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Anxiety symptoms bias memory assessment in older adults

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Abstract

Background—Older adults with anxiety and/or depression experience additional memory dysfunction beyond that of the normal aging process. However, few studies have examined test bias in memory assessments due to anxiety and/or depressive symptoms. The current study investigated the influence of self-reported symptoms of anxiety and depression on the measurement equivalence of memory tests in older adults.

Method—This is a secondary analysis of the Advanced Cognitive Training for Independent and Vital Elderly dataset, a randomized controlled trial of community-dwelling older adults. Baseline data were included in this study ($n = 2802$). Multiple indicators multiple causes modeling was employed to assess for measurement equivalence, differential item functioning (DIF), in memory tests.

Results—The DIF was present for anxiety symptoms but not for depressive symptoms, such that higher anxiety placed older adults at a disadvantage on measures of memory performance. Analysis of DIF impact showed that compared with participants scoring in the bottom quartile of anxious symptoms, participants in the upper quartile exhibited memory performance scores that were 0.26 standard deviation lower.

Conclusion—Anxious but not depressive symptoms introduce test bias into the measurement of memory in older adults. This indicates that memory models for research and clinical purposes should account for the direct relationship between anxiety symptoms and memory tests in addition to the true relationship between anxiety symptoms and memory construct. These findings support routine assessments of anxiety symptoms among older adults in settings in which cognitive testing is being conducted.

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Conflict of interest

None declared.

Keywords

older adults; memory; anxiety; DIF; MIMIC modeling

Normal aging is associated with a decline in memory (for review, see Hedden and Gabrieli, 2004). Additionally, aspects of memory performance may be disrupted by neuropsychiatric symptoms, such as anxiety and depression. Older adults experiencing depressive symptoms exhibit poorer concurrent performance on memory tasks (e.g., Gallo *et al.*, 2003; Bearden *et al.*, 2006; Rexroth *et al.*, 2013) and greater decline in memory performance over time (e.g., Spira *et al.*, 2012; Zahodne *et al.*, 2014). Although less is known about the detrimental effects of anxiety symptoms on memory among older adults, higher anxiety has been linked with poorer memory (e.g., Butters *et al.*, 2011), particularly when it is comorbid with depression (Kizilbash *et al.*, 2002; Beaudreau and O'Hara, 2009; Lyche *et al.*, 2011). Moreover, memory impairment in late life shares neurobiological roots with anxiety and depression (Naismith *et al.*, 2012), which can lead to subsequent development of anxiety and depression (e.g., Steinberg *et al.*, 2008). Given these findings, it is important to establish accurate measurement of memory performance across varying levels of anxious and depressive symptoms, particularly sub-threshold levels. We need to have non-biased tests in order to improve our understanding of memory functioning. Memory abilities are complex and can generally be broken into immediate and delayed recall. Assessment of memory functioning can include verbal and nonverbal information. Research has demonstrated diminished immediate memory, using list learning and prose text, related to level of anxiety and domain-specific anxiety (Davidson *et al.*, 1991; Leininger and Skeel, 2012). Stillman *et al.* (2012) found that anxiety was inversely related to immediate and delayed story recall tasks. Depressive symptoms are negatively related to memory and specific subtypes of depression, or clusters of depressive symptoms yield different effects (O'Bryant *et al.*, 2011).

The Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) study has yielded several generative papers elucidating the relationship between depressive symptoms and cognition. Gallo and colleagues (2003) found that depressive symptomatology was related to everyday functioning as mediated through memory and problem-solving abilities. Memory performance was also significantly different at baseline for participants with relatively elevated levels of depressive symptoms (Lohman *et al.*, 2012). These findings indicate a true relationship with depressive symptoms and memory construct. Rexroth *et al.* (2013) found that age, education, and race were significantly related to cognitive performance at baseline. They suspected that clinical depression was associated with poorer memory performance.

In the previously reviewed studies, researchers assumed that measures of memory performance assessed the same construct across the entire spectrum of depressive and anxiety symptoms. To date, ACTIVE data have not been used to directly test measurement equivalence of memory tests across the spectrum of anxious and depressive symptoms. Measurement equivalence refers to the accurate assessment of the same construct across groups. One important aspect of measurement equivalence is differential item functioning

(DIF), which presents as inaccurate and unequal probability of endorsing a trait that results from test bias rather than true dissimilarity on the underlying construct. Assessing DIF provides valuable insight into whether variance in memory tests is explained by anxiety and/or depressive symptoms even after accounting for true relationships between anxiety and depression symptoms with the underlying latent memory construct. A biased measure of memory performance may consistently lead a subgroup of older adults with high depressive symptoms to score differently than the overall group, even after accounting for the effect of depressive symptoms on the latent memory construct. In other words, specific measures of cognition may be more vulnerable to bias related to mood states, and therefore, scores on these measures will be less precise reflections of the underlying cognitive construct depending on the level of anxiety and depressive symptoms. Although, to our knowledge, no study has evaluated DIF due to anxiety symptoms on memory performance among older adults, previous research indicates that cognitive measures exhibit item bias because of differences of social withdrawal and psychomotor agitation, independent of the underlying level of cognitive functioning (Mast, 2005).

Existing literature yields sparse findings with respect to the bias in memory assessment of community-dwelling older adults across self-reported symptoms of anxiety and depression. However, previous research has examined DIF in measures of depressive symptoms due to cognitive status (Fieo *et al.*, 2015), pain (Karp *et al.*, 2008), and ethnicity (Broekman *et al.*, 2008). One paper using the ACTIVE sample used the multiple indicators multiple causes (MIMIC) modeling to examine DIF in memory performance due to race (Aiken Morgan *et al.*, 2010). In MIMIC modeling, one can examine whether group differences are entirely at the construct level (i.e., DIF not present) or if some of the differences are due to particular items that form the construct (i.e., DIF present). Aiken Morgan *et al.* (2010) found that African Americans, on average, scored significantly lower than Caucasians on cognitive measures, but the differences were at the construct level and not due to DIF.

The current study investigated the influence of self-reported symptoms of depression and anxiety on the measurement equivalence of memory tests in the ACTIVE study. We sought to explore if there was an additional pathway that anxiety and depressive symptoms may directly relate to the tests as well as the latent construct, thereby indicating test bias. We hypothesized that DIF would be present on the tests of memory based upon self-reported symptoms of depression and anxiety.

Method

The ACTIVE study

The ACTIVE study is a longitudinal randomized controlled trial of older adults, above the age of 65 years. ACTIVE investigated whether educational training (i.e., memory, reasoning, and processing speed) in late adulthood improved the cognitive abilities of older adults. ACTIVE was conducted in six metropolitan areas across the eastern USA. Details on the screening, eligibility criteria, and recruitment have been previously reported (Jobe *et al.*, 2001; Ball *et al.*, 2002).

Participants

Briefly, ACTIVE participants were selected in a manner to ensure a diverse sample of older adults who, at enrollment: (i) were at least 65 years of age; (ii) had a mini-mental state examination score of ≥ 22 ; (iii) were not diagnosed with Alzheimer's disease; (iv) did not experience substantial functional decline (self-reported need for weight-bearing support or full caregiver performance of dressing, personal hygiene, or bathing more than or equal to three times in the previous week); (v) had sufficient hearing, vision, and proficiency in English to complete interviews; (vi) had no medical conditions that would predispose them to imminent functional decline or death (e.g., stroke within the past year, certain cancers, or current chemotherapy/radiation treatment); and (vii) had no recent cognitive training.

Only baseline data were included in this analysis ($n = 2802$). At baseline, participants were between 65 and 94 years of age, and 73% reported Caucasian race (African American: 26%). Individuals who reported race other than Caucasian or African American ($n = 46$) were excluded. To ensure that models would be directly comparable, only individuals with complete covariate data (Table 1) were included ($n = 2408$). Excluded individuals were more likely to be African American (42% vs. 24%; $p < 0.001$) and had 0.6 fewer years of education ($p < 0.001$) than the participants with complete covariate data.

Measures

Rivermead Behavioral Memory Test—Paragraph Recall—The Rivermead Behavioral Memory Test (RBMT)—Paragraph Recall (Wilson *et al.*, 1991) is a measure of prose memory. Participants read a short paragraph of approximately four to five sentences containing 21 distinct propositions and then must write down as much of the story as possible in 2 min.

Hopkins Verbal Learning Test—The Hopkins Verbal Learning Test (HVLT) (Brandt, 1991) is a measure of verbal memory and is useful in distinguishing between demented/amnesic and cognitively healthy elderly. It consists of a 12-item word list, composed of four words drawn from each of three semantic categories. Three free recall trials are followed by a yes/no recognition trial.

Rey Auditory Verbal Learning Test—The Rey Auditory Verbal Learning Test (AVLT) (Rey, 1941) evaluates verbal memory and learning. The AVLT consists of a 15-item list of semantically unrelated words presented over five trials, followed by the presentation of a distractor list. The sixth trial requires participants to recall words from the original list. After a brief delay, a yes/no recognition trial is presented.

A memory composite score was created using the RBMT, the HVLT, and the AVLT. The HVLT and AVLT were modified in three ways: (i) word lists were pre-recorded on an audiotape for consistent administration across testing sites; (ii) participants, instead of testers, wrote the words they could recall; and (iii) because of time constraints, the delayed recall was dropped.

Depressive symptoms—Depressive symptoms were measured with the 12-item version of the Center for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977), on which depressive symptoms in the past week are rated on a four-level ordinal scale (“rarely or none of the time” = 0, “most or all of the time” = 3, range 0–36).

Personality in Cognition—The Personality in Intellectual Aging Contexts evaluates older adults’ beliefs about their intellectual aging (Lachman *et al.*, 1982). The anxiety scale (PIC5) measures how intellectual tasks can influence anxiety. Item responses ranged from 1 (strongly agree) to 6 (strongly disagree), and items for a given dimension were summed for a total score. Personality traits are strongly related to anxiety disorders (Brandes and Bienvenu, 2006). Items on the PIC5 represent domain-specific anxiety assessment related to thinking abilities and may be a close reflection of social anxiety disorder (social phobia) given the performance aspect of cognitive testing. For example, “I am afraid that I wouldn’t do very well on an intelligence test or a similar kind of test at this time.” Domain-specific scales are better than general scales when relating to behavioral outcomes (Lachman, 1986).

Demographics—Age (in years), sex (0=male, 1=female), race (0=Caucasian, 1=African American), and education (in years) were included as covariates.

Procedure

Data analyses—The MIMIC modeling was conducted using MPLUS 7.11 (Muthén and Muthén, 1998–2015 [Muthén and Muthén, LA, CA, USA]). Our base model and modeling strategy were similar to previously published work on DIF in the ACTIVE study (Aiken Morgan *et al.*, 2010). Modeling was performed in four stages. (i) We formed a latent variable for memory using the three memory tests, controlling for age, sex, race, and education (model 1). (ii) We assessed differential item function (DIF) due to demographic characteristics (models 2–4). DIF was present if the direct path from a demographic covariate to a memory item significantly improved the model ($p < 0.05$ for the difference in chi squared (χ^2)). Given that there were only three memory tests in our memory construct, we could only account for DIF on one memory indicator per covariate. (iii) For each of the mental health items, we added the path from that item to the memory construct and also assessed for DIF due to that mental health item (models 5–7). (iv) We formed a final model with both mental health items, including any statistically significant DIF (model 8; Figure 1). Standardized loadings (based on both latent and observed variables’ variances) are presented, with their standard errors in Figure 1. Model fit was evaluated using χ^2 , root mean square error of approximation (RMSEA), comparative fit index (CFI), Tucker–Lewis index (TLI), and Akaike information criterion, using conventional criteria for good model fit: $CFI > 0.95$, $TLI > 0.95$, and $RMSEA < 0.05$ (Reeve *et al.*, 2007). Factor scores for memory in models 7 and 8 were standardized before subtracting them.

Results

We constructed MIMIC models with memory as the latent construct using HVLT total recall, AVLT total recall, and the RBMT as the indicators. Sex, education, race, and age were included as covariates (model 1; fit indices are in Table 2). Next, we looked for DIF due to

demographic variables. The final model with DIF due to demographics included the direct paths of sex on the RBMT, and education and race on the AVLT (model 4). Model fit was excellent ($RMSEA = 0.032$, $CFI = 0.996$, and $TLI = 0.989$). With demographic DIF accounted for, the memory indicators have stronger loadings on the latent construct, and most of the demographic influences on memory are stronger as well (Table 3, comparing model 4 with model 1).

Having accounted for the effects of the demographic variables, the CES-D was introduced as an additional covariate (model 5). The direct path was statistically significant, and no DIF in memory items due to the CES-D was found. Similarly, in model 6, the PIC5 was added to the model that accounted for demographic effects (model 4). An additional direct path from the PIC5 to the AVLT was needed in model 7. Accounting for this DIF produces a modest increase in the loading of AVLT on the latent memory construct (Table 3, comparing models 7 and 8). We compared the predicted memory performance in models 6 and 7, which differ only by the presence of the direct path from PIC5 to AVLT. When we extracted the factor scores for memory, accounting for DIF due to anxiety lowered the memory scores for those with more anxiety symptoms, with a decrease of 0.26 standard deviation for those in the top quartile of the PIC5, compared with those in the bottom quartile.

Finally, the CES-D was added an additional covariate to model 7. The final model had $RMSEA = 0.026$, $CFI = 0.990$, and $TLI = 0.996$, indicating excellent fit. There were no additional paths added to the estimates based upon statistical consideration (i.e., model saturation) and theoretical knowledge of appropriate paths. The standardized estimates for the final model 8 are included in Figure 1. Overall, we see strong loading of demographic variables on the latent construct of memory. In addition, PIC5 and CES-D had significant negative direct relationships with memory. These negative relationships indicate that increased symptomatology is correlated with worse memory performance, controlling for DIF. The PIC5 had a much stronger relationship with memory ($\beta = -0.25$) than did the CES-D ($\beta = -0.08$). The DIF with the largest magnitude was due to sex ($\beta = -0.21$) on the RBMT, indicating better performance by men. There was smaller but statistically significant DIF due to race ($\beta = 0.09$), education ($\beta = -0.05$), and PIC5 ($\beta = 0.09$) with the AVLT total recall. The path from PIC5 to AVLT (DIF) was of much smaller magnitude than the path from the PIC5 to the memory construct (Table 3).

Discussion

This study assessed the influence of anxiety and depressive symptoms on memory performance using MIMIC modeling to assess for measurement equivalence of memory tests in a community-based sample of cognitively healthy older adults. We found a direct relationship between the anxiety symptoms and the AVLT word list learning memory test (measurement bias) that remained even after accounting for the true relationship between anxiety symptoms and the latent construct of memory (DIF present). However, symptoms of depression did not affect the measurement equivalence of memory tasks (DIF not present), although depression was a valuable contributor to the best model of memory performance. These findings are largely consistent with previous research (Kizilbash *et al.*, 2002).

Anxiety symptoms had an effect on memory assessment even after accounting for the effects of demographic variables known to influence cognitive test performance. Individuals with more anxiety symptoms demonstrated worse memory performance, consistent with previous research (Airaksinen, Larsson, & Forsell, 2005). In addition, anxiety symptoms had a direct effect (measurement bias) on the AVLT, a measure of word list learning and memory, over and above the true effect of anxiety symptoms on the overall memory construct. This direct effect on the AVLT suggests that there is bias on this memory test because of the level of anxiety symptoms, such that those who reported relatively higher number of anxiety symptoms on the PIC5 demonstrated worse performance. The PIC5 had the strongest relationship with the AVLT. The AVLT word list contains semantically unrelated words and is longer than the HVLT, making it more cognitively demanding, which may explain the relationship with the PIC5. Adverse effects of anxiety on cognitive performance are greater on difficult than easy tasks (Eysenck, 1985).

Depressive symptoms had only a small negative influence on memory functioning, without DIF present, which is consistent with previous findings (Hamilton *et al.*, 2014). The main effect of depression on the memory construct may sufficiently capture the impact of depression on memory functioning. However, it has been pointed out that clusters of depressive symptoms may elucidate the relationship with cognitive functioning better than the global score of depressive symptoms (O'Bryant *et al.*, 2011). This may explain the small relationship with memory construct found in this present study.

Despite these interesting findings, this study has several limitations. This study used an established memory construct (Aiken Morgan *et al.*, 2010) that did not include delayed recall. Immediate versus delayed recall is an important distinction in assessment of memory functioning. Psychiatric symptoms may differentially affect immediate versus delayed recall, which cannot be assessed with the current data. Prospectively examining test bias in assessment of memory with delayed recall would be a good next step. Another limitation is that the ACTIVE sample is composed of a highly motivated sample of healthy, community-dwelling older adults that volunteered for a cognitive intervention study. Thus, the findings may not generalize to clinical populations. In addition, future studies should use samples that delineate history of psychiatric conditions and current psychiatric conditions compared with others without a history of psychiatric complaints.

In the current analyses, anxiety symptoms were measured using a domain-specific questionnaire about intellectual abilities. A general survey of clinical anxiety symptoms may yield different findings. Memory assessment in this study examined immediate recall of verbal information using list and prose format. This study did not assess the neural basis of anxiety or memory functioning, and the presence of DIF cannot definitively conclude that there is a common underlying neural basis between anxiety and memory. A review by Holzsneider and Mulert (2011) identified a similar neurological network composed of the anterior cingulate, insula, and amygdala in individuals with clinical and sub-clinical levels of anxiety. Prefrontal cortex activation is thought to represent emotion regulatory control (Bruhl *et al.*, 2014). As a result, anxiety may reduce attention and learning capacity leading to lower memory performance. The mechanisms that allow for anxiety symptoms to reduce memory performance are not well understood (Stillman *et al.*, 2012). However, there are

theories that address possible mechanisms for anxiety to reduce cognitive performance. The processing efficiency theory (Eysenck and Calvo, 1992) was extended with the development of the attentional control theory (Eysenck *et al.*, 2007; Derakshan and Eysenck, 2009). These theories highlight several opportunities for anxiety to disrupt cognitive functioning (Elliman *et al.*, 1997). As one potential opportunity relevant to this study, the processing efficiency theory may interfere with the phonological loop involved in the rehearsal of verbal information. Impaired rehearsal may reduce potential retention of information. As another potential opportunity based on the attentional control theory, inhibition function of the central executive may be vulnerable to anxiety. On a verbal learning task (e.g., word list or story), the examinee must inhibit irrelevant information and attend to target stimuli. Disruption in this process could lead to diminished recall performance. However, a complicating factor to these theories is that individuals may have the ability to compensate for these decrements of indeterminate size with increased motivation and effort. It is important to note that this study did not directly examine mechanisms for anxiety to influence memory.

Despite these limitations, this study suggests that anxiety symptoms influence the measurement equivalence of memory tests in older adults in addition to their direct negative (or true) influence on the latent memory construct. Importantly, there is a negative, unique, and differential impact on certain measures of verbal immediate memory with sub-threshold symptoms of anxiety. This finding has significant research implications, because regression models of memory performance using self-reported anxiety scores as a covariate may inadequately account for the impact of anxiety on memory. Because this study uses a well-characterized sample of community-dwelling cognitively healthy older adults, our findings also reveal that even sub-threshold levels of anxiety symptoms have a detrimental effect on assessment of immediate memory using word list and prose format (Stillman *et al.*, 2012).

Therefore, the results of this study supports routine measurement of anxiety symptoms in both research studies and clinical settings in which older adults are administered cognitive measures. Our current findings suggest that domain-specific anxiety symptoms influence performance on measures of word list recall in cognitively healthy older adults highlighting the need for statistical models, which account for the direct relationship between anxiety symptoms and memory tests. Domain specific is highly correlated with anxiety disorders and thereby highlights broader importance of anxiety in memory assessment. This novel information adds to the limited body of literature on the effects of anxiety and depressive symptoms on cognitive performance in older adults.

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Key point

- Anxiety symptoms introduce test bias in the measurement of memory in older adults.

Figure 1.

Final memory model, with standardized loadings (standard errors).

Note. The solid lines represent paths of measurement invariance. The bolded solid line highlights the measurement invariance in the AVLT from the anxiety scale. PIC5, Personality in Cognition, Anxiety Scale; CES-D, Center for Epidemiological Studies Depression Scale; AVLT, Rey Auditory Verbal Learning Test; HVL, Hopkins Verbal Learning Test; RBMT, Rivermead Behavioral Memory Test.

Table 1 Participant characteristics ($n = 2408$)

Characteristic	<i>N</i> (%) or mean (SD)
African American	583 (24%)
Female	1833 (76%)
Age	73.5 (5.8)
Education (years)	13.6 (2.7)
PIC5	19.4 (9.1)
CES-D	5.2 (5.1)
AVLT	48.4 (10.2)
HVLT	26.1 (5.3)
RBMT	6.4 (2.8)

SD, standard deviation; PIC5, Personality in Cognition, Anxiety Scale; CES-D, Center for Epidemiological Studies Depression Scale; AVLT, Rey Auditory Verbal Learning Test; HVLT, Hopkins Verbal Learning Test; RBMT, Rivermead Behavioral Memory Test.

Table 2

Model fit indices

Paths	Model	χ^2	df	RMSEA	CFI	TLI	AIC
Memory items and demographics $\rightarrow$ memory construct	Model 1	225.051	8	0.106	0.933	0.875	41,601.8
+ Female $\rightarrow$ RBMT	Model 2	64.191	7	0.058	0.982	0.962	41,442.9
+ Race $\rightarrow$ AVLT	Model 3	35.796	6	0.045	0.991	0.977	41,416.5
+ Education $\rightarrow$ AVLT	Model 4	17.272	5	0.032	0.996	0.989	41,400.0
+ CES-D $\rightarrow$ memory	Model 5	17.535	7	0.025	0.997	0.992	41,356.5
Model 4 + PIC5	Model 6	43.726	7	0.047	0.989	0.972	41,273.3
+ PIC5 $\rightarrow$ AVLT	Model 7	19.922	6	0.031	0.996	0.988	41,251.5
Model 7 + CES-D	Model 8	20.628	8	0.026	0.990	0.996	41,234.8

χ^2 , normal theory weighted least squares χ^2 ; df, degrees of freedom; RMSEA, root mean square error of approximation; CFI, comparative fit index; TLI, Tucker–Lewis index; AIC, Akaike information criterion; RBMT, Rivermead Behavioral Memory Test; AVLT, Rey Auditory Verbal Learning Test; CES-D, Center for Epidemiological Studies Depression Scale; PIC5, Personality in Cognition, Anxiety Scale.

Table 3

Standardized loadings for each model

Path	1	2	3	4	5	6	7	8
Memory by								
AVLT	0.84	0.84	0.87	0.90	0.90	0.89	0.93	0.93
HVLT	0.81	0.80	0.80	0.79	0.79	0.80	0.79	0.79
RBMT	0.55	0.62	0.62	0.62	0.62	0.62	0.62	0.62
Memory on								
African American	-0.24	-0.24	-0.29	-0.29	-0.29	-0.27	-0.27	-0.27
Female	0.30	0.34	0.34	0.33	0.33	0.35	0.34	0.34
Age	-0.42	-0.41	-0.41	-0.40	-0.39	-0.38	-0.37	-0.37
Education	0.29	0.29	0.29	0.33	0.30	0.25	0.23	0.23
PIC5	—	—	—	—	—	-0.22	-0.27	-0.25
CES-D	—	—	—	—	-0.12	—	—	-0.08
AVLT on								
Education	—	—	—	-0.08	-0.08	-0.07	-0.05	-0.05
African American	—	—	0.09	0.09	0.09	0.08	0.09	0.09
PIC5	—	—	—	—	—	—	0.09	0.09
RBMT on female	—	-0.23	-0.23	-0.22	-0.22	-0.22	-0.21	-0.21

AVLT, Rey Auditory Verbal Learning Test; HVLT, Hopkins Verbal Learning Test; RBMT, Rivermead Behavioral Memory Test; PIC5, Personality in Cognition, Anxiety Scale; CES-D, Center for Epidemiological Studies Depression Scale.