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The Relationship between Functional Status and Judgment/ Problem Solving Among Individuals with Dementia

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Name of institution at which research was conducted: University of California San Francisco Memory & Aging Center

Abstract

Objective—To determine the relationship between functional status (independent activities of daily living) and judgment/problem solving and the extent to which select demographic characteristics such as dementia subtype and cognitive measures may moderate that relationship in older adult individuals with dementia.

Methods—The National Alzheimer's Coordinating Center Universal Data Set was accessed for a study sample of 3,855 individuals diagnosed with dementia. Primary variables included functional status, judgment/problem solving, and cognition.

Results—Functional status was related to judgment/problem solving ($r = 0.66$; $p < .0005$). Functional status and cognition jointly predicted 56% of the variance in judgment/problem solving ($R\text{-squared} = .56$, $p < .0005$). As cognition decreases, the prediction of poorer judgment/problem solving by functional status became stronger.

Conclusions—Among individuals with a diagnosis of dementia, declining functional status as well as declining cognition should raise concerns about judgment/problem solving.

Keywords

Dementia; Judgment/problem solving; Functional status

Judgment and problem solving are required when completing activities of everyday living such as writing checks, responding appropriately to strangers, and keeping track of appointments. Damage to the brain, including that caused by certain subtypes of dementia, is associated with the loss of function in judgment and problem solving (Auning, *et al.*, 2011; Fellows and Farah, 2005; Fellows and Farah, 2007; Wallis and Rich, 2011). While the linkage between a decline judgment and problem solving and a decline in functional activities is intuitive, no studies have examined this relationship among individuals with one of the most serious neurodegenerative conditions in older adults, that of dementia. When health care professionals suspect that a decline in judgment and problem solving accompanies a decline in functional status in this population, a targeted specialized assessment of judgment and problem solving may not always be conducted due to time constraints, lack of resources or insufficient expertise. If an empirical relationship between functional status and judgment and problem solving can be documented, it may stimulate health care professionals to obtain a detailed assessment of judgment and problem solving in

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individuals when declining functional status is noted during a routine examination. Therefore, the purpose of this study was to determine if an empirical relationship exists between judgment and problem solving and functional status and the extent demographics (including dementia subtype) and cognition (mental status and executive function) may moderate that relationship in individuals with dementia.

Background

Judgment and Problem Solving

Judgments are used to identify viable options and the personal degree of satisfaction with potential viable options. Problem solving, on the other hand, is an operation that involves making probabilistic predictions about various options in order to first identify those viable options (Collins *et al.*, 1997). Both are, however, closely related, dependent on processes carried out in the frontal lobe, and shown to decline with age (Burton *et al.*, 2006; Gomez-Beldarrain *et al.*, 2004; Heidrich and Denny, 1994).

There is evidence that judgment and problem solving differ across dementia subtypes such as Alzheimer's disease (AD), vascular dementia (VaD), lewy body dementia (LBD), semantic dementia, and frontotemporal dementia (FTD). In such studies judgment and problem solving is measured as a single construct (judgment/problem solving). Studies have demonstrated that individuals with frontotemporal dementia (FTD), scored worse in judgment/problem solving (Du, 2006; Rosen et al, 2004). Based on the close association of the neurophysiological mechanisms involving frontal lobe processes and the practice of measuring judgment and problem solving together as a single construct when assessing impairment from dementia in research and clinical settings, judgment and problem solving (judgment/problem solving) are considered as a unified whole in this paper.

Functional Status as a Predictor

Instrumental activities of daily living (IADLs) are frequently used as a clinically relevant threshold for suspecting dementia and referring patients to a specialist (de Lepeleire *et al.*, 2004). In fact, a recent review suggested that multidimensional assessments sensitive to differentiating dementia severity stages, rather than specific assessments, are needed in daily practice (Robert *et al.*, 2010). One study demonstrated that diminishing IADLs predicted a clinical diagnosis of dementia 10 years out and suggests it as an early screening tool (Peres *et al.*, 2008). However, no studies have demonstrated functional status as a predictor of judgment and problem solving, also a concern of health care professionals.

Functional status can be measured by examining activities of daily living (ADLs) (i. e., bathing, mobility), instrumental ADLs (IADLs) (i. e., shopping, managing finances) performed independently, or both. Functional status has the ability to discriminate between individuals with dementia and those without (Coley *et al.*, 2011; McLaughlin *et al.*, 2011). Studies document declining functional status (both ADLs and IADLs) with advancing age, less education, a diagnosis of dementia and the global severity level of dementia (Marshall *et al.*, 2006; Zanetti *et al.*, 1998) and, not surprisingly, IADLs show earlier deficits than ADLs in demented individuals (Baird, 2006; Peres *et al.*, 2008).

Declining functional status (ADLs and IADLs) differs by subtype (Gure et al., 2010). Specifically, individuals with VaD have more ADL (eating, toileting, and transferring) and IADL (grocery shopping and cooking) limitations. Interestingly, compromised functional status directly accounts for the majority of care costs in individuals Alzheimer's Disease (AD) and dementia with Lewy bodies (DLB) (Zhu *et al.*, 2008; Zhu *et al.*, 2006a; Zhu *et al.*, 2006b). Additional research is warranted examining functional status and dementia subtypes.

Functional status has been demonstrated to be related to cognition, but, again, findings appear mixed. In persons with a moderate to severe decline in functional status, specifically in ADLs, there was no relationship between functional status and cognitive status (Richmond *et al.*, 2011). Some studies have demonstrated relationships between impaired cognition (i.e., memory and mental status) and poor functioning in ADLs and IADLs among individuals with dementia, including AD (McGuire *et al.*, 2006; Sabbagh *et al.*, 2007). Similarly, functional status is affected by deficits within specific cognitive domains, particularly executive functions (EF) (Cummings, 2003; Levinoff *et al.*, 2006) and therefore, differing levels of cognition and/or dementia subtype may affect the relationship between judgment/problem solving and functional status. Given these results, this study hypothesized that there was a relationship between judgment/problem solving and functional status. Additional variables were examined for a moderating effect on that relationship.

Method

Data were accessed from the National Alzheimer's Coordinating Center (NACC) Uniform Data Set (UDS) were collected from the 29 National of Institute on Aging (NIA) funded Alzheimer's Disease Centers (ADCs). The UDS, available since 2005, contains data on standardized clinical examination findings, cognitive testing, and diagnostic evaluations (Beekly *et al.*, 2007; NACC, no date). Data from individuals with dementia (N=3855) with data from first visits covering a two year period between September 2005 to September 2007 were utilized for this study. Participants at ADC study sites sign informed consent to participate. The primary authors' Committee for Human Subjects approved this study's protocol.

Measures

Judgment/Problem solving—In order to measure judgment/problem solving, the National Alzheimer's Coordinating Center Uniform Data Set (NACC UDS) utilizes one six-item subscale on the Clinical Dementia Rating Scale (CDR) instrument.

As background, the overall CDR is a valid and reliable global measure for staging dementia impairment consisting of six areas (or sub scales): memory, orientation, judgment/problem solving (subscale utilized for this study), community affairs, home and hobbies, and personal care (Morris, 1997; Oremus *et al.*, 2000; Rockwood *et al.*, 2000; Tractenberg, 2010). The CDR data are collected by a CDR certified data collector via a semi-structured interview with an informant/proxy. A box score (sum of sub scale scores) (CDR score) and a total score (rule-based score ranging from 0 = none to 3 = severe impairment) (Global CDR score) are calculated for each patient. Specifically, the CDR Judgment/Problem Solving sub scale that was used for this study has six questions (e. g. can he/she handle a household emergency a) as well as before, b) worse than before because of thinking, or c) worse than before). Subscale score ranges from 0 to 3.0 with zero indicating no impairment, 0.5 questionable, 1.0 mild, 2.0 moderate, and 3.0 severe impairment.

Functional Status—Functional status was operationalized as functional abilities in independent activities of daily living (IADLs) such as maintaining finances and shopping, as measured by the Functional Activities Questionnaire (FAQ) and administered to an informant/proxy. The FAQ has 10 items with a four point ordinal rating scale (0: normal, 1: has difficulty; but does by self; 2: requires assistance; 3: dependent on others). A total score between 0 and 30 is calculated by summing the ten individual item responses, with less than or equal to 4 deemed normal (McDowell, 2006; Pfeffer *et al.*, 1982). Discriminant and predictive validity have been established (Pfeffer *et al.*, 1982).

Cognition—Mental status and executive function were used to operationalize cognition. The Mini-Mental State Exam (MMSE) measuring orientation to time and place, immediate and delayed recall, language, and visual construction was used to assess mental status. MMSE total scores can range between 0–30, with a lower score representing greater mental status impairment. Scores greater than or equal to 28 are considered normal (McDowell, 2006).

The Trail Making Test - Part B (TMT-B) measured executive function. Scoring reflects the number of seconds taken to complete the test and does not include scoring for accuracy. Scores can range 0–300, with a higher score representing greater executive function impairment. If the patient has not finished the TMT-B by 300 seconds, then 300 seconds is entered as the final score by the sites (NACC, 2006). Normative scores have been determined by age and education ranging from 49 to 168 seconds (Tombaugh, 2004).

Dementia subtype—Because there is evidence of symptom differences between individuals with different dementia subtypes, dementia subtype was included as a variable. Subtypes included: probable Alzheimer’s disease (AD), possible AD, dementia with Lewy bodies (DLB), vascular dementia (VaD), frontotemporal dementia (FTD), and an ‘other’ category (alcohol-related dementia, primary progressive aphasia, semantic dementia, progressive supranuclear palsy, corticobasal degeneration, Huntington’s disease, prion disease, Parkinson’s disease dementia, and dementia of undetermined etiology).

Data Analyses

Descriptive statistics were used to describe patient characteristics, judgment/problem solving, and functional status. Analysis of variance (ANOVA) was used to determine if either functional status or judgment/problem solving differed by cognitive status or dementia subtype. Bivariate correlation was utilized to determine the relationship between functional status and judgment/problem solving.

Hierarchical regression, with predictor variables being entered sequentially in a predetermined order, was employed to determine which variables predicted judgment/problem solving and then to test the moderating effect of study variables on the association between functional status (FAQ-NACC) and judgment/problem solving (the dependent variable) (Aiken & West, 1991; Cohen, et al., 2003). In other words, hierarchical regression was used to understand if the relationship between judgment/problem solving and functional status was conditioned on levels of other variables such as mental status. For this analysis the independent variables were grand-mean centered to allow interpretation of their predictive association in the same model as their interaction. By centering the independent variables statistical control is achieved so that the inclusion of additional predictors do not substantially change parameter estimates (Aiken & West, 1991; Cohen, et al. 2003). The analyses were conducted by first entering FAQ-NACC and each of the other independent variable scores into the first model, and then adding the interaction of two variables (as a product term) in a second model. Each model was evaluated using an F statistic for R square change and, if significant, the associated plot was observed.

Results

The final sample of 3855 had a mean age of 75 (SD 10) years, with 54.6% female, 64.4 % married, and 84.2% living in a single family residence (see Table 1). The majority of individuals in each dementia subtype were non-Hispanic white, lived with their spouse or partner, and resided in a single family residence. Probable Alzheimer’s disease (AD) accounted for the largest dementia subtype group at 67.7%.

Cognition, as measured by Mini-Mental State Exam (MMSE) and the Trail Making Test - Part B (TMT-B), revealed a mean of 19.2 (SD 7.1) and 215.0 (SD 87.6) respectively, both indicating moderate cognitive loss in this sample (see Table 1). Significant differences between dementia subtypes were found for cognition (worse scores for probable Alzheimer's disease and vascular dementia) ($p < .005$). The judgment/problem solving mean score was 1.3 (SD 0.8) indicating mild impairment. Functional status mean total score was 18.6 (SD 8.9) indicating mild to moderate impairment in independent activities of daily living.

Judgment/problem solving scores were significantly related to functional status scores ($r = 0.662$, $p < .001$).

Judgment/problem Solving, Functional Status and Cognition

Cognition was significantly related to judgment/problem solving scores (MMSE scores: $r = -.684$; $p < .001$ and TMT-B scores: $r = 0.202$, $p < .001$). Cognition and functional status were also significantly related (MMSE scores: $r = -0.588$; $p = .001$). and (TMT-B scores: $r = 0.260$, $p < .001$).

Judgment/Problem Solving, Functional Status, and Dementia Subtype

There were significant differences between the dementia sub-types for both mean judgment/problem solving scores ($F = 14.13$; $df = 5/3849$; $p < .001$) and mean total functional status scores ($F = 14.13$; $df = 5/3849$; $p = 0.0005$) (see Table 2). Individuals with dementia with Lewy bodies (DLB) scored the highest on judgment/problem solving (1.7, SD 0.9) indicating more impairment than the other sub-types. Individuals with VaD scored highest on the FAQ (21.1, SD 8.1) indicating more functional impairment than other dementia sub-types.

Cognition and Dementia Subtype as Moderators of Functional Status-Judgment/Problem Solving

Using hierarchical regression, both functional status scores and cognition (MMSE) scores jointly predicted 56% of the variance in judgment/problem solving scores ($R\text{-squared} = .56$, $F = 2304.01$, $df = 2,3666$, $p < .001$). As can be seen in Table 3, Model 1, both functional status and cognition scores have substantial contributions to the prediction of judgment/problem solving. Cognition scores uniquely predicted 9% of the variance and functional status scores uniquely predicted 14% of the variance (squared part correlations). Both effects were medium and therefore were clinically meaningful, with worse test performance predicting poorer judgment. Two other independent variables, living situation and residence, were significant at the specified alpha, but both effects were medium, with FAQ total scores predicting an increase of more than a third of a SD on the judgment scale, and the MMSE predicting close to one half of a SD unit change on the judgment scale. The five other independent variables of age, gender, education, dementia subtype, and EF were not significant.

Model 2, also seen in Table 3, allowed us to determine the effect of the *interaction* of the cognition and functional status scores. The interaction itself predicted an additional 4% of the variance in judgment/problem solving scores ($R\text{-squared change} = .036$, $F_{\text{change}} = 320.90$, $df = 2,3665$, $p < .001$).

Finally, the moderated effect of the association between judgment/problem solving and functional status was examined by cognition (MMSE) quartiles (see Figure). The figure illustrates how judgment/problem solving is predicted by functional status scores and the centered cognition scores. The association between judgment/problem solving and functional status scores was stronger for individuals with poor scores (scores < 17) in

cognition, and less strong for individuals with mid-level (scores 17–21) to higher scores (scores 21–24) in cognition. The association between judgment/problem solving and functional status is weakest for individuals with the highest performance (scores over 24) in cognition. Note that functional status scores vary more with higher scores on judgment/problem solving within each cognition classification. This is merely a plotting artifact for the interaction between two continuous variables, with one having been recoded as a categorical variable.

Limitations

Generalization of findings is limited by a non-random sample. Volunteers in the National Alzheimer's Coordinating Center longitudinal research, from which the data for this study was drawn, represent an educated population and lack ethnic diversity. The use of academic centers as research sites may contribute to a more homogeneous population. Further, data for this study were collected at the first visit to the research sites so the findings do not imply directionality.

Some authors have argued that functional status and other variables should be measured utilizing an observational method rather than informant or proxy data (Beer *et al.*, 2010; Gaussoin, 2012) because of issues around caregiver over and under estimating functional problems (Teresi and Holmes, 1997). Such an approach can be both a time intensive and costly undertaking. Future work is needed to investigate if proxy reports (i. e., caregivers) are indeed inferior to true individual observation. The judgment/problem solving subscale on the CDR (6 items within the scale) has been determined to be useful in determining an overall rating of dementia, however it may not have the strongest psychometric properties for use in research. There is a need for more detailed measures of judgment/problem solving and subsequent psychometric testing of those measures in this population. However, utilizing these nationally derived data from a range of clinical settings is an important first step in empirically documenting how functional status relates to judgment/problem solving among persons with dementia and across dementia subtypes and, thus, findings can form the basis for future studies.

Discussion

Cognition, functional status and judgment/problem solving were examined across using a large sample of individuals with moderately compromised cognition collected through Alzheimer's disease research centers. Findings demonstrated cognition moderating a strong relationship between functional status and judgment/problem solving among individuals with dementia with lower reported functional performance predicting poorer judgment/problem solving. Evaluating judgment/problem solving has traditionally meant that patients are referred for capacity to consent evaluations, costly and lengthy processes. Using the evidence generated from this study, the necessity of such evaluations by neuropsychologists and others might occur in a timelier manner and with increased confidence on the part of the health care professional.

Dementia Subtypes

The most prevalent dementia subtypes were represented in this study. Individuals with dementia with Lewy bodies (DLB) were more globally impaired by their dementia as demonstrated by their Global Clinical Dementia Rating Score and scored lowest in judgment/problem solving. Our findings regarding poor judgment/problem solving in individuals with DLB may offer an explanation to the findings of other studies that have documented individuals with (DLB) a have poor quality of life and high rates of health care utilization (Boström *et al.*, 2007). Our findings also point to the complexity of judgment/

problem solving requiring coordination of numerous areas of the brain and the need for future studies to utilize more detailed measures of judgment/problem solving.

Similar to the work of Gure and colleagues (2010) this study also demonstrated that individuals with vascular dementia (VaD) presented with the most functional impairment. Unlike most other dementia subtypes, VaD is not a neurodegenerative disease. There are several VaD disorders and all are due to cerebrovascular disease involving macro and/or microvascular arteriosclerosis. Pathophysiology involves hypoperfusion anoxia and tissue loss (Mendenz and Cummings, 2003). The multiple co-morbidities, such as strokes due to cerebrovascular disease, may affect functional status to a greater degree than in other dementia subtypes. There is agreement that the diagnosis of VaD is a challenge and prospective longitudinal studies are needed to better understand the pathological and clinical implications of this heterogeneous dementia subtype.

Judgment/Problem Solving, Functional Status and Cognition

Judgment/problem solving was related to functional status, mental status, and executive function (EF) and served as the beginning step to building the hierarchical regression model. Functional status and mental status did predict a significant amount of the variance in judgment/problem solving. And, mental status not only had a direct influence on judgment/problem solving, it also had a dynamic moderating effect on the relationship between functional status and judgment/problem solving. Specifically, as mental status decreases, the prediction of judgment/problem solving by functional ability is stronger. When health care professionals assess that the mental status of their patient has become more compromised, their routine assessment of IADL functioning may be an even stronger indicator of compromised judgment/problem solving.

A dilemma not addressed by this study concerns the question of which occurs first – a decline in judgment/problem solving or functional status. It may be argued that a decline in judgment/problem solving, reflective of a decline in cognition, would precede a decline of functional status. On the other hand, should a decline in functional status precede a decline in judgment/problem solving, the mechanism would operate in the reverse. For example, a worsening chronic illness may result in a significant loss of mobility leading to social isolation. Social isolation may result in decreased cognitive stimulation leading to a decline in cognition as evidenced by worsening judgment/problem solving. Longitudinal designs may better elucidate the temporal nature of the relationship between declining judgment/problem solving and functional status.

Recommendations for Future Research and Practice

This study has demonstrated an empirical relationship between functional status and judgment/problem-solving among individuals with dementia. It is important to now examine this relationship in older adults not yet diagnosed with dementia. Declining functional status and judgment/problem solving among individuals not yet diagnosed with dementia may be an indicator that these individuals need further evaluation of neurological and cognitive function.

Additional study implications for health care professionals are related to the finding that functional status and judgment/problem solving are significantly different across the dementia subtypes. This indicates that knowledge of the subtype may help providers better anticipate functional, cognitive, and judgment/problem solving issues in their patient with dementia.

Prior studies suggest that problem solving abilities decline with advancing age in the general population. We believe health care providers do consider issues of judgment/problem

solving in their general older adult patient population when mental status declines but may not always when functional status declines. In other words, alterations in functional status, without a specific underlying physiological cause, may not always raise concerns about mental status and judgment/problem solving.

Conclusion

Despite the fact that judgment/problem-solving is needed for every day functioning and, when impaired, affects decisions that could affect individuals' safety, finances, and future, it may not always be systematically assessed due to time constraints and lack of efficient measures. Findings from this study indicate health care professionals can use both compromised functional status and mental status as indicators to help predict the status of judgment/problem solving among their individuals with dementia. Finding declining functional status among individuals with dementia can be an alert to health care professionals to take the time to assess judgment/problem solving made by these individuals.

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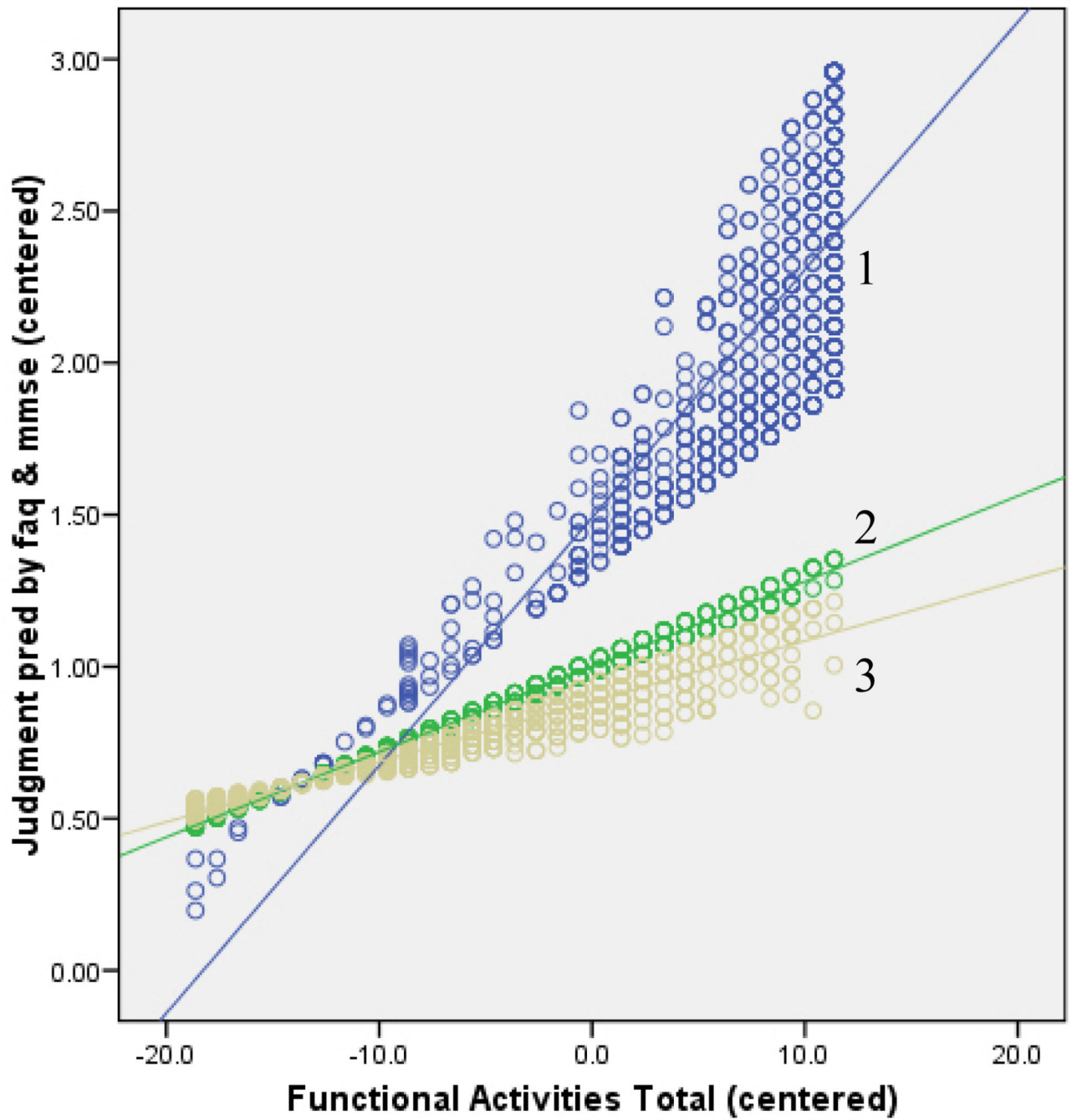


Figure.
 The Mini Mental State Exam (MMSE) moderated effect of the association between judgment/problem solving and functional activities
 MMSE Scores
 1= at or below the first quartile
 2= within the second and third quartiles
 3= at or above the fourth quartile

Table 1

Characteristics of Study Sample

Characteristic	(N=3855)
Age, mean (SD)	75.7 (10.0)
Female, n (%)	2103 (54.6)
Race or ethnicity, n (%)	
Non-hispanic (NH) white	2997 (78.3)
NH black	471 (12.3)
Hispanic	280 (7.3)
Other	80 (2.1)
Years of education, mean (SD)	15.0 (9.8)
Living Situation, n (%)	
Lives with spouse	2356 (61.3)
Lives with relative/friend	590 (15.3)
Lives alone	537 (14.0)
Other	362 (9.4)
Dementia Subtype, n (%)	
Probable Alzheimer's disease (AD)	2607 (67.6)
Possible AD	337 (8.7)
Dementia with Lewy bodies	213 (5.5)
Vascular dementia	267 (6.9)
Frontotemporal dementia	68 (1.8)
Other (e. g. semantic, Parkinson's dementia)	363 (9.4)
Clinical Dementia Rating (CDR), Sum mean (SD) [normal = 0]	7.3 (4.6)
Global CDR (impairment), n (%)	
None	19 (0.5)
Questionable	952 (24.7)
Mild	1679 (43.6)
Moderate	794 (20.6)
Severe	411 (10.7)
Mini-Mental Status Exam, mean (SD) [normal = 28]	19.2 (7.7)
Trail Making Test Part B, seconds to complete, mean (SD) [normal range 49–168 or less]	215.0 (87.6)

Table 2

FAQ Total Scores and CDR Judgment Scores According to Dementia Sub-type

Characteristic	Any Dementia (n=3855)	Probable AD (n=2607)	Possible AD (n=337)	DLB (n=213)	VaD (n=267)	FTD (n=68)	Other (n=363)	P-value
FAQ, Mean (SD) [normal <4]	18.6 (8.9)	18.7 (8.8)	17.3 (8.9)	20.6 (8.6)	21.1 (8.1)	20.1 (8.4)	16.1 (10.0)	<.001
Judgment/Problem Solving, Mean (SD) [normal = 0]	1.3 (0.8)	1.3 (0.8)	1.2 (0.8)	1.7 (0.9)	1.4 (0.8)	1.3 (0.8)	1.1 (0.8)	<.001

Note: Based on Brown-Forsythe tests, Dunnett T3 post hoc testing

Table 3
 Hierarchical Regression Analysis Predicting Judgment/Problem Solving with Function and Cognition (N = 3855)

Model	Unstandardized Coefficients		95% CI for B		t-test	p-Value	Lower Limit	Upper Limit	Partial Correlation
	Beta Coefficient	Std. Error	Lower Limit	Upper Limit					
1									
	Function (centered)	.033	.001	.031	.036	<.001	.031	.036	.298
	Cognition (centered)	-.052	.002	-.055	-.049	<.001	-.055	-.049	-.378
2									
	Function (centered)	.040	.001	.037	.042	<.001	.037	.042	.342
	Cognition (centered)	-.038	.002	-.042	-.035	<.001	-.042	-.035	-.247
	Function by Cognition Interaction (centered)	-.003	.000	-.003	-.002	<.001	-.003	-.002	-.189

$F=320.90$, $df=2,3665$, R -squared change = .035, $p<.001$