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Mild Worry Symptoms Predict Decline in Learning and Memory in Healthy Older Adults:

A 2-Year Prospective Cohort Study

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Abstract

Objective—Theoretical models of cognitive aging are increasingly recognizing the importance of anxiety and depressive symptoms in predicting age-related cognitive changes and early dementia. This study examined the association between mild worry and depressive symptoms, and cognitive function in healthy, community-dwelling older adults.

Method—A total of 263 healthy older adults participated in an observational prospective cohort study that assessed worry and depression symptoms, and a broad range of cognitive functions over a 2-year period.

Results—Older adults with mildly elevated worry symptoms at baseline performed worse than older adults with minimal worry symptoms on measures of visual and paired associate learning. They were also more likely to show clinically significant (> 1.5 standard deviation) decline in visual learning and memory at a 2-year follow-up assessment (9.4% versus 2.5%; odds ratio = 3.8).

Conclusion—Assessment of worry symptoms, even mild levels, may have utility in predicting early cognitive decline in healthy, community-dwelling older adults.

OBJECTIVE

Theoretical models of cognitive aging are increasingly recognizing that anxiety symptoms are associated with reduced cognitive function^{1–4} and may predict age-related cognitive decline, as well as dementia.^{1,5–7} According to these models, anxiety symptoms interfere with cognitive performance by diverting and preoccupying attentional resources to fear- and threat-related information.^{1,2,8,9} Because anxiety-related thoughts are verbal in nature and depend on working memory and executive control, anxiety is thought to interfere predominantly with performance on verbal tasks and tasks that require complex attention and coordination, but not with simple visuospatial tasks with low executive demands.^{1–3,8–10}

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A growing body of research has documented the association between elevated anxiety and reductions in cognitive function in older adults.¹ This research has shown that older adults with clinically elevated anxiety symptoms score lower on global cognitive screening measures,^{6,11–13} as well as on measures of episodic memory^{4,12} and executive function (e.g., set-shifting^{12,14}). Similarly, studies of older adults with mild cognitive impairment (MCI) have found higher rates of anxiety symptoms compared to healthy controls^{15–17} and studies of older adults with generalized anxiety disorder (GAD) have found poorer global cognitive function⁶ and reductions in episodic memory and attentional shifting¹² compared to nonanxious, age-matched controls.

Clinically elevated anxiety also predicts cognitive decline in older adults.^{6,7,11} In a sample of 137 older adults referred for evaluation of memory complaints, Sinoff and Werner⁶ found that greater severity of anxiety symptoms at baseline predicted greater decline on the Mini Mental State Exam 1–5 years later. Similarly, DeLuca and associates¹¹ found that, in a sample of 79 older adults with depression, those with comorbid anxiety (generalized anxiety or panic disorder) experienced greater decline on a composite measure of memory than older adults with depression alone over a 4-year period. These studies suggest that clinically elevated anxiety symptoms may predict greater cognitive decline in nondemented older adults.

Mild anxiety symptoms may also be associated with cognitive reductions in healthy older adults, though few studies have examined this possibility.¹ In a sample of 102 healthy, community-dwelling older adults, Beaudreau and O'Hara² found that mildly elevated anxiety symptoms were associated with reduced processing speed and response inhibition, but that only response inhibition was specifically associated with anxiety after controlling for depressive symptoms. Wetherell and associates³ evaluated the longitudinal association between mild anxiety and cognition in a sample of 704 healthy older adults who participated in the Sweden Adoption/Twin Study of Aging. At the initial evaluation, greater state anxiety was associated with poorer memory, verbal abstract reasoning, and visual recognition; and greater neuroticism was associated with poorer visual recognition memory and visuospatial abilities and processing. However, neither anxiety nor neuroticism predicted cognitive decline in this study.

Depressive symptoms may also have a deleterious effect on cognition.^{2,4,5,18–21} In a study of 3,107 healthy elderly, Bierman and colleagues⁴ found that mild depressive symptoms were associated with poorer performance on measures of general cognition, information-processing speed, verbal learning, and visuospatial-problem solving. Other studies have found that depressive symptoms may interact with anxiety symptoms in reducing cognitive function. Beaudreau and O'Hara,² for example, found that the interaction of depressive and anxiety symptoms was associated with reduced performance on measures of episodic and semantic memory, but that depressive symptoms were not independently associated with cognitive performance. Prospective studies have found that depressive symptoms are associated with cognitive decline,^{5,19–21} and that the effect of anxiety on cognitive function is indirectly mediated by depression.⁶ A possible explanation for the association between depressive symptoms and reduced cognitive function is that elaborative, ruminative processing of negative information may reduce effort and attention to demanding cognitive tasks.^{22,23} According to some researchers, late-life depression may be an early manifestation of cognitive decline and neurodegenerative disease.²⁴

Given the importance of early detection of cognitive decline, more prospective studies are needed to evaluate associations between mild anxiety and depressive symptoms, and cognitive decline in healthy older adults. Despite research suggesting that worry symptoms are associated with reduced processing speed²⁵ and attentional biases to threat-related

information²⁶ and that they may have an especially detrimental effect on cognitive function in older adults,¹ little is known about the relationship between this specific aspect of anxiety and cognitive function. Identification of specific dimensions of anxiety associated with cognitive function and/or decline may help identify potentially modifiable aspects of anxiety that may help preserve cognitive function and slow or prevent cognitive decline in late-life.¹

The current study examined the association between mild worry and depressive symptoms, and cognitive function in healthy, community-dwelling older adults. On the basis of processing efficiency theory^{8,9} and results of prior studies,^{1,2,6,11} we hypothesized that: (a) greater worry symptoms would be associated with reduced performance on tests of visual attention and learning and memory; (b) mild depressive symptoms would be related to reduced psychomotor speed; and (c) greater baseline worry, but not depressive, symptoms at baseline would predict decline on measures of these cognitive functions over a 2-year follow-up.

METHODS

Participants

A total of 263 healthy community-dwelling older adults residing in the greater Melbourne, Australia area participated in this observational prospective cohort study. Testing was conducted at two sites in the greater Melbourne area, which included a community setting at the state headquarters of a disease advocacy group (Alzheimer Australia) and a clinical research unit in the memory clinic of a large metropolitan hospital. Data from the initial visit and 1- and 2-year follow-ups were analyzed in this study. A research assistant conducted the assessments at both sites using staggered appointments. Participants were recruited via an advertising campaign that included an announcement on a radio talk show, articles in the Alzheimer Australia advocacy group newsletter, and a news release from the advocacy group that was published in several local newspapers.

Inclusion criteria were: (a) age of 50 years or older; (b) willingness to nominate a physician to be kept informed of the study participation and results; (c) willingness to be informed of their results during the study and to accept the potential risk that participation in the study may find that their cognitive performance to be impaired or declining; (d) willingness to attend all study visits at one of the two testing sites; and (e) ability and willingness to provide informed consent. Exclusion criteria were: (a) any known cognitive impairment due to a neurologic or medical disorder; (b) any other condition that might make it difficult to complete testing over a 2-year period; (c) uncorrectable visual impairment; (d) physical handicap or condition preventing effective use of a computer keyboard or 2-button mouse; and (e) unwillingness to undergo testing using a computer. The study was approved by the local institutional ethics committee and all participants provided written informed consent. Additional details about the study are reported elsewhere.²⁷

Mood and Anxiety Measures

The Penn State Worry Questionnaire (PSWQ) is a 16-item self-report measure used to assess pathological worry in both clinical and nonclinical populations.²⁸ The PSWQ was designed to assess the generality, excessiveness, and uncontrollability of pathologic worry. It has been shown to have good internal consistency in samples consisting of individuals recruited from the community²⁹ and older adults with GAD.³⁰ It also has good test-retest reliability.²⁸ A cut score of 50 has been recommended to identify GAD in older adults.³¹

The Patient Health Questionnaire-9 (PHQ-9) is a reliable and valid 9-item self-report screening instrument that assesses depressive symptoms over the past 2 weeks.³² Scores

range from 0 to 27, with higher scores indicative of greater depressive symptoms. A cut score of 10 has been recommended to identify probable major depressive disorder.³²

Cognitive Measures

All of the cognitive measures utilized in this study are part of the CogState cognitive test battery, which is described in detail elsewhere.^{27,33} These measures were selected because they are brief, repeatable, resistant to practice effects, and have demonstrated good acceptability, efficiency, and stability for the repeated assessment of cognitive function in healthy older adults.²⁷ Brief descriptions of the tasks are provided below.

The Detection (DET) task is a simple reaction time test that measures psychomotor speed. In this task, the participant must press the “Yes” key as quickly as possible when a card presented in the center of the screen turns face-up. The task ends when 35 correct trials were recorded. Mean speed of performance for correct responses is the outcome measure.

The Identification (IDN) task is a choice reaction time test that measures visual attention. In this task, the participant must press the “Yes” key as quickly as possible when the presented card is red or “No” if it is black. The task ends when 30 correct trials are recorded. Mean speed of performance for correct responses is the outcome measure.

The One-Card Learning (OCL) task assesses visual attention and recognition memory. In this task, participants are asked to respond “Yes” if the face-up card appeared previously in the task and “No” if it had not. Six cards were repeated in a total of 42 cards. Mean accuracy is the outcome measure.

The Continuous Paired Associate Learning Test (CPAL) assesses visual learning and memory. In this task, participants are asked to learn and remember figures hidden beneath different locations on the screen. They must then tap the target on the central location to begin. As each picture to be learned is revealed, they tap each location and remember where the picture was located. Total errors are the outcome measure.

The One-Back test (OBK) assesses visual attention and working memory. In this task, participants are asked to respond “Yes” if the face-up card was exactly the same as the card that immediately preceded it or “No” if it was not this card. The task ends when 30 correct trials are recorded. Mean speed of performance for correct responses is the outcome measure.

The International Shopping List Test (ISLT) assesses verbal learning and memory.³⁴ It is a 12-word, three-trial, verbal list-learning test that is similar in design to other verbal list learning tasks such as the Hopkins Verbal Learning Test.³⁵ In the ISLT, the presentation of stimuli and the recording of responses are controlled by a computer. For each 12-word list that is used, the software selects at random the order in which words are presented to subjects. Total words recalled during immediate and delayed trials are outcome measures. The ISLT was administered only at the 2-year visit.

Data Analysis

Distributions of response times for the Detection, Identification, and One-back tasks were normalized using logarithmic base 10 transformations. Distributions of proportion accuracy on the OCL task were normalized using an arcsine transformation. Because PSWQ scores at the baseline visit were bimodally distributed and PHQ-9 scores were negatively skewed, a median split procedure was applied to separate the sample into “minimal worry” and “mildly elevated worry” groups; and “minimal depression” and “mildly elevated depression” groups. Independent-samples *t*-tests and χ^2 tests were used to compare demographic characteristics

of the worry groups; depression group was entered as a covariate in analyses. Mixed model repeated-measures analyses of covariance using restricted maximum likelihood estimation and an unstructured covariance structure were used to analyze cognitive test scores. Age, baseline worry group (minimal versus mildly elevated), baseline depression group (minimal versus mildly elevated), time (baseline, and 1- and 2-year follow-up assessments), baseline cognitive test score, and the interaction terms of worry group $\times$ time, depression group $\times$ time, and worry group $\times$ depression group $\times$ time were entered as fixed effects; subject and time were entered as random effects. To reduce the likelihood of making a Type I error, alpha was 0.01 in these analyses. Cohen's d values were computed to estimate magnitudes of group differences in cognitive test scores at the 1- and 2-year follow-up assessments. When significant group differences were noted, χ^2 analyses were conducted to examine the percentage of individuals in the minimal worry and mildly worry groups who had clinically significant (≥ 1.5 standard deviations) decline on these measures; logistic regression analyses with age, worry group, depression group, and worry $\times$ depression group interaction entered as independent variables were then conducted to examine the odds ratios of clinically significant cognitive decline by worry group.

Multivariate analysis of covariance (MANCOVA) with age and mild worry and depression groups, computed at the 2-year visit and entered as independent variables, was used to analyze the relationship between worry symptoms and ISLT performance at the 2-year visit.

RESULTS

Worry and Depression Group Classification

Median split of PSWQ scores at baseline resulted in two groups: one with “minimal worry” symptoms ($n = 122$; mean $[M] = 10.77$; standard deviation $[SD] = 6.67$) and another with “mildly elevated worry” symptoms ($n = 141$; $M = 37.11$; $SD = 10.10$). Median split of PHQ-9 scores resulted in a “minimal depression” group ($n = 111$, $M = .44$, $SD = 0.50$) and a “mildly elevated depression” group ($n = 152$, $M = 4.60$, $SD = 3.55$). Ninety-nine (65.1%) participants in the mildly elevated worry group were in the mildly elevated depression group ($\chi^2(1) = 19.22$, $p < 0.001$). Fourteen (5.3%) participants met or exceeded the recommended cut score of 50 on the PSWQ; 10 (3.8%) participants met or exceeded the recommended cut score of 10 on the PHQ-9.

Demographics

Table 1 displays demographic characteristics of the minimal worry and mildly elevated worry groups. The mean age of the full sample was 61.6 ($SD = 7.0$; range: 50–86). A total of 187 (71.1%) were women and 76 (28.9%) were men. A total of 105 (58.9%) participants completed up to secondary education (12th grade) and 108 (41.1%) completed tertiary education (college degree). The majority of participants (84%) had computer experience. Demographic variables did not differ by group.

Mixed model analyses of PSWQ scores showed that worry symptoms remained stable over time ($F_{[1, 204]} = 2.66$, $p = 0.10$) in both the minimal worry (1-year: $M = 11.53$, $SD = 15.12$; 2-year: $M = 13.26$, $SD = 16.34$) and mildly elevated worry groups (1-year: $M = 30.21$, $SD = 15.19$; 2-year: $M = 29.29$, $SD = 16.50$). Similarly, PHQ-9 scores remained stable over time in both groups ($F_{[1, 204]} = 0.87$, $p = 0.35$; minimal worry group, 1-year: $M = 1.56$, $SD = 2.98$; 2-year: $M = 1.56$, $SD = 3.31$; mildly elevated worry group, 1-year: $M = 3.24$, $SD = 2.97$; 2-year: $M = 2.92$, $SD = 3.32$).

Table 2 shows fixed effect estimates for mixed model analyses of cognitive test scores. Main effects of mildly elevated worry were significant for visual learning and memory on the CPAL test and marginally for visual attention/recognition memory on the OCL test, but not

for simple or choice reaction time, and visual attention/working memory on the DET, IDN, and OBK tests, respectively, with the mildly elevated worry group performing worse on these tests than the minimal worry group (small effect sizes). The main effect of mildly elevated depression was marginally significant for simple reaction time on the DET test (see Table 2), with the mildly elevated depression group evidencing slower performance on this measure than the minimal depression group ($M = 2.522$, $SD = 0.084$ versus $M = 2.492$, $SD = 0.086$; $d = 0.34$). None of the interactions of mildly elevated worry and mildly elevated depression were significant.

Significant worry group $\times$ time effects emerged for visual learning and memory on the CPAL test and marginally for visual attention/recognition memory on the OCL test (see Table 2); Table 3 displays means and standard errors for all tests by worry group status. Table 4 shows mean scores on each cognitive test at the 1- and 2-year follow-up assessments. Compared to the minimal worry group, the mildly elevated worry group scored significantly lower on the CPAL measure of visual learning and memory and marginally lower on the OCL measure of visual attention/recognition memory at the 2-year follow-up (small-to-medium effect sizes).

Chi-square analysis revealed that the mildly elevated worry group was more likely than the minimal worry group to show clinically significant (≥ 1.5 standard deviation) decline in visual learning and memory performance on the CPAL (9.4% versus 2.5%, $\chi^2(1) = 5.43$, $p = 0.020$). Logistic regression analysis revealed that mildly elevated worry was associated with significantly greater odds of decline on this test (Wald $\chi^2_{[1]} = 3.99$, $p = 0.046$; OR = 3.83; 95% CI = 1.03–14.28); age (Wald $\chi^2_{[1]} = 3.46$, $p = 0.063$), baseline depression group (Wald $\chi^2_{[1]} = 0.00$, $p = 0.99$), and the interaction of worry and depression group (Wald $\chi^2 = 0.00$, $p = 0.99$) were not significant in this analysis.

To evaluate the processing efficiency hypothesis that reductions in working memory may mediate the association between worry and performance on complex measures of cognition such as the CPAL,^{8,9} mediational analyses were conducted.³⁶ Results of these analyses suggested that working memory performance (i.e., OBK scores) fully mediated the relationship between baseline worry group and visual learning and memory performance (i.e., CPAL scores) at the baseline ($F_{[2, 248]} = 3.56$, 0.030 ; β for OBK = .13, $t = 2.03$, $df = 248$, $p = 0.043$; β for worry group = 0.08, $t = 1.24$, $df = 248$, $p = 0.22$) and 1-year ($F_{[2, 255]} = 4.23$, $p = 0.016$; β for OBK = 0.15, $t = 2.42$, $df = 255$, $p = 0.016$; β for worry group = 0.08, $t = 1.26$, $df = 255$, $p = 0.21$) assessments. At the 2-year assessment, worry group was associated with visual learning and memory ($F_{[2, 160]} = 7.45$, $p = 0.001$; β for worry group = 0.24, $t = 3.20$, $df = 160$, $p = 0.002$), but working memory (i.e., OBK scores) did not mediate this association (β for OBK = 0.14, $t = 1.86$, $df = 160$, $p = 0.064$). Baseline worry group was associated with decline in CPAL performance over the 2-year period ($F_{[2, 160]} = 3.13$, $p = 0.047$; $\beta = 0.13$, $t = 2.00$, $df = 160$, $p = 0.047$), but change in working memory performance over this period did not mediate this association (β for change in OBK = 0.03, $t = 0.54$, $df = 160$, $p = 0.59$).

Analysis of verbal learning and memory performance on the ISLT at the 2-year follow-up revealed that compared to the minimal worry group, the mildly elevated worry group recalled fewer words on the delayed memory trial ($M = 8.56$, $SD = 2.61$ versus $M = 9.30$, $SD = 2.54$; $F_{[1, 181]} = 5.12$, $p = 0.025$, $d = 0.32$); immediate verbal recall scores did not differ ($M = 25.83$, $SD = 5.22$ versus $M = 26.26$, $SD = 5.19$, $F_{[1, 181]} = 0.45$, $p = 0.50$, $d = 0.09$). Age was associated with significantly worse performance for both immediate ($F_{[1, 181]} = 22.50$, $p < 0.001$) and delayed recall ($F_{[1, 181]} = 22.53$, $p < 0.001$), but mildly elevated depression ($F_{[2, 181]} = 0.35$, $p = 0.70$) and the interaction of mildly elevated worry and depression ($F_{[2, 181]} = .93$, $p = 0.40$) were not. Figure 1 shows ISLT performance by worry

group. Working memory (i.e., OBK scores) did not mediate the association between worry group and immediate and delayed ISLT performance (both β 's <0.10 , t 's <1.39 , p 's >0.16).

CONCLUSIONS

This study examined the association between mild worry and depressive symptoms, and cognitive function in healthy, community-dwelling older adults. Mildly elevated worry symptoms were associated with poorer performance and predicted clinically significant decline on a measure of visual learning and memory. Older adults with mildly elevated worry symptoms also scored lower on a measure of delayed verbal recall at the 2-year assessment. Magnitudes of associations between anxiety and visual learning and memory were in the small-to-moderate range, which is consistent with previous studies^{2–4} (e.g., β 's of associations between measures of state anxiety and visual learning and memory ranging from 0.20 to 0.25 in study of 704 healthy older adults).³ To our knowledge, results of the current study are among the first to demonstrate that mildly elevated worry symptoms are associated with cognitive decline in healthy older adults and that this effect is independent of mild depressive symptoms.

Previous studies have found that mild anxiety symptoms were associated with poorer performance on measures of vocabulary, verbal reasoning, visuoconstruction, and visual learning³ and processing speed/attentional shifting, inhibition, naming, and episodic verbal memory.^{2,14} Combined with results of the current study, these findings suggest that mildly elevated worry symptoms in healthy older adults have a deleterious effect on tasks that involve speed-dependent processing, learning, and higher-level executive functions such as shifting, inhibition, and reasoning.

Performance on a measure of working memory (i.e., one-back task) mediated the association between worry symptoms and performance on a measure of visual learning and memory (i.e., paired associate learning task). These results provide support for Eysenck's processing efficiency theory,^{8,9} which suggests that anxiety/worry interferes with processing and storage resources of attentional and working memory systems. They also corroborate previous reports, which have noted that worry symptoms, in particular, are associated with reduced processing speed²⁵ and biases in attention to threat information,²⁶ which in turn negatively affect cognitive function. Greater worry may also be associated with ruminative thinking, which may reduce performance on complex cognitive tasks, such as the CPAL.^{22,23} The finding that worry symptoms remained stable throughout the 2-year study period suggests that they may be useful in predicting cognitive decline at any timepoint.

The current study extends the literature on the role of mild anxiety in predicting cognitive decline in healthy older adults. Although some previous studies of healthy older adults did not find that state anxiety predicted subsequent cognitive decline,^{3,37} studies of older adults referred for evaluation of memory complaints,⁶ older adults with depression and comorbid anxiety,¹¹ as well as a large prospective cohort of healthy older adults⁷ did find that anxiety symptoms predicted greater cognitive decline over time. Results of the current study extend these findings to suggest that healthy older adults with mildly elevated worry symptoms at an initial evaluation show greater decline in visual learning and memory over time, and that this effect is independent of age, and baseline cognitive performance and depressive symptoms. One explanation for why mild anxiety was associated with cognitive decline in the current study but not in other studies^{3,37} may relate to the specificity of anxiety symptoms assessed. Worry symptoms, in particular, may be associated with cognitive decline, whereas more general measures of anxiety that reflect noncognitive aspects of anxiety (e.g., somatic symptoms) may not. Additional studies that employ multidimensional

measures of anxiety are needed to evaluate the specificity of anxiety symptoms in predicting cognitive decline.

Mild depressive symptoms were marginally associated with reduced performance on a measure of simple reaction time, but not on other measures; they were also not associated with cognitive decline. Given that previous studies have found that more severe depressive symptoms may be associated with reductions in performance on more complex cognitive tasks,⁴ one possible explanation for this finding is that mild depressive symptoms involve less ruminative thinking and elaborative processing of negative information than more severe depressive symptoms,^{22,23} which in turn may preserve performance on more complex cognitive tasks (e.g., visual learning and memory, working memory).

Worry symptoms at the initial evaluation were associated with greater likelihood of clinically significant decline in visual learning and memory with individuals in the mildly elevated worry group being 3.8 times more likely than those in the minimal worry group to have experienced clinically significant decline on this measure over the 2-year follow-up. Given that paired associate learning may predict early dementia,^{38,39} these results underscore the importance of assessing worry symptoms in individuals at-risk for neurodegenerative disease. Accumulating evidence suggests that anxiety and depression are risk factors for MCI and Alzheimer disease^{5,19–21,40–42} For example, a recent population-based study of 9,965 elderly individuals found that, relative to healthy controls, individuals with MCI were twice as likely to have a broad range of neuropsychiatric symptoms, including apathy, agitation, anxiety, irritability, and depression.¹⁵ Anxiety symptoms may also be an indicator of neurodegenerative disease, as evidenced by a population-based study of older adults, which found that 83.3% of those with MCI and anxiety symptoms developed AD over a 3-year follow-up compared to 40.9% of those with MCI without anxiety and 6.1% of cognitively intact individuals.⁵ Anxiety and worry are also associated with subjective cognitive impairment,^{43,44} which is in turn related to greater cognitive decline and incident dementia. Although subjective cognitive impairment was not assessed in the current study, greater worry symptoms may, at least in part, be related to concerns about declining cognition.

Methodological limitations of this study must be noted. First, the sample consisted predominantly of female, middle-aged to older adults, which may limit generalizability of findings to this population. Second, a brief battery of cognitive tests and two select measures of worry and depressive symptoms were employed. Thus, it is not clear whether results would differ if other cognitive and psychiatric symptom measures or assessments of trait anxiety were administered. Third, data distributions required that a median split procedure be employed to divide the sample into groups at baseline, which may have reduced statistical power. Further, given the low level of symptoms and minimal variance on both the PSWQ and PHQ-9, it remains to be examined whether results would differ if larger samples with greater severity and variability of anxiety/worry and depressive symptoms were examined. Fourth, the relation between anxiety and cognitive performance may be more complex than observed in most studies. For example, the association between anxiety and cognition may be curvilinear in nature^{4,37} and may differ as a function of severity of cognitive decline.⁴⁵ In the current study, few older adults met screening criteria for clinically significant worry or depression, so an examination of the nonlinearity of this association was not possible. More research in larger samples of older adults followed for longer periods of time is needed to assess how the full range of anxiety and depressive symptoms relates to cognitive function, especially because the relationship between baseline psychological symptoms and cognitive impairment may become more pronounced over time.^{18,45} Finally, participants in the current study were highly motivated to participate and

the vast majority had computer experience. Thus, whether results of this study apply to older adults who are less motivated and less familiar with computers awaits additional research.

Despite these limitations, these results are the first, to our knowledge, to suggest that mild worry symptoms are independently associated with and predict decline in learning and memory in healthy, community-dwelling older adults. More research is needed to evaluate the neurobiologic mechanisms underlying the association between worry and cognitive functioning in healthy older adults and to evaluate the potential prognostic utility of mild worry in detecting early neurodegenerative disease.

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Figure 1. Means and 95% confidence intervals for International Shopping List Test performance by worry group (scores are adjusted for age and PHQ-9 score at 2-year follow-up assessment).

Table 1

Demographic and clinical characteristics of the sample by worry group status at initial visit

	Minimal Worry	Mildly Elevated Worry	t (261) or $\chi^2(1)$	p
N	122	141		
Age	61.0 (SD=6.3)	62.2 (SD=7.4)	1.40	.16
Gender (%female)	83 (68.0%)	104 (73.8%)	1.04	.31
Education			1.52	.27
Primary/Secondary	67 (54.9%)	88 (62.4%)		
Tertiary	55 (45.1%)	53 (37.6%)		
Computer experience (%yes)	111 (91.0%)	118 (83.7%)	3.09	.12

Note. SD=standard deviation

Table 2

Fixed effect estimates generated by linear mixed model analyses of cognitive test scores

	Simple reaction time (DET)		Choice reaction time (IDN)		Visual attention/recognition memory (OCL)		Visual learning and memory (CPAL)		Visual attention/working memory (OBK)	
	F	p	F	p	F	p	F	p	F	p
Mild worry	3.68	.056	3.06	.081	5.74	.017	10.88	.001	1.67	.20
Mild depression	6.64	.011	.40	.53	1.75	.19	.50	.48	0.00	.99
Time	26.61	<.001	17.83	<.001	4.93	.027	13.81	<.001	1.80	.18
Baseline cognitive score	45.20	<.001	140.83	<.001	19.69	<.001	91.18	<.001	181.80	<.001
Age	13.82	<.001	10.59	.001	11.41	.001	10.77	.001	5.28	.022
Mild worry × time	3.20	.075	1.38	.24	4.65	.032	10.57	.001	2.60	.11
Mild depression × time	.46	.50	1.17	.28	.57	.45	.10	.75	0.00	.99
Mild worry × mild depression	2.76	.098	1.90	.17	2.78	.097	.54	.46	.66	.42
Mild worry × mild depression × time	3.20	.075	1.20	.27	1.59	.21	1.13	.29	2.51	.12

Note. Significant effects ($p < .01$) are highlighted in bold.

DET=Detection task; IDN=Identification task; OCL=One-card learning task; CPAL=Continuous Paired Associate Learning task; OBK=One back task.

F and p values are derived from mixed model analyses of covariance. Numerator and denominator degrees of freedom=1, 239 for age; 1, 228 for baseline cognitive score; 1, 201 for mild worry and depression groups; and 1, 175 for time, mild worry × time, mild depression × time, mild worry × depression, and mild worry × mild depression × time.

Table 3

Means and standard errors for cognitive measures across all assessments by worry group

	Minimal Worry M (SD)	Mildly Elevated Worry M (SD)	Cohen's d
Simple reaction time (DET)	2.493 (.077)	2.513 (.083)	.25
Choice reaction time (IDN)	2.704 (.044)	2.715 (.047)	.24
Visual attention/recognition memory (OCL)	1.057 (.088)	1.029 (.095)	.30
Visual learning and memory (CPAL)*	28.036 (22.50)	37.473 (23.72)	.41
Visual attention/working memory (OBK)	2.896 (.055)	2.906 (.071)	.16

Note. Values are adjusted for age and depression group status.

M=mean; SD=standard deviation.

DET=Detection task; IDN=Identification task; OCL=One-card learning task;

CPAL=Continuous Paired Associate Learning task; OBK=One back task.

Estimates are derived from mixed model analyses of covariance shown in Table 2; group comparisons are based on F tests of the main effect of mild worry group.

Numerator and denominator degrees of freedom for all analyses=1, 201.

* Groups differ significantly, $p < .01$.

Table 4

Means and standard errors for cognitive measures at 1- and 2-year follow-up assessments by worry group

	Minimal Worry M (SD)	Mildly Elevated Worry M (SD)	Cohen's d
<i>1-year follow-up (n=253)</i>			
Simple reaction time (DET)	2.505 (.088)	2.538 (.107)	.33
Choice reaction time (IDN)	2.711 (.055)	2.726 (.059)	.26
Visual attention/recognition memory (OCL)	1.057 (.099)	1.047 (.119)	.09
Visual learning and memory (CPAL)	27.522 (24.87)	29.812 (27.30)	.09
Visual attention/working memory (OBK)	2.896 (.066)	2.913 (.071)	.25
<i>2-year follow-up (n=195)</i>			
Simple reaction time (DET)	2.482 (.099)	2.489 (.107)	.07
Choice reaction time (IDN)	2.698 (.055)	2.703 (.059)	.09
Visual attention/recognition memory (OCL)	1.057 (.110)	1.011 (.119)	.40
Visual learning and memory (CPAL)*	28.549 (31.76)	45.134 (32.12)	.52
Visual attention/working memory (OBK)	2.897 (.077)	2.899 (.083)	.02

Note. Means are adjusted for age and baseline PHQ-9 scores.

M=mean, SD=standard deviation.

Estimates are derived from mixed model analyses of covariance shown in Table 2; group comparisons are based on F tests of the interaction term of mild worry group $\times$ time.

Numerator and denominator degrees of freedom for all analyses=1, 175.

* Groups differ, $p < .01$