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# Depressive Symptoms Impair Everyday Problem-Solving Ability through Cognitive Abilities in Late Life

**Yung-Chieh Yen, MD, MSc, PhD**,
Department of Psychiatry, E-Da Hospital and College of Medicine, I-Shou University, Kaohsiung County, Taiwan

**George W. Rebok, PhD**,
Department of Mental Health, Johns Hopkins University Bloomberg School of Public Health, Baltimore, Maryland

**Joseph J. Gallo, MD, MPH**,
Department of Family Medicine and Community Health, University of Pennsylvania, Philadelphia, Pennsylvania

**Richard N. Jones, ScD**, and
Hebrew Senior Life, Institute for Aging Research, Boston, Massachusetts

**Sharon L. Tennstedt, PhD**
New England Research Institutes, Watertown, Massachusetts

## Abstract

**Background—**The association between depression and functional disability in late life remains unclear. This study aimed to explore the relationship between depressive symptoms and daily functioning through the mediation of cognitive abilities, measured by memory, reasoning, and speed of processing.

**Methods—**We recruited 2,832 older adults (mean age = 73.6 years, SD = 5.9) participating in the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) Study. Structural equation modeling (SEM) was applied to illustrate the relationship between depressive symptoms and everyday problem-solving ability through the mediation of cognitive abilities.

**Results—**Depressive symptoms were associated with impaired everyday problem-solving ability directly and indirectly mediated via learning and memory, and reasoning. Although depressive symptoms were associated with speed of processing, speed of processing was not significantly related to everyday problem-solving ability.

**Conclusions—**This study conceptualizes the possible relationships between depressive symptoms and daily functioning with mediation of cognitive abilities and provides a feasible model for the prevention of functional impairment related to geriatric depressive symptoms.

### Keywords

depression; cognition; everyday function; elderly

Corresponding Author: George W. Rebok, PhD. Department of Mental Health, Johns Hopkins University Bloomberg School of Public Health, 624 N. Broadway, 8th Fl., Baltimore, MD 21205 (phone: 410-955-8550; fax: 410-955-9088; grebok@jhsph.edu).

## Introduction

Dementia, delirium, and depression in late life call for our attention because they are related to functional disability, poorer quality of life, and the demands they put on family members or caregivers.[1] Depression is predicted to be second to cardiovascular disease as a worldwide cause of disability in 2020.[2–5] Functional disability related to depression in the older adults population thus becomes an important issue in attempts to prevent or intervene on disability in late life.

Studies on the association between depression and functional disability can be traced back to the 1960's.[6] Later studies suggested that functional disability may lead to depression, [7–11] whereas some other longitudinal or prospective cohort studies propose the possibility that depression may lead to functional disability.[12–22] Some researchers have proposed that the relationship between depression and disability in older adults may be reciprocal or potentially spiraling.[23] In addition, cognitive impairment is considered to interact with depression in the relationship with functional disability.[21,24]

Symptoms or syndromes of depression have been noted to precede cognitive decline and dementia in previous studies.[25,26] These results suggest that depression may play a role in the development of functional disability related to cognitive processes. However, the intermediate cognitive process between depression and functional disability had never been empirically tested, although previous researchers found that fluid and crystallized intellectual abilities were the direct predictors of functioning in everyday life, while working memory and speed of processing merely had an indirect effect on functioning.[29–31] The hypothesis of a "depression-executive dysfunction syndrome" was proposed to describe the conditions of elderly patients with decreased energy and cognitive impairment, principally the ability to planning and attention.[32] Furthermore, slowed processing speed was found to be the core cognitive deficit of late-life depression and was closely followed by impaired executive function (Sheline et al., 2006).[31] Later Gallo et al.[17] concluded that memory and reasoning abilities were both important mediators in the relationship of depression and functional performance in a pilot study of the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) Study.[33,34] The findings have not yet been replicated in another sample.

The relationship of depression to functional disability through the possible associations of depression and memory, reasoning, and speed of processing is important when interventions aim at decreasing the disability of older adults. Efficient management of depression as well as the improvement of cognitive abilities that may underlie the process of functional decline will then be justified for their roles in prevention of disability of older adults. To identify the possible pathways between depression and functional disability, this study examines the participants in the ACTIVE study with comprehensive measures of cognitive abilities and everyday problem-solving ability. The conceptual framework that guides the analysis of the potential relationship of depressive symptoms, cognition, and everyday problem-solving is shown in Figure 1. In the model, we propose that depressive symptoms affect memory, reasoning, speed of processing abilities, and everyday problem-solving ability, in accordance with previous studies.[17, 28,29]

## Method

### Subjects

Recruitment of participants for the ACTIVE trial was conducted from March 1998 to October 1999. Details of the subject sample and the recruitment procedures have been published elsewhere.[33–35] Self-reported data include age, years of education, gender,

ethnicity, and the sum of reported health conditions, ranging from 0 to 8. Depressive symptoms, cognitive abilities, and everyday problem-solving ability of the participants were measured as described below. For this study, we used only the baseline data of the ACTIVE study participants.

## Measures

*Depressive symptoms* were assessed using the Center for Epidemiological Studies-Depression (CES-D) scale.[36] The 12-item version of this measure asks participants to report the frequency (never or less than once a day, 1–2 days, 3–4 days, 5–7 days) during the past week that they experienced certain symptoms or feelings. A total score derived from the four CES-D subscale scores was Blom transformed before analysis.

*Learning and memory* assessment focused on episodic verbal memory tasks. The Hopkins Verbal Learning Test (HVLT)[37] evaluates new verbal learning and memory. Total words correctly recalled over three trials were employed in this study. In the Rey Auditory-Verbal Learning Test (AVLT),[38] the number of words recalled across five trials provided an index of new learning. Total number of words correctly recalled over five trials was used as score in the analysis. The subscale of Rivermead Behavioral Memory Test[39] that assesses memory for stories was employed in this study. The number of idea units presented in the story that were correctly recalled was used as the score on this task.

*Reasoning* assessment focused on tasks requiring identification of patterns in letter or word series problems. Word Series (WS)[40] tested whether participants could determine the pattern of words in a list and then select the word that will come next in the series. The total number of word series correctly completed in six minutes was scored and used in the analysis. Letter Series (LS) was an adaptation of the number series and letter series tests of Thurstone.[41] Participants were asked to discover one or more rules or patterns. The total number of series correctly completed in six minutes was recorded and used in the analysis. In Letter Sets (LT),[42] participants viewed a set of letters and had to identify the set that did not use the same pattern rules as other sets in that group. The total number of letter sets correctly identified in seven minutes was recorded and used in analysis.

*Speed of processing* assessment focused on identifying the minimum stimulus duration at which participants could identify and localize information under varying levels of cognitive demand. Useful Field of View (UFOV) Tasks 2–4[43–45] were included in the analysis. For each task, the dependent variable was the shortest presentation time needed by participants to complete the task 75% of the time. Task 1 was not included because of its simplicity and lack of ability to distinguish participants with mild impairment from ones without impairment.

Outcome measures were aspects of functional activities. *Everyday problem-solving* represented the ability to correctly identify and reason information in everyday stimuli (e.g., forms, charts, medical labels). The Everyday Problems Test (EPT)[46] and the Observed Tasks of Daily Living (OTDL),[47,48] both performance-based and measured via paper-and-pencil testing and behavioral stimulations of everyday tasks, were applied in this study.

## Analysis

To evaluate the relationships between the above variables, data were analyzed in two phases: (1) Descriptive analyses included examination of distributions of the sociodemographics, health conditions, depressive symptoms, cognitive abilities, and everyday problem-solving ability. (2) An *a priori* structural equation model (SEM) (see Figure 1) was estimated to evaluate the conceptual models dealing with depressive symptoms, cognitive abilities, and everyday problem-solving ability. The *a priori* model

was then modified and tested to explore the possible relationships between depressive symptoms, cognitive abilities, and everyday problem-solving ability. In those analyses, CES-D was treated as a single continuous variable measuring depressive symptoms. Four latent variables were created: 1) learning and memory ability represented by HVLT, AVLT, and the Rivermead Behavioral Memory Test; 2) reasoning ability by the Word Series, Letter Series, and Letter Sets tests; 3) speed of processing ability by the UFOV Tasks 2–4; and 4) everyday problem-solving ability by the EPT and OTDL tasks. Data on the depressive symptoms and the above indicator variables for the latent variables were Blom-transformed to better fit the hypothesis of normal distribution.[49] Standardized measures of association were reported to account for the differing scales of the instruments employed. Models included covariates (gender, age, race, education, and health conditions) that are significantly associated with depression, cognitive abilities, and everyday problem-solving ability when using linear regression. Since participants were clustered in six sites, robust standard errors of measures of these associations were estimated. Differences in $\chi^2$ for nested models were examined to assess improvement in fit offered by freeing parameters of interest that relate depression to the variables under study. The value of Akaike Information Criterion (AIC) for each model was also compared.[50] The AIC accounts for both model fit and parsimony.[51] The model with smallest AIC value was selected. At the same time, three other indicators were used to examine the fitness of the model. Tucker-Lewis Index (TLI) and Comparative Fit Index (CFI) of the selected model should be 0.90 or more; the root mean square error of approximation (RMSEA) of the selected model should be less than 0.10. The direct and indirect effects (through cognitive abilities) of depression on everyday problem solving performance were calculated when standardized measures of association were reported. The structural equation models with latent variables were estimated with Mplus version 4.1.[52] Two-tailed tests of significance with type I error rate set at .05 were used.

## Results

Depressive symptoms, cognitive abilities, and everyday problem-solving ability for all participants are listed in Table 1. Seventy-six percent of participants were women and 72% were white, with a mean age of 73.6 (SD 5.9) years and a mean education of 13.5 (SD 2.7) years. Structural equation modeling was employed to operationalize the conceptual model of the mediation of cognitive process in the relationship of depressive symptoms and everyday problem-solving ability. Standardized parameter estimates and measures of model fit were estimated for all models that included paths from depressive symptoms to learning and memory, reasoning, processing speed abilities, or everyday problem-solving ability. In the selected model dealing with depressive symptoms (CES-D), cognitive abilities (measured by learning and memory, reasoning, and speed of processing), and everyday problem-solving ability (Figure 2), we found that all coefficients estimated for the paths from depressive symptoms to learning and memory, reasoning, speed of processing, and everyday problem-solving ability were significantly different from the null value of zero.

### Depressive symptoms and cognitive abilities

Based on our estimate for the path from depressive symptoms to learning and memory, a one standard deviation increase in depressive symptoms can be expected to be associated with a 0.114 standard deviation decrease (95% confidence interval [CI], [−0.140, −0.088]) in learning and memory ability. Similarly, for the path from depressive symptoms to reasoning ability, a one standard deviation increase in depressive symptoms can be expected to be associated with a 0.041 standard deviation decrease (95% CI [−0.056, −0.026]) in reasoning ability. For the path from depressive symptoms to speed of processing, a one

standard deviation increase in depressive symptoms can be expected to be associated with a 0.061 standard deviation decrease (95% CI [−0.030, −0.091]) in processing speed.

### Depressive symptoms and everyday problem-solving ability

**Direct effect—**For the path directly from depressive symptoms to everyday problem-solving ability, a one standard deviation increase in depressive symptoms can be expected to be associated with a 0.043 standard deviation decrease (95% CI –[0.062, −0.023]) in everyday problem-solving ability. This direct effect accounts only for the association between depressive symptoms and everyday problem-solving ability without the mediation of learning and memory, reasoning, and speed of processing.

**Through learning and memory—**The effect of a one standard deviation increase in depressive symptoms through learning and memory to everyday problem-solving ability leads to an expected 0.064 standard deviation decrease in everyday problem-solving ability. It is calculated (see Figure 2) by adding −0.114×0.317 and −0.114×0.464×0.522 from two possible pathways in the selected model. It is notable that this learning and memory-mediated effect is greater than the direct effect of depressive symptoms to everyday problem solving ability. *Through reasoning.* A one standard deviation increase in depressive symptoms through reasoning ability leads to an expected 0.021 standard deviation decrease in everyday problem-solving ability. It is calculated (see Figure 2) by -0.041×0.522 from the only pathway in the model.

**Through speed of processing—**A one standard deviation increase in depressive symptoms through speed of processing leads to an expected 0.027 standard deviation decrease in everyday problem-solving ability. It is calculated (see Figure 2) by adding 0.061x(−0.389)×0.317, 0.061×(−0.389) ×0.464×0.522, 0.061× (−0.030), and 0.061× (−0.368) ×0.522 from four possible pathways in the model.

**Total effect—**Summing all possible pathways in the selected model, a one standard deviation increase in depressive symptoms is associated with a 0.155 standard deviation decrease in everyday problem-solving ability. The total effect of depressive symptoms on everyday problem-solving ability is composed of the direct effect (0.043) and the above three indirect effects through learning and memory, reasoning, and speed of processing (0.064, 0.021, and 0.027 respectively).

## Discussion

Previous work has shown that depression affects the cognitive abilities of memory,[53–55] executive reasoning,[32, 56–58] and speed of processing,[31,32, 59–61] and that depression impairs daily function.[62] Results of this analysis support the direct relationship of depression with both cognitive abilities and everyday problem-solving ability. The results move beyond what has been reported previously by showing that depression also affects everyday problem-solving ability through its effects on learning and memory, reasoning, and speed of processing. In addition, results of the model suggest that the effect of depression on one cognitive ability (processing speed) in turn has an additional effect on other cognitive abilities that interfere with everyday problem-solving, a finding supported by the work of Nebes et al.[62] In our study, the effects of depressive symptoms (measured by the CES-D) on cognitive abilities and everyday problem-solving are small though statistically significant due to large sample size. On the other hand, the change of CES-D score in the clinical setting can be quite large if the patient has severe depressive symptoms or the treatment of depression is effective.[63,64] In that case, the effect of depressive symptoms will not be trivial.

## Common bases for depression and cognitive impairment in later life

Depression and cognitive impairment may independently or jointly contribute to the development of late-life daily functioning disability, yet the relationship between depression and cognitive impairment remains uncertain. Older adults appear to be at greater biological vulnerability to depression and cognitive impairment in comparison with younger adults. Considering the connection between depression and medical disorders, the National Institutes of Health consensus conference on depression in late life came to the conclusion that "The hallmark of depression in the elderly is its association with medical comorbidity."[65] Biological risk factors of late-life depression such as genetics, neurotransmitter dysfunction, endocrine changes, and cardiovascular diseases have been an increasing focus of research. Kumar et al.[66] identified two neurobiological pathways to late-life major depressive disorder: one represented by vascular or non-vascular medical comorbidity that contributes to whole brain high-intensity lesions; the other one represented by smaller frontal lobe volume. These two neurobiological pathways lead to cognitive impairment as well. On the other hand, Yen et al. [67] noted that the APOE epsilon4 allele was associated not only with cognitive impairment but also with geriatric depression in a community study. This finding suggests that the APOE epsilon4 allele is closely related to the common neurobiology of geriatric depression and cognitive impairment in late life.

Reasoning ability in our study is a good measure of executive function, encompassing a set of cognitive skills responsible for planning, initiation, sequencing, and monitoring of complex goal-directed behaviors. Executive function impairment has been noted to be associated with lesions of the frontal cortex and its basal ganglia-thalamic connections in previous researches.[68] Considerable overlap between those lesions and depression is noted. Patients of major depression mainly exhibit cognitive inhibition deficits, problem-solving impairment, and planning deficits. Frontal systems impairment in major depression patients may further cause functional disability.[69,70]

## Strengths of the study

The sample of this study was composed of over 2,800 relatively healthy and independently living participants from six areas in the United States. Consistent with the intervention objective of preventing functional decline, a sampling goal for the ACTIVE study was to identify participants at risk but who had not yet experienced functional decline. Diversity in representation of older adults was another goal, with a particular emphasis on representation of African-Americans, who have been consistently under-represented in most previous cognitive training research with older adults.[34] African-Americans were well-represented in our sample.

Structural equation modeling (SEM) was used in this study to explicitly model measurement error in the instruments employed in operationalizing the constructs within the conceptual model that guided analysis. Among the strengths of SEM is the ability to model constructs as latent variables — variables which are not measured directly, but are estimated in the model from measured variables, like learning and memory, reasoning, speed of processing, and everyday problem solving in this study. This allows explicit capture of unreliability of measurement in the model, allowing the structural relations between latent variables to be accurately estimated. Therefore, we could calculate separate estimates of the mediation of depressive symptoms with functional performance through learning and memory, reasoning, and speed of processing.

The measures of cognitive abilities and daily function in this analysis were performance-based tests. This may minimize the frequently documented effect that depressed persons tend to rate their abilities more poorly than non-depressed persons.[71] As the functional

outcomes were cognitively demanding, persons with functional impairment (i.e., with lower everyday problem-solving ability scores) may have represented the 'preclinical' phase of the disablement process, identifying a focus for prevention.[72]

### Limitations of the study

The data reported here are cross-sectional. We are not sure the extent to which the association of depressive symptoms to cognitive abilities or functional performance occurred because people with poor cognition or functioning tend to be more depressed. Although depressive symptoms in late life may predict functional disability in older persons, persistent depression is thought to be associated with a greater linear increase in functional disability than remitted depression.[73] On the other hand, certain neuropsychological abilities (e.g., visuospatial ability, attention, executive function) that may be relevant in the relationships of depression and functional status also were not evaluated in this study. If one or more of these measures were included, the observed relationships between depressive symptoms, cognitive abilities, and problem-solving ability might change.

In this study, overall level of depressive symptomatology was not high. The possibility of selection bias can't be ruled out as more depressed older adults might tend to refuse to be recruited. Treatment for depression may be another explanation for the mild depressive symptomatology. However, diagnosis and treatment of depressive disorders was not included.

Our finding that the relationship of depressive symptoms to daily function disability occurs partly through the association of depressive symptoms and learning and memory, and reasoning suggests that interventions aimed at decreasing the disability due to geriatric depressive symptoms must take cognitive functioning into account. Treatment of depression that relies on the cognitive ability of older adults (e.g., to recognize negative thoughts or to be diligent in taking medications) may need to address learning and memory as well as reasoning concurrently. More studies on the relationships of depression and daily function incorporating other cognitive abilities or mediators are still needed. However, our study indicates a direction for future intervention research that targets the improvement of cognitive functioning among older persons with depressive symptoms to prevent associated disability and decline in quality of life.

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**Figure 1.**
Hypothesized models guiding the analysis of the relationships of depressive symptoms, memory, reasoning, speed of processing, and functioning.

**Figure 2.**

Structural equation model relating depression scores to performance measures of function through measures of memory, reasoning, and speed of processing.

**Note:** Standardized parameter estimates are provided. Covariates (i.e., gender, age, race, education, and health conditions) were included in the analysis but not shown here. $X^2$ test (df=1) was applied for the significance of each coefficient in the selected model. (CES-D, Center for Epidemiologic Studies Depression Scale; *p<0.05; **p<0.01; ***p<0.001)

## Table 1

Characteristics of participants (N=2,812)

| | Range | Indication of larger values | Mean (SD) or count (%) |
|---|---|---|---|
| **Age** (years) | 65–94 | | 73.6 (5.9) |
| **Educational level** (years) | 4–20 | | 13.5 (2.7) |
| **Gender** (women) | | | 2146 (75.8) |
| **Ethnicity** (non-White) | | | 773 (27.3) |
| **Reported health conditions** | 0–8 | Worse health | 2.2 (1.4) |
| **Depressive symptoms** | | | |
| CES-D* score | 0–34 | More depressed | 5.2 (5.1) |
| **Learning & memory** | | | |
| Hopkins Verbal Learning Test | 1–36 | Better memory | 26.0 (5.6) |
| Rey Auditory-Verbal Learning Test | 0–73 | Better memory | 48.5 (10.6) |
| Rivermead Behavioral Memory Test | 0–17 | Better memory | 6.3 (2.8) |
| **Reasoning** | | | |
| Word Series | 0–30 | Better reasoning | 9.5 (4.9) |
| Letter Series | 0–30 | Better reasoning | 10.0 (5.6) |
| Letter Sets | 0–15 | Better reasoning | 5.7 (2.8) |
| **Speed of processing** | | | |
| Useful Field of View Task 2 | 0–500 | Slower processing | 131.8 (123.0) |
| Useful Field of View Task 3 | 0–500 | Slower processing | 318.2 (135.5) |
| Useful Field of View Task 4 | 0–500 | Slower processing | 453.3 (77.7) |
| **Everyday problem-solving** | | | |
| Everyday Problems Test | 0–28 | Better functioning | 18.7 (5.7) |
| Observed Tasks of Daily Living | 1–28 | Better functioning | 17.6 (4.4) |

*CES-D, Center for Epidemiologic Studies Depression 12-Item Scale.