic Strategy

Data were analyzed using PASW/SPSS 18 (IBM Corp., Armonk, NY). A block-wise hierarchical regression analysis was done in four steps, guided by the literature. To investigate age moderation on the relationships between the other predictors and episodic memory, we generated interaction terms between age and the corresponding predictors. In the first block, we predicted episodic memory with age, depressive symptoms, and the age by depressive symptoms cross-product term (becomes the interaction term). The potential

covariates of gender, ethnicity, and education thought to protect episodic memory were added to the second block. Health covariates of perceived health, frailty, and number of chronic conditions were added to the third block. The fourth block included the addition of the cross-product terms (interactions) between age and 1) gender 2) chronic conditions 3) perceived health and 4) frailty. Since several higher order interaction terms were included in the model; all continuous variables were *z*-scored and all categorical variables were dummy coded with the group serving as the reference category noted in Tables 3 and 4. It should be noted that age was treated as a continuous variable in the following analyses. The tables and figures treated age as an ordinal variable using the age groups in order to increase ease of interpretation of descriptive statistics as well as the interaction pattern. Missing data points were excluded using the pairwise method in SPSS.

Results

Tables 4 and 5 show the results from the block-wise hierarchical regression analysis. The beta weights are shown, and, since all variables were *z*-scored, each weight reflects standard deviation units. The *p*-values are shown for each weight and the increment in the amount of variance (%) accounted for the addition of each block is shown along with the respective *p*-value.

Sample 1

As shown in Table 4, the hypotheses for the effect of depressive symptoms on episodic memory and the interaction with age were supported. The significant main and interaction effects of depressive symptoms indicate that a higher number of depressive symptoms negatively impacted episodic memory. The interaction term suggests the effect was more pronounced for older adults. Figure 1 shows the interaction with scores at -1 , 0 and $+1$ standard deviation units for the CES-D. As illustrated in Figure 1, depressive symptoms had little effect on episodic memory in younger adults, but reduced performance in middle-aged and older adults (about 0.4 – 0.5 SD units comparing low to high depressive symptoms).

Demographic Variables.—The addition of gender, education level, and ethnicity accounted for a significant amount of additional variance. The prediction that depressive symptoms and the interaction with age would affect episodic memory over and above gender and education was supported. The effect of gender on episodic memory, with better episodic memory by females, replicated what was found in other studies. Table 4 demonstrates the protective factor of education. Those who had achieved lower levels of education showed significantly poorer memory performance compared with those who attained higher levels of education. The negative impact associated with being a member of a minority group (e.g. African American, Multi-Racial, Other ethnicity) on episodic memory was also found in this sample.

Health Conditions and Frailty.—It was expected that the burden of chronic conditions, physical frailty, and worse perceived health compared to others would negatively impact episodic memory performance. The addition of these variables contributed a significant amount of variance. However, only the beta weight for frailty reached significance level,

supporting the negative impact of frailty on memory performance. The addition of these variables weakened the interaction of depressive symptoms with age, including the main effect of depressive symptoms. However, the effects of age, gender, education, and ethnicity remained significant.

Interactions.—In sample 1, the addition of interaction terms beyond block 3 did not account for a significant amount of variance. The protective effect of female gender was not more pronounced for older adults either. The evidence also did not support the predicted negative impact of poor health factors on memory performance of older adults. The effect of depressive symptoms and the interaction of it with age were still not significant while the effects of age, gender, education, and ethnicity remained significant.

Sample 2

Again, as shown in Table 5, the hypothesis that the effect of depressive symptoms on episodic memory impacts older adults more than younger adults was supported. A higher number of depressive symptoms negatively impacted episodic memory. The effect was more pronounced for older adults, though only significantly so for the model shown in Block 1 using age, CES-D, and their interaction, without the additional predictors (see Figure 2).

Demographic Variables.—As with sample 1, the addition of gender, education level, and ethnicity in block 2 accounted for a significant amount of variance. The effects of age and depressive symptoms on episodic memory after controlling for the demographic variables remained significant, whereas the interaction of depressive symptoms with age was not significant with the addition of the demographic variables. The protective effects of female gender, higher education, and the negative impact associated with being a member of African American or other ethnicity on episodic memory were also found in sample 2.

Health Conditions and Frailty.—As seen in sample 1, the failure to find an effect from the burden of chronic conditions on episodic memory performance in block 3 was replicated. The interaction of depressive symptoms with age was still not significant, whereas the main effects of age, depressive symptoms, gender, education, and ethnicity remained significant.

Interactions.—In contrast to sample 1, the addition of interaction terms beyond block 3 did account for a significant amount of variance. In sample 2, the effect of frailty trended in the expected direction over the lifespan, as supported by the significant interaction between age and frailty, suggesting that the effect of frailty was more harmful to episodic memory performance in older adults. The results for sample 2 also differed from sample 1 in that identifying as female protected episodic memory over the lifespan: the significant interaction between age and gender. However, as found in sample 1, the interaction between age and depressive symptoms was still not significant, while the main effects of age, depressive symptoms, gender, education and ethnicity remained significant. The failure to find the interactions between age and the other two health factors (i.e. chronic conditions and perceived health) was also replicated in sample 2.

Discussion

The main purpose of the study was to investigate the relationship between depressive symptoms and episodic memory over the lifespan with the expectation that older adults, who often have lower rates of depressive episodes, would be more negatively impacted in episodic memory performance by depressive symptoms. The data also afforded the opportunity to examine the relationship with the specific covariates of gender, education, ethnicity, frailty, and health that had been shown previously as protective and risk factors for memory decline.

Our new contribution to the currently available evidence in the field is demonstrating that the relationship between depressive symptoms and episodic memory is moderated by age across the adult lifespan. Young adults, who tended to show more depressive symptoms than older adults, showed little or no relationship between depressive symptoms and episodic memory performance. Middle-aged, and particularly older adults showed much stronger associations between depressive symptoms and episodic memory performance. Interestingly, the high level of depressive symptoms in young adults is inconsistent with the assumption that lower states of positive affect (e.g. higher depressive mood) is often associated with increased age, which would result in poor recall from long-term memory (Allen et al., 2011). Given that young adults with more depressive symptoms did not show a significant relationship between depressive symptoms and episodic memory performance, another possible explanation is that vulnerability for the effect of depressive symptoms on episodic memory would increase with adult age. It is also conceivable that young adults were not susceptible to motivation-related symptoms of depression that might impair sustained attention and elaborative encoding and retrieval processes for long-term memory (e.g. Bäckman & Forsell, 1994; Bäckman, Hill, & Forsell, 1996). Another effect that was robust across samples was the negative impacts of depressive symptoms on memory performance in older adults being weakened by the addition of some individual difference factors (e.g. gender, education, and ethnicity) and health variables.

Another contribution of the current study is the replicability of the interaction (using just age, depressive affect and their interaction as predictors of memory performance) and the main effects across two large, diverse samples. Given the inconsistent findings on the interaction of depressive symptoms with age on cognitive function, it is particularly interesting that we successfully replicated the interaction effect across samples. It should be further noted that in contrast to previous studies we used relatively large samples of normal functioning adults instead of using depressive patients. It would be informative to see if the interaction of depressive symptoms with age on memory performance in non-clinical adult samples is replicated in other studies. Also, consistent with prior work (Bierman et al., 2005; González et al., 2008; Sachs-Ericsson, Joiner, & Blazer, 2008), a main effect of depressive symptoms was found in both samples with higher levels predicting lower episodic memory performance over the theoretically-relevant covariates such as ethnicity (Sachs-Ericsson & Blazer, 2005), frailty (St. John, Tyas, & Montgomery, 2013), education (Jefferson et al., 2011), and gender (Lachman et al., 2013). Increasing age was associated with lower episodic memory performance in both samples and this finding is also consistent with prior studies (Piolino et al., 2002; Verhaeghen & Salthouse, 1997). Moreover, while the main effect of

depressive symptoms remained, higher education was related to better performance (Jefferson et al., 2011). Females were generally superior in episodic memory performance relative to men (Herlitz et al., 1997; Lachman et al., 2013; Meinz & Salthouse, 1998; van Hooren et al., 2007). Finally, consistent with prior findings, poorer episodic memory performance was reported in several ethnic minorities across the lifespan in comparison to the ethnic majority after other effects were accounted for (Sachs-Ericsson, & Blazer, 2005). Future studies are needed to isolate the mechanisms behind the benefits of education and female gender and the risk factors faced by ethnic minorities.

Interestingly, inconsistent with our expectation, the negative effect of chronic health on memory was not found after controlling for demographic factors (i.e. gender, education, & ethnicity) in either sample. The negative impact of frailty on memory was only found in sample 1. These findings might be associated with the fact that the samples exhibited relatively low levels of frailty (i.e. high scores on the frailty measure) and chronic conditions. Another possible explanation is that the current study relied on self-report of health conditions and frailty as opposed to a review of medical records or measurement of physical function by a trained therapist. Participants who were having difficulty remembering may not have recalled which medical conditions they had been previously diagnosed with or could have overestimated their physical ability. While the SF-36 measure is widely used and has good properties, more sensitive measures of health, cardiovascular disease in particular, and physical functioning might have permitted a more sensitive test of negative effects of ill health. It will be necessary to see if the effects of chronic health and frailty on memory performance can be found with a more direct assessment of medical conditions and physical function.

Another novel finding was the interaction between age and gender for episodic memory performance found in one of the two samples. Identifying as female gender acted as a greater protective factor later in life only in sample 2 ($p = .046$). In fact, the protective effect of female gender on episodic memory has been reported regardless of age and previous studies have not been successful in demonstrating evidence of an interaction between age and gender on episodic memory performance (e.g. Herlitz, Nilsson, & Bäckman, 1997; Meinz & Salthouse, 1998; van Hooren et al., 2007). However, caution is needed in generalizing to the population as around 60% of both samples were female, which does not represent the actual proportion found in the population. According to the most recent U.S. census data (Howden & Meyer, 2011) the overall male to female ratio was 49.1 percent male in 2000 and 49.2 percent male in 2010. Howell and Meyer (2011) found that the population of males aged 60 and older also grew during the decade, noting that, "Males aged 60 to 74 increased by 35.2 percent while their female counterparts increased by 29.2 percent. A narrowing of the mortality gap between men and women at older ages in part accounts for this difference (p.4)." Therefore, a disproportionate gender representation might be one possible explanation for this interaction.

A caveat from this study is that our samples had a higher proportion of depressive affect (over 16 on the CES-D) than the national averages and the participants in sample 2 were not screened with the BSI. Thus, our samples might still include some individuals with relatively higher depressive symptoms and/or the other types of psychiatric conditions. It should also

be noted that, except for the effect of age, the significant beta weights of predictors were modest in terms of the amounts of variance accounted for in both samples. However, the fact that there were measureable effects of variables in both samples is still important. It is also noteworthy that at the time that both studies were conducted, none of these variables were under primary investigation, helping to avoid experimenter and participant bias.

Another caveat from this study is that there was an inconsistent pattern of interactions between the two samples. The interaction between age and depressive symptoms became statistically insignificant after controlling for the demographic variables (at Block 2) in sample 2 although it was still significant in sample 1. Also, the interactions of age with gender, and with frailty were found only in sample 2. One way to interpret the differences is to consider relationships between age and the other variables. As many people note, age can be a proxy variable for other proximal variables (e.g. health condition, frailty) that are related to outcome variables associated with age-related decline in cognition. Thus, when a relationship such as the interaction between age and depressive symptoms on episodic memory performance is weakened by adding the other significant predictors to the equation, it is suggestive that those predictors also carried some of the age variance. Similarly, the interaction of age with gender, and with frailty appeared to be not consistent enough to be statistically significant over and above the other factors in both samples. The fact that the level of frailty in older adults was higher in sample 2 ($M = 28.85$, $SD = 5.26$) than in sample 1 ($M = 29.53$, $SD = 4.66$) might be another possible reason for why the interaction was found only in sample 2, $t(971) = 2.13$, $p = .03$. But, it is still unclear why the demographic variables had less impact in sample 1 than sample 2. One candidate was a possible difference in distribution of demographic variables between the two samples given that female gender and higher educational attainment might be the protective factor for age-related decline in memory. For instance, the proportion of female gender was a little higher in sample 2 (61%) than in sample 1 (58%). However, chi-square tests did not support significant difference in the distribution of gender or education level between the two samples. In sum, the inconsistent patterns of interactions between the samples implies that while those interactions are theoretically meaningful as an indicator of age moderation, they may not be clinically significant for a population of community-dwelling older adults. To further clarify possible mechanisms underlying the differences in the interactions investigators should first look to see if these interactions can be replicated elsewhere.

In summary, the current study examined the relationship between age, depressive symptoms, and episodic memory in two large and diverse non-clinical lifespan samples of adults. The unique contribution of this study concerns how the relationships between depressive symptoms and episodic memory are moderated by age after controlling for the other variables. In both samples, the effect of depressive symptoms on episodic memory performance was more pronounced for older adults, suggesting that depressive symptoms are more harmful to episodic memory performance later in the adult lifespan. This is in line with a hypothesis that general capacity for cognition declines with age, hence challenges to cognition from additional factors, such as depressive affect, have stronger impact later in adulthood. It is also possible that depressive symptoms would provoke a cumulative negative influence on cognition that would be observed more noticeably later in life similar to that of chronic stress. Longitudinal, rather than cross-sectional studies are needed to test this

hypothesis, and studies could also probe learning strategies. Nonetheless, the results support the claim that depressive symptoms should be included as part of the large and complex list of variables that negatively impact cognition during the aging process.

Our results are also consistent with the view that normative age changes in the brain affecting episodic memory performance may be influenced by depressive symptoms, gender, education, and minority status, although further studies are necessary to clarify mechanisms underlying the effects of those factors. Another possibility is that for older adults both increased depressive symptoms (rarer in older adults than younger ones) and poor episodic memory (more prevalent in older than younger adults) are being driven by a common factor, such as negative changes in brain physiology associated with disease processes such as cardiovascular disorders or early-stage dementia. Longitudinal studies would be needed to assess this latter hypothesis. These findings also suggest the possibility that interventions with older adults aimed at improving depressive symptoms may also have positive spillover effects on episodic memory performance. Taken together, the findings indicate the importance of measuring and studying depressive symptoms during the course of aging in order to understand the complex relationship between age, affect, physical functioning, and cognition.

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Figure 1.

Interaction of age and depressive symptoms on memory performance for sample 1. Low, medium, and high depressive symptoms represent -1, 0, and +1 SD units.

Figure 2.

Interaction of age and depressive symptoms on memory performance for sample 2. Low, medium, and high depressive symptoms represent -1 , 0 , and $+1$ SD units.

Table 1.

Descriptive Statistics of Sample 1

Measures	Younger (17–39)	Middle aged (40–59)	Older (60–92)
Sample size	470	273	461
Age (<i>M, SD</i>)	22.02 (4.69)	49.93 (4.50)	70.49 (5.12)
Sex			
Male	177	97	180
Female	239	176	281
Education			
<High School	7	11	10
High School	83	25	58
Some College	349	109	143
Bachelor's Degree	26	75	138
Master's Degree	4	39	75
Doctoral Degree	1	14	37
Ethnicity (<i>N, %</i>)			
African American	71 (15)	67 (25)	49 (11)
American Indian/Alaska Native	4 (.85)	1 (.37)	3 (.65)
Asian/Pacific Islander	45 (10)	4 (1)	3 (.65)
Hispanic Latino	78 (17)	34 (13)	23 (5)
Multi-Racial	14 (3)	7 (3)	2 (.44)
White/Caucasian	242 (52)	156 (57)	373 (81)
Other	16 (3)	4 (1)	6 (1)
CES-D (<i>M, SD</i>)	10.37 (7.00) ¹	9.41 (7.68)	7.78 (6.04) ²
<i>N</i> of CES-D >=16 (%)	107 (22.8)	60 (22.00)	51 (11.06)
Chronic Conditions (<i>M, SD</i>)	.450 (.951)	.878 (1.18)	1.37 (1.34)
Perceived Health (<i>M, SD</i>)	11.72 (2.45)	10.89 (2.80)	11.39 (2.49)
Frailty (<i>M, SD</i>)	33.35 (2.82)	30.60 (5.15)	29.53 (4.66)

Note.

¹Four participants did not complete the measure.²Nine participants did not complete the measure.

Table 2.

Descriptive Statistics of Sample 2

Measures	Younger (17–39)	Middle aged (40–59)	Older (60–92)
Sample size	687	91	554
Age (<i>M, SD</i>)	20.52 (3.00)	52.88 (4.86)	72.18 (6.80)
Sex			
Male	287	26	206
Female	400	65	348
Education ¹			
<High School	6	9	20
High School	173	16	75
Some College	440	37	185
Bachelor's Degree	53	16	140
Master's Degree	13	10	99
Doctoral Degree	1	3	33
Ethnicity (<i>N, %</i>)			
African American	127 (19)	34 (37)	87 (16)
American Indian/Alaska Native	1 (.15)	0 (0)	0 (0)
Asian/Pacific Islander	90 (13)	3 (3)	2 (.36)
Hispanic Latino	80 (12)	29 (32)	67 (12)
Multi-Racial	18 (3)	0 (0)	6 (1)
White/Caucasian	350 (52)	24 (26)	381 (69)
Other	19 (3)	1 (1)	11 (2)
CES-D (<i>M, SD</i>)	12.07 (8.93) ²	12.79 (10.04)	9.60 (7.55) ³
<i>N</i> of CES-D ≥ 16 (<i>N, %</i>)	175 (25.47)	31 (34.06)	106 (19.13)
Chronic Conditions (<i>M, SD</i>)	.328 (.630)	1.43 (1.31)	2.01 (1.31)
Perceived Health (<i>M, SD</i>)	11.81 (2.18)	10.85 (2.68)	11.18 (2.43)
Frailty (<i>M, SD</i>)	33.30 (2.61)	29.64 (5.25)	28.85 (5.25)

Note.

¹Three participants did not report education level.²Eight participants did not complete the measure.³Thirteen participants did not complete the measure.

Table 3.

Correlations between Age and the Outcome Measures

Variables	1	2	3	4	5	6
Sample 1						
1 Age	-					
2 CES-D	-.17**	-				
3 Chronic Conditions	.34**	.08**	-			
4 Perceived Health	-.06*	-.31**	-.31**	-		
5 Frailty	-.38**	-.17*	-.38**	.51**	-	
6 Episodic Memory	-.47**	.01	-.18**	.09**	.26**	-
Sample 2						
1 Age	-					
2 CES-D	-.12**	-				
3 Chronic Conditions	.64**	.03	-			
4 Perceived Health	-.14**	-.32**	-.34**	-		
5 Frailty	-.48**	-.17**	-.57**	.48**	-	
6 Episodic Memory	-.56**	-.03	-.37**	.12**	.32**	-

*
p < .05**
p < .01

Table 4.

Hierarchical Regression Analyses on Episodic Memory Performance in Sample 1

Predictors	Increment R^2	β	P^I
Block 1			
Age		-.48	<.001
CES-D		-.08	.004
Age X CES-D		-.06	.017
Block 2 (Demographic Variables)	.15		<.001
Age		-.60	<.001
CES-D		-.06	.008
Age X CES-D		-.05	.045
Sex (M=0, F=1)		.20	<.001
Education		.17	<.001
Ethnicity ^I			
African American		-.26	<.001
American Indian/Alaska Native		-.03	.147
Asian/Pacific Islander		-.04	.118
Hispanic Latino		-.18	<.001
Multi-Racial		.00	.976
Other		-.09	<.001
Block 3 (Health)	.01		.025
Age		-.56	<.001
CES-D		-.05	.074
Age X CES-D		-.04	.081
Sex (M=0, F=1)		.21	<.001
Education		.16	<.001
Ethnicity ^I			
African American		-.26	<.001
American Indian/Alaska Native		-.03	.160
Asian/Pacific Islander		-.04	.102
Hispanic Latino		-.19	<.001
Multi-Racial		.00	.874
Other		-.09	<.001
Chronic Conditions		-.00	.927
Perceived Health		-.01	.727
Frailty		.09	.006
Block 4 (Interactions)	.00		.541
Age		-.58	<.001
CES-D		-.05	.077
Age X CES-D		-.03	.194
Sex (M=0, F=1)		.21	<.001

Predictors	Increment R^2	β	P^1
Education		.17	<.001
Ethnicity ¹			
African American		-.26	<.001
American Indian/Alaska Native		-.03	.181
Asian/Pacific Islander		-.04	.075
Hispanic Latino		-.18	<.001
Multi-Racial		.00	.904
Other		-.09	<.001
Chronic Conditions		.00	.884
Perceived Health		-.01	.845
Frailty		.08	.017
Age X Sex		.03	.265
Age X Chronic Conditions		-.00	.895
Age X Perceived Health		.03	.244
Age X Frailty		.00	.909

Note.

¹The significant p-values are highlighted in bold.

²White/Caucasian is the reference group.

Table 5.

Hierarchical Regression Analyses on Episodic Memory Performance in Sample 2

Predictors	Increment R^2	β	P^I
Block 1			
Age		-.57	<.001
CES-D		-.10	<.001
Age X CES-D		-.05	.042
Block 2 (Demographic Variables)	.10		<.001
Age		-.64	<.001
CES-D		-.06	.010
Age X CES-D		-.02	.314
Sex (M=0, F=1)		.19	<.001
Education		.18	<.001
Ethnicity ^I			
African American		-.20	<.001
American Indian/Alaska Native		.00	.940
Asian/Pacific Islander		-.04	.080
Hispanic Latino		-.03	.168
Multi-Racial		-.05	.048
Other		-.08	.001
Block 3 (Health)	.01		.535
Age		-.61	<.001
CES-D		-.06	.019
Age X CES-D		-.02	.360
Sex (M=0, F=1)		.19	<.001
Education		.18	<.001
Ethnicity ^I			
African American		-.20	<.001
American Indian/Alaska Native		-.01	.916
Asian/Pacific Islander		-.04	.070
Hispanic Latino		-.04	.139
Multi-Racial		-.05	.042
Other		-.08	<.001
Chronic Conditions		-.03	.423
Perceived Health		-.02	.409
Frailty		.03	.338
Block 4 (Interactions)	.01		.028
Age		-.60	<.001
CES-D		-.05	.041
Age X CES-D		-.03	.323
Sex (M=0, F=1)		.19	<.001

Predictors	Increment R^2	β	P^1
Education		.18	<.001
Ethnicity ¹			
African American		-.20	<.001
American Indian/Alaska Native		.00	.886
Asian/Pacific Islander		-.05	.043
Hispanic Latino		-.03	.171
Multi-Racial		-.05	.034
Other		-.08	.001
Chronic Conditions		-.04	.238
Perceived Health		-.03	.349
Frailty		.07	.060
Age X Sex		.05	.046
Age X Chronic Conditions		.01	.529
Age X Perceived Health		.04	.141
Age X Frailty		-.07	.034

Note.

¹The significant p-values are highlighted in bold.

²White/Caucasian is the reference group.