OXFORD
UNIVERSITY PRESS

Archives of Clinical Neuropsychology 32 (2017) 972–979

Archives of CLINICAL NEUROPSYCHOLOGY

Effects of Age and Gender on Recall and Recognition Discriminability

Lisa V. Graves[1], Charles C. Moreno[2], Michelle Seewald[2], Heather M. Holden[1], Emily J. Van Etten[2], Vedang Uttarwar[3], Carrie R. McDonald[1,3,4], Lisa Delano-Wood[1,4], Mark W. Bondi[1,4], Steven Paul Woods[5], Dean C. Delis[1,4], Paul E. Gilbert[1,2,*]

[1]*San Diego State University/University of California San Diego Joint Doctoral Program in Clinical Psychology, San Diego, CA, 92120, USA*
[2]*Department of Psychology, San Diego State University, San Diego, CA 92120, USA*
[3]*Multimodal Imaging Laboratory, University of California San Diego, La Jolla, CA 92093, USA*
[4]*Department of Psychiatry, University of California San Diego School of Medicine, La Jolla, CA 92093, USA*
[5]*Department of Psychology, University of Houston, Houston, TX 77004, USA*

*Corresponding author at: SDSU/UCSD Joint Doctoral Program in Clinical Psychology, 6363 Alvarado Court, Suite 103, San Diego, CA 92120, USA. Tel.: +1-619-594-7409; Fax: +1-619-594-3773.
E-mail address: pgilbert@mail.sdsu.edu (P.E. Gilbert).

Editorial Decision 27 February 2017; Accepted 6 March 2017

Abstract

Objective: Recall and recognition memory abilities are known to decline with increasing age, yet much of the evidence stems from studies that used simple measures of total target recall or recognition. The California Verbal Learning Test-Second Edition (CVLT-II) includes a new measure of recall discriminability that is analogous to recognition discriminability. These discriminability measures yield more thorough assessments of recall and recognition by accounting for intrusion and false positive errors, respectively. Research also has shown that women outperform men on verbal episodic memory tests. However, gender differences in recall and recognition discriminability and the age-by-gender interaction on these constructs have not been thoroughly examined.
Method: Cognitively healthy adults ($N = 223$) 18–91 years in age completed the CVLT-II. Multiple regression analyses were conducted to examine effects of age, gender, and the age-by-gender interaction on CVLT-II subtypes of recall and recognition discriminability.
Results: Discriminability scores decreased with increasing age, and women outperformed men. There was an age-by-gender interaction on total, immediate, and free recall discriminability – the negative association between age and scores was stronger in men than in women. Exploratory analyses revealed an inverted U-shaped relationship between age and recall discriminability scores in women.
Conclusions: The present findings support and expand upon the extant literature on aging, gender, and verbal episodic memory, plus describe a novel age-by-gender interaction intrinsic to subtypes of recall discriminability. The findings suggest that methods traditionally used to assess recognition memory function can be used to elucidate age- and gender-related changes in recall ability across the adult lifespan.

Keywords: Learning and memory; Aging; Gender effects

Introduction

Older adults generally perform more poorly than young adults on tests of verbal episodic memory, including simple measures of recall and recognition found on the California Verbal Learning Test (CVLT; Delis, Kramer, Kaplan, & Ober, 1987; Ebert & Anderson, 2009; Kausler, 1994; Turner & Pinkston, 1993; Van der Linden, Philippot, & Heinen, 1997; Woodruff-Pak & Finkbiner, 1995). Additionally, women tend to perform better than men on tests of verbal episodic memory including the CVLT (Bleecker, Bolla-Wilson, Agnew, & Meyers, 1988; Herlitz, Nilsson, & Backman, 1997; Kramer, Delis, & Daniel, 1988; Kramer, Yaffe, Lengenfelder, & Delis, 2003; Lundervold, Wollschlager, & Wehling, 2014; Rabbitt, Donlan, Watson, & McInnes, 1995), and evidence suggests that gender may moderate the effects of healthy aging on verbal episodic memory decline. For example, one CVLT study reported that men show a steeper age-related decline than women in the transition from middle to older age on CVLT-II (Delis, Kramer, Kaplan, & Ober, 2000) indices of learning, recall, recognition, semantic

doi:10.1093/arclin/acx024 Advance Access publication on 17 March 2017

clustering, consistency, primacy effect, intrusions, and false positives (Lundervold et al., 2014). However, this study did not include a young adult group for comparison or an assessment of the recall and recognition discriminability subtypes that are available with the CVLT-II. Another study reported that performances on Trial 5 recall, long delay free recall, and (total) recognition discriminability were negatively correlated with age in younger (16–47 years) and older (55–89 years) men and in older but not younger women (Kramer et al., 2003). However, this study also did not examine performance on all CVLT-II subtypes of recall and recognition discriminability and excluded healthy adults ranging 48–54 years in age. Nonetheless, as Kramer and colleagues (2003) noted, examining the interactive effect of age and gender on verbal episodic memory decline is important in light of the existing evidence for earlier and more extensive age-related decreases in cortical gray matter in men relative to women, particularly in the left hemisphere, as well as evidence for a positive influence of estrogen and estradiol on verbal memory performance in women. Taken together, the extant literature suggests that further investigation of verbal episodic memory using more thorough measures of recall and recognition and more comprehensive samples that include a wider range of the human lifespan may improve efforts to elucidate the age-related trajectory of verbal episodic memory decline.

Recall and recognition refer to two mechanisms by which encoded information may be retrieved from memory. In contrast to recall, recognition involves retrieval in the presence of a cue and therefore requires less depth of processing. Accordingly, recognition has been shown to be less impaired than recall as a function of healthy aging (Craik & McDowd, 1987). Very early methods for assessing recall and recognition yield single scores that reflect the total number of target items recalled or recognized but often do not account for intrusion errors (recall of non-target items) or false-positive errors (recognition of non-target items). Beginning in the mid to late 20th century, signal detection theory (SDT) was applied in studies of recognition memory to more accurately assess recognition memory function by taking sensitivity and response bias into account. Over the last half century, SDT has indeed become a gold standard approach for assessing recognition memory function. Delis and colleagues included a recognition discriminability index on the first edition of the CVLT (Delis et al., 1987), but it was not until the CVLT-II (Delis et al., 2000) that the SDT techniques were applied in the assessment of recall to yield a new measure of *recall discriminability*. Analogous to recognition discriminability, which analyzes hit rates relative to false-positive rates, recall discriminability is represented as a single score that factors in an examinee's target recall *and* intrusion rate to yield a more thorough assessment of recall ability. Specifically, Delis and colleagues adapted the method for scoring recognition discriminability using *d'* (Macmillan & Creelman, 1991) for computing recall discriminability.

In addition to *total* recall discriminability (i.e., total target recall relative to total intrusion errors), the CVLT-II includes other subtypes of recall discriminability, which are described in more detail in Table 1. Although it is suspected that both recall and recognition discriminability generally decline with increasing age, the degree to which age-related decline varies across subtypes of recall and recognition discriminability remains to be examined. Furthermore, neither the effect of gender nor an age-by-gender interaction on the subtypes of recall and recognition discriminability has been examined. Thus, the objective of the present study was to explore the effects of age and gender and the age-by-gender interaction on the CVLT-II subtypes of recall and recognition discriminability in a large sample of healthy adults ranging 18–91 years in age.

Method

Participants

Research participants included 223 healthy adults ranging 18–91 years in age, 120 of which were women. The sample included 59 young adults (18–25 years), 59 older adults (aged 65 years and older), and 105 participants between the ages of 25

Table 1. CVLT-II subtypes of recall and recognition discriminability

Subtype	Definition
Recall discriminability	Recall of List A target items relative to:
Total	Intrusion errors on all recall trials
Immediate	Intrusion errors on Trials 1–5
Delayed	Intrusion errors on delayed recall trials (short and long, free and cued)
Free	Intrusion errors on immediate and delayed free recall trials
Cued	Intrusion errors on cued recall trials
Recognition discriminability	Endorsement of List A target items relative to:
Total	All distractor items
Source	List B distractor items
Semantic	List B and novel distractor items semantically related to List A target items
Novel	Novel distractor items

and 65 years. Older adults were characterized as cognitively healthy based on Dementia Rating Scale-2 scores (DRS-2; Jurica, Leitten, & Mattis, 2001) scores. DRS-2 scores of older adults ranged from 130 to 144, with a mean of 140.54 (SD = 3.17). Healthy young adult participants primarily were undergraduate students who were recruited from a participant pool within the Department of Psychology at San Diego State University (SDSU) and assessed at the Center for Healthy Aging and Neurodegenerative Disease Research (CHANDR). Healthy middle-aged adults were recruited from the San Diego community by CHANDR, the Multimodal Imaging Laboratory at the University of California, San Diego (UCSD), and the HIV Neurobehavioral Research Center (HNRC). Healthy older adults were recruited from the San Diego community by CHANDR and the Normal Aging Laboratory of one of the authors (M.W.B.) at UCSD using flyers (posted with approval by public sites/institutions) and outreach to senior centers. Exclusionary criteria for healthy adults recruited by all sites included any history of: neurological disorders, stroke, traumatic brain injury (or loss of consciousness lasting more than 30 min), major medical conditions (e.g., cancer and/or current cancer treatment), major psychiatric disorders (with the exception of a mood disorder for which symptoms are managed with medication), substance abuse disorder, learning disability, insufficient proficiency of the English language, and any major vision or hearing difficulty that would affect testing. Participants provided informed written consent for participation approved by the Institutional Review Boards of SDSU and UCSD.

CVLT-II

The CVLT-II was administered to all participants using standard administration procedures outlined by Delis and colleagues (2000). The CVLT-II involves the presentation of word-lists and provides a multitude of verbal learning and memory indices, including immediate recall, free and cued recall over short and long delays, and recognition memory. In the present study, short- and long-delay tests of recall were separated by an interval of approximately 20 min, during which other nonverbal neuropsychological measures were administered. All subtypes of recall and recognition discriminability were of primary interest in the present study. Only raw recall and recognition discriminability scores were examined as standardized scores are corrected for age and gender on the CVLT-II and the use of standardized scores would therefore not allow the aims of the present study to be addressed. CVLT-II data were scored using CVLT-II software (Delis & Fridlund, 2000).

Statistical Analyses

Analyses were conducted in the Statistical Package for the Social Sciences (SPSS) Version 22. Multiple regression analyses were used to examine effects of age and gender on indices of recall and recognition memory, while controlling for other demographic factors when appropriate.

Results

Demographic information is presented in Table 2. Men and women in the study sample did not differ in average age or years of education ($ps > .05$). Older adults completed significantly more years of education than young adults ($p < .001$) and middle-aged adults ($p < .05$); young and middle-aged adults did not differ in years of education completed ($p > .05$). Education was included as a covariate in regression analyses. No other variables were controlled for in regression analyses.

Effects of Age and Gender and the Age-by-gender Interaction on Recall and Recognition Discriminability

Multiple regression analyses were conducted to examine the effects of age and gender and their interaction on recall and recognition discriminability scores, while controlling for years of education. Main effects of age and gender and the age-by-gender interaction term were included in the same regression model. Scores on all subtypes of recall discriminability (total, immediate, free, delayed, cued) and recognition discriminability (total, source, semantic, novel) were examined. Bonferroni corrections for multiple corrections were applied ($\alpha = .05/9 = .005$).

Analyses revealed a significant omnibus effect of age, gender, and the age-by-gender interaction on all subtypes of recall and recognition discriminability: total recall discriminability, $F(4, 218) = 21.68$, $p < .001$, $R^2 = .29$; immediate recall discriminability, $F(4, 218) = 19.29$, $p < .001$, $R^2 = .26$; delayed recall discriminability, $F(4, 218) = 15.05$, $p < .001$, $R^2 = .22$; free recall discriminability, $F(4, 218) = 20.65$, $p < .001$, $R^2 = .26$; cued recall discriminability, $F(4, 218) = 15.11$, $p < .001$, $R^2 = .22$; total recognition discriminability, $F(4, 218) = 16.12$, $p < .001$, $R^2 = .23$; source recognition discriminability, $F(4, 218) = 13.40$, $p < .001$, $R^2 = .20$; semantic recognition discriminability, $F(4, 218) = 17.34$, $p < .001$, $R^2 = .24$; and novel recognition discriminability, $F(4, 218) = 12.98$, $p < .001$, $R^2 = .19$.

Table 2. Mean and standard deviation values on demographic variables and discriminability measures in the study sample

	Men	Women
Demographic variable		
n	103	120
Age	45.54 (21.96)	46.49 (21.68)
Education	15.33 (2.47)	15.23 (1.86)
Discriminability measure		
Total recall	2.25 (0.54)	2.51 (0.44)
Immediate recall	2.28 (0.47)	2.49 (0.38)
Delayed recall	2.44 (0.79)	2.78 (0.66)
Free recall	2.20 (0.49)	2.43 (0.40)
Cued recall	2.47 (0.84)	2.84 (0.67)
Total recognition	3.23 (0.77)	3.53 (0.53)
Source recognition	3.07 (0.72)	3.35 (0.47)
Semantic recognition	2.89 (0.83)	3.23 (0.54)
Novel recognition	3.06 (0.67)	3.29 (0.48)

Table 3. The effect of age on recall and recognition discriminability subtypes

Discriminability	Subtype	*B*	*t*	*p*	*sr*
Recall	Total	−.024	5.33	<.001	−.305
	Immediate	−.022	5.50	<.001	−.320
	Delayed	−.029	4.17	<.001	−.250
	Free	−.022	5.48	<.001	−.316
	Cued	−.029	4.02	<.001	−.241
Recognition	Total	−.025	4.07	<.001	−.242
	Source	−.024	4.16	<.001	−.252
	Semantic	−.028	4.27	<.001	−.252
	Novel	−.020	3.54	<.001	−.215

Note: *sr* = the semipartial correlation coefficient, which measures the relationship between discriminability scores and age after partialling out the correlations between age and other predictors in the model; the R^2 change after including age in the regression model is equal to the squared semipartial correlation (i.e., sr^2).

Effect of age on recall and recognition discriminability. Multiple regression analyses revealed a significant main effect of age on all subtypes of recall and recognition discriminability (*p*s < .001). As age increased, recall and recognition discriminability scores significantly decreased. Inferential and descriptive statistics for the effect of age on each subtype of recall and recognition discriminability are provided in Table 3.

Effect of gender on recall and recognition discriminability. Multiple regression analyses also revealed a significant main effect of gender on all subtypes of recall and recognition discriminability (*p*s < .005). Women had significantly higher scores than men on all subtypes of recall and recognition discriminability. Exploratory bivariate correlation analyses revealed that total recall and recognition discriminability scores were significantly correlated in the study sample, $r(222) = .76$, $p < .001$, and that this correlation was observed in both men, $r(103) = .80$, $p < .001$, and women, $r(120) = .68$, $p < .001$. Inferential and descriptive statistics for the effect of gender on each subtype of recall and recognition discriminability are provided in Table 4.

Age-by-gender interaction on recall and recognition discriminability. Furthermore, multiple regression analyses revealed a significant age-by-gender interaction on total, immediate, and free recall discriminability (see Table 5). Post-hoc regression analyses were conducted to examine the simple effects of age on total, immediate, and free recall discriminability scores in men and women. For these subtypes of recall discriminability, the negative association between age and scores was stronger in men than in women. Inferential and descriptive statistics for the age-by-gender interaction on each subtype of recall and recognition discriminability are provided in Table 5.

Additional analyses were conducted to elucidate the nature of observed gender differences in recall and recognition discriminability. Independent *t*-tests revealed that women scored significantly higher than men on Trials 1–5 Recall, $t(221) = 4.01$, $p < .001$, Short Delay Free Recall, $t(221) = 3.32$, $p = .001$, Long Delay Free Recall, $t(221) = 2.73$, $p = .007$, and Long Delay Cued Recall, $t(221) = 3.20$, $p = .002$, and that men made significantly more intrusion errors than women on total recall,

Table 4. The effect of gender on recall and recognition discriminability subtypes

Discriminability	Subtype					Men		Women	
		B	*t*	*p*	*sr*	*M*	*SE*	*M*	*SE*
Recall	Total	.260	3.93	<.001	.259	2.25	0.05	2.51	0.04
	Immediate	.214	3.72	<.001	.246	2.28	0.05	2.49	0.03
	Delayed	.340	3.47	.001	.230	2.44	0.08	2.78	0.06
	Free	.233	3.88	<.001	.255	2.20	0.05	2.43	0.04
	Cued	.372	3.64	<.001	.240	2.47	0.08	2.84	0.06
Recognition	Total	.303	3.43	<.001	.227	3.23	0.08	3.53	0.05
	Source	.278	3.43	.001	.225	3.07	0.07	3.35	0.04
	Semantic	.343	3.68	<.001	.242	2.89	0.08	3.23	0.05
	Novel	.234	3.00	.003	.199	3.06	0.07	3.29	0.04

Note: *sr* = the semipartial correlation coefficient, which measures the relationship between discriminability scores and gender after partialling out the correlations between gender and other predictors in the model; the R^2 change after including gender in the regression model is equal to the squared semipartial correlation (i.e., sr^2).

Table 5. The age-by-gender interaction on recall and recognition discriminability subtypes

Discriminability	Subtype	Age-by-gender interaction				Simple effects of age by gender					
						Men			Women		
		B	*t*	*p*	*sr*	*B*	*t*	*p*	*B*	*t*	*p*
Recall	Total	.009	3.31	.001*	.190	−.015	6.43	<.001	−.006	3.39	.001
	Immediate	.009	3.71	<.001*	.216	−.013	6.34	<.001	−.004	2.57	.011
	Delayed	.010	2.46	.015	.148	−.018	5.17	<.001	−.008	3.08	.003
	Free	.009	3.55	<.001*	.204	−.014	6.54	<.001	−.005	2.98	.004
	Cued	.010	3.32	.021	.139	−.019	4.98	<.001	−.009	3.20	.002
Recognition	Total	.008	2.12	.035	.126	−.017	4.90	<.001	−.009	4.47	<.001
	Source	.009	2.50	.013	.152	−.016	4.66	<.001	−.006	3.37	.001
	Semantic	.009	2.31	.022	.136	−.019	4.97	<.001	−.009	4.52	<.001
	Novel	.006	1.77	.079	.108	−.014	4.29	<.001	−.008	4.16	<.001

*Significant at level of .005

Note: *sr* = the semipartial correlation coefficient, which measures the relationship between discriminability scores and the age-by-gender interaction after partialling out the correlations between the age-by-gender interaction and other predictors in the model; the R^2 change after including the age-by-gender interaction term in the regression model is equal to the squared semipartial correlation (i.e., sr^2).

$t(221) = 2.83$, $p = .005$, delayed recall, $t(221) = 3.07$, $p = .002$, and cued recall, $t(221) = 3.45$, $p = .001$, after correcting for multiple comparisons ($\alpha = .01$). Additionally, women had significantly more hits on recognition than men, $t(221) = 2.37$, $p = .019$, and men made significantly more false positive errors than women, $t(221) = 2.79$, $p = .006$. This evidence highlights the importance of using discriminability measures that take intrusion and false positive errors into account in the assessment of recall and recognition abilities. Furthermore, these exploratory findings are based on a sample of healthy adults, and it is likely that more robust gender differences in intrusion and false positive errors would be observed in more cognitively impaired samples.

Analysis of Linear and Quadratic Effects of Age on Recall and Recognition Discriminability in Men and Women

Since previous research has suggested that a quadratic effect of age on verbal episodic memory may be present in women (Lundervold et al., 2014), regression analyses also were conducted to test for linear and quadratic effects of age on recall and recognition discriminability scores in men and women separately, while controlling for years of education. Bonferroni corrections for multiple corrections were applied ($\alpha = .05/9 = .005$). The analyses revealed a significant quadratic effect of age (over and above a linear effect) on all subtypes of recall discriminability in women: total recall – $F(1, 116) = 15.57$, $p < .001$; immediate recall – $F(1, 116) = 11.91$, $p = .001$; delayed recall – $F(1, 116) = 16.80$, $p < .001$; free recall – $F(1, 116) = 16.96$, $p < .001$; cued recall – $F(1, 116) = 11.79$, $p = .001$. The quadratic effect in women reflected an inverted U-shaped relationship between age and scores. Age effects on total recall discriminability scores in men and women are illustrated in Fig. 1.

Discussion

The present study examined the effects of age and gender and the age-by-gender interaction on the CVLT-II subtypes of recall and recognition discriminability in a sample of healthy men and women ranging 18–91 years in age. Two notable differences of the present study relative to previous work examining age and gender effects on verbal episodic memory were the inclusion of a large adult sample with a wide age range and the examination of multiple, more thorough indices of verbal recall and recognition. Although discriminability indices have traditionally been used to assess recognition memory function, the same methods have only recently been applied in the assessment of recall ability. Thus, the present analyses of the effects of age and gender and their interaction on recall discriminability in particular are novel and informative.

There was a significant age-by-gender interaction on all total, immediate, and free recall discriminability. Although recall discriminability scores generally decreased with increasing age, men demonstrated a stronger negative association between age and scores than women. This finding supports and expands upon Lundervold and colleagues' (2014) report of lower performance in men than women with a steeper age-related decrease in men. Additionally, a quadratic effect reflecting an inverted U-shaped relationship between age and all subtypes of recall discriminability was observed in women but not in men in the present study. Together, these observations complement findings reported by Kramer and colleagues (2003) suggesting that verbal memory decreases with increasing age in younger men but not in younger women (16–47 years), whereas both older men and women (55–89 years) show age-related impairment. Kramer and colleagues (2003) interpreted their findings to be in line with the evidence from previous studies for a positive effect of estrogen (Carlson & Sherwin, 2000; Drake et al., 2000; Maki, Zonderman, & Resnick, 2001; Sherwin, 1999, 2000; Verghese et al., 2000) on verbal memory in women. Although hormone levels were not examined in the present study, the observation of an inverted U-shaped relationship between age and recall discriminability scores in women is in line with this evidence. Similar to the findings reported by Kramer and colleagues (2003), the present findings also complement evidence from neuroimaging studies for earlier and more extensive hippocampal atrophy in men relative to women (Coffey et al., 1998; Gur et al., 1991; Pruessner, Collins, Pruessner, & Evans, 2001). Moreover, a longitudinal study of aging and memory reported that women outperform men on episodic memory up until the age of approximately 70 years, after which these gender differences begin to diminish (Herlitz et al., 1997). Although the present study utilized cross-sectional data, the observation of an inverted U-shaped relationship between age and recall discriminability scores in women complements the findings reported in the study by Herlitz and colleagues (1997).

No age-by-gender interaction effects on recognition discriminability measures were observed. Recognition memory has been shown to be less impaired than recall in healthy aging (Craik & McDowd, 1987). Thus, it was not surprising to see that the present study provided evidence for more robust age-by-gender interaction effects on recall discriminability using a sample of healthy adults. However, more robust interaction effects on recognition discriminability could perhaps be expected in more cognitively impaired populations.

In general, scores on all subtypes of recall and recognition discriminability decreased with increasing age. This finding is consistent with and expands upon evidence from earlier studies of age-related impairment in verbal episodic memory that used samples with more restricted age groups and ranges (Delis et al., 1987; Ebert & Anderson, 2009; Kausler, 1994; Turner & Pinkston, 1993; Van der Linden et al., 1997; Woodruff-Pak & Finkbiner, 1995). Additionally, women performed better

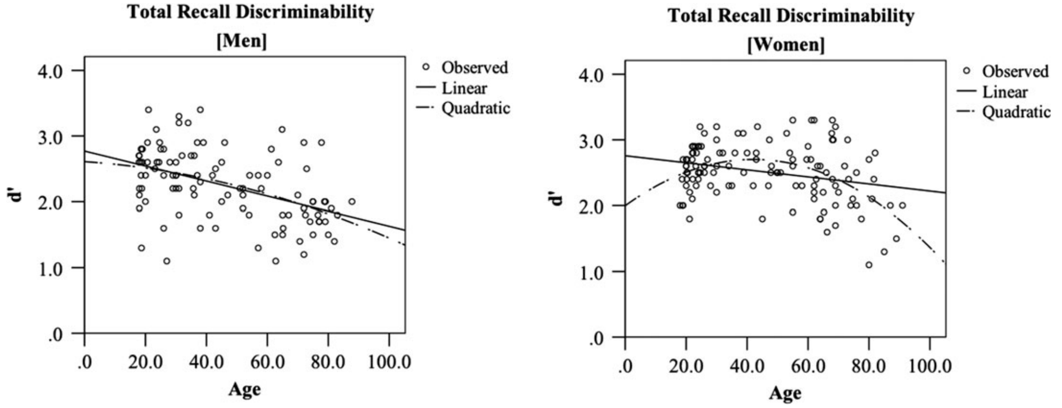

Fig. 1. Relationship between age and total recall discriminability scores in men and women. Solid line represents linear effect of age on scores and dotted line represents quadratic effect of age on scores.

than men on all subtypes of recall and recognition discriminability, which also is consistent with and expands upon previous evidence of a tendency of women to outperform men on tasks of verbal episodic memory (Bleecker et al., 1988; Herlitz, et al., 1997; Kramer et al., 1988; Lundervold et al., 2014; Rabbitt et al., 1995).

Given that the findings of the present study were based on retrospective analyses using archival data, we were unable to locate ethnicity data on all participants in the study sample. We acknowledge that this is a limitation of the present study and we believe it will be important for future studies to more closely examine and address the generalizability of age and gender effects on recall and recognition memory function across diverse samples of individuals.

The present findings demonstrate that the negative association between age and recall discriminability is stronger in men than in women. Additionally, there is a fairly linear negative association between age and recall discriminability in men, whereas the negative association between age and recall discriminability appears to be more robust in later years in women. The present findings bolster the existing literature on age, gender, and verbal episodic memory by offering novel insight into the effects of age and gender and the age-by-gender interaction on more thorough indices and subtypes of recall and recognition discriminability.

Conflict of Interest

None declared.

Funding

This work was supported by the National Institutes of Health (grant numbers R01 AG034202 to P.E.G., K24 AG026431 to M.W.B., R01 NS065838 to C.R.M., 2T34GM008303-26 to C.C.M., and R25 AG043364 to E.J.V.E.).

Acknowledgments

Dr. Delis is a co-author of the CVLT-II and receives royalties for the test.

References

Bleecker, M. L., Bolla-Wilson, K., Agnew, J., & Meyers, D. A. (1988). Age-related sex differences in verbal memory. *Journal of Clinical Psychology*, *44*, 403–411.

Carlson, L. E., & Sherwin, B. B. (2000). Higher levels of plasma estradiol and testosterone in healthy elderly men compared with age-matched women may protect aspects of explicit memory. *Menopause (New York, N.Y.)*, *7*, 168–177.

Coffey, C. E., Lucke, J. F., Saxton, J. A., Ratcliff, G., Unitas, L. J., Billig, B., et al. (1998). Sex differences in brain aging: A quantitative magnetic resonance imaging study. *Archives of Neurology*, *55*, 169–179.

Delis, D. C., & Fridlund, A. J. (2000). *CVLT-II comprehensive scoring system and computerized report*. San Antonio, TX: The Psychological Corporation.

Delis, D. C., Kramer, J. H., Kaplan, E., & Ober, B. A. (1987). *California Verbal Learning Test*. San Antonio, TX: The Psychological Corporation.

Craik, F. I., & McDowd, J. M. (1987). Age differences in recall and recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *13*, 474–479.

Delis, D. C., Kramer, J. H., Kaplan, E., & Ober, B. A. (2000). *California Verbal Learning Test–II* ((2nd ed.)). San Antonio, TX: The Psychological Corporation.

Drake, E. B., Henderson, V. W., Stanczyk, F. Z., McCleary, C. A., Brown, W. S., Smith, C. A., et al. (2000). Associations between circulating sex steroid hormones and cognition in normal elderly women. *Neurology*, *54*, 599–603.

Gur, R. C., Mozley, P. D., Resnick, S. M., Gottlieb, G. L., Kohn, M., Zimmerman, R., et al. (1991). Gender differences in age effect on brain atrophy measured by magnetic resonance imaging. *Proceedings of the National Academy of Science USA*, *88*, 2845–2849.

Herlitz, A., Nilsson, L. G., & Backman, L. (1997). Gender differences in episodic memory. *Memory & Cognition*, *25*, 801–811.

Ebert, P. L., & Anderson, N. D. (2009). Proactive and retroactive interference in young adults, healthy older adults, and older adults with amnestic mild cognitive impairment. *Journal of the International Neuropsychological Society*, *15*, 83–93. doi:10.1017/S1355617708090115.

Jurica, P. J., Leitten, S., & Mattis, S. (2001). *Dementia Rating Scale-2: Professional manual*. Lutz, FL: Psychological Assessment Resources.

Kausler, D. H. (1994). *Learning and memory in normal aging*. San Diego, CA: Academic Press.

Kramer, J. H., Delis, D. C., & Daniel, M. H. (1988). Sex differences in verbal learning. *Journal of Clinical Psychology*, *44*, 907–915.

Kramer, J. H., Yaffe, K., Lengenfelder, J., & Delis, D. C. (2003). Age and gender interactions on verbal memory performance. *Journal of the International Neuropsychological Society*, *9*, 97–102.

Lundervold, A. J., Wollschlager, D., & Wehling, E. (2014). Age and sex related changes in episodic memory function in middle aged and older adults. *Scandinavian Journal of Psychology*, *55*, 225–232.

Macmillan, N. A., & Creelman, D. C. (1991). *Detection theory: A user's guide*. New York: Cambridge University Press.

Maki, P., Zonderman, A., & Resnick, S. (2001). Enhanced verbal memory in nondemented elderly women receiving hormone replacement therapy. *American Journal of Psychiatry*, *158*, 227–233.

Pruessner, J. C., Collins, D. L., Pruessner, M., & Evans, A. C. (2001). Age and gender predict volume decline in the anterior and posterior hippocampus in early adulthood. *Journal of Neuroscience*, *21*, 194–200.

Rabbitt, P., Donlan, C., Watson, P., & McInnes, L. (1995). Unique and interactive effects of depression, age, socioeconomic advantage, and gender on cognitive performance of normal healthy older people. *Psychology and Aging*, *10*, 307–313.

Sherwin, B. B. (1999). Can estrogen keep you smart? Evidence from clinical studies. *Journal of Psychiatry and Neuroscience*, *24*, 315–321.

Sherwin, B. B. (2000). Oestrogen and cognitive function throughout the female lifespan. *Novartis Foundation Symposium*, *230*, 188–196.

Turner, M. L., & Pinkston, R. S. (1993). Effects of a memory and aging workshop on negative beliefs of memory loss in the elderly. *Educational Gerontology*, *19*, 359–373. doi:10.1080/0360127930190501.

Van der Linden, M., Philippot, P., & Heinen, P. (1997). Effect of age, education and verbal efficiency on memory performance and memory self-assessment. *Archives de Psychologie*, *65*, 171–185.

Verghese, J., Kuslansky, G., Katz, M. J., Crystal, H. A., Buschke, H., & Lipton, R. B. (2000). Cognitive performance in surgically menopausal women on estrogen. *Neurology*, *55*, 872–874.

Woodruff-Pak, D. S., & Finkbiner, R. G. (1995). Larger nondeclarative than declarative deficits in learning and memory in human aging. *Psychology and Aging*, *10*, 416–426.