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The utility of the Montreal Cognitive Assessment in predicting need for fitness to drive evaluations in older adults☆,☆☆

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ABSTRACT

Objectives: With age, older adults (≥65 years) become increasingly vulnerable to cognitive disorders that may impair driving ability. Health practitioners are often tasked with screening older drivers and may recommend fitness to drive (FTD) evaluations for those potentially needing driving rehabilitation or cessation. Here, we examine whether the Montreal Cognitive Assessment (MoCA), which mainly tests cognitive ability, may identify older adults who might benefit from FTD testing.
Methods/design: 264 older drivers (≥65 years), recruited from three primary care clinics, completed the MoCA and FTD evaluation. We compared literature-based MoCA cut-points (≥26 and < 26, respectively) and sensitivity analysis-determined MoCA cut-points to participant demographic and health characteristics as related to their ability to predict FTD score.
Results: Median age was 73, 89% were White, and 54% were male. Most (83%) had abnormal (fail or conditional pass) FTD test outcomes. Overall, 57% had abnormal literature-based MoCA scores. For participants with abnormal MoCA scores (< 26), increasing 4-m Gait Speed test scores (OR = 11.81) and age (OR = 1.05) increased odds of abnormal FTD test scores. For those with normal MoCA scores (26–30), self-reported excellent health status versus fair health decreased likelihood of abnormal FTD test scores (OR = 0.33) while being female increased likelihood (OR = 2.93). Sensitivity analysis determined a separate abnormal MoCA score cutoff (< 28); 81% had abnormal MoCA scores and were more likely to have abnormal FTD scores with increasing age (OR = 1.07). Those with normal MoCA scores (28–30) experienced increased likelihood of abnormal FTD scores when female (OR = 4.97) and decreased likelihood when they were able to follow road signs (OR = 0.12).
Discussion: MoCA may be valuable when identifying those who might benefit from FTD evaluations among those with both normal and abnormal cognitive function, especially when

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accounting for factors like gait speed, age, and gender. Future research should further explore these factors' roles in predicting abnormal FTD test outcomes.

1. Introduction

As the older population (≥65 years) grows, the prevalence of cognitive disorders like Alzheimer's disease and related dementias (ADRD) will also increase. By 2050, the number of older adults in the United States with Alzheimer's is expected to nearly double to 88 million (Alzheimer's Association, 2017). Some cognitive impairments may affect driving ability, decreasing self-awareness and ability to self-regulate while driving (Devlin and McGillivray, 2014). Almost 40 million licensed drivers are older adults (U.S. Department of Transportation, 2016). One study found that around 4% of drivers who were ≥75 years had dementia, while another found that this population may continue to drive up to three years after diagnosis (Stout et al., 2018; Foley et al., 2000; Odenheimer, 1993). Prior work suggests older drivers with dementia are at least twice as likely to crash as those without dementia, yet also that milder levels of cognitive impairment may not significantly reduce the ability to drive (Carr and Ott, 2010). Maintaining driving ability benefits older adults, by enabling mobility, community involvement, and well-being. Therefore, decisions about driving cessation among older adult must weigh risks and benefits.

Health practitioners play an important role in screening older adults for cognitive impairment and informing decisions about driving. For example, practitioners may recommend fitness to drive (FTD) evaluations for older adults who may be unsafe drivers (Dickerson, 2014). FTD testing, the gold standard of driving ability, may help determine who should consider driving cessation or who may benefit from training or vehicle modifications (American Geriatrics Society and Pomidor, 2016). Yet, FTD programs are relatively underutilized in the US, so offering FTD testing to every older adult may be inefficient and costly (Betz et al., 2014).

The Montreal Cognitive Assessment (MoCA) is a quick, paper-based tool often used in clinical settings that might be useful in identifying certain populations who may benefit most from further FTD testing, whether they are cognitively impaired or not. The MoCA takes approximately 10 min to complete and assesses attention and concentration, executive cognitive function, memory, language, visuoconstructional skills, calculations, conceptual thinking, and orientation. The Mini-Mental State Exam (MMSE) has been used as a cognitive test in considering driving ability, although previous studies now reveal this test may not be optimal in predicting FTD test scores (Crizzle et al., 2012; Freund and Szinovacz, 2002; Joseph et al., 2014). The MoCA may be better-suited because it adopts important visual and cognitive domains related to driving, unlike the MMSE which examines information processing speed, visual search, and attention (Tombaugh and McIntyre, 1992). The MoCA is utilized to determine the presence of mild cognitive impairment (MCI) in older adults (Nasreddine et al., 2005). Past research has found mixed results with regards to MoCA's ability to determine the need for FTD testing. While one study found that MoCA was predictive of FTD assessment need, others suggested MoCA was not the optimal test or that it may work best in combination with other cognitive tools (Bowers et al., 2013; Esser et al., 2016; Kwok et al., 2015). Research shows that MoCA has high sensitivity and specificity in determining the presence of cognitive impairments, so further investigation to consider other MoCA score cutoffs that may better predict FTD may be a valuable undertaking (Crizzle et al., 2013; Nasreddine et al., 2005).

In this secondary analysis from a larger study (Betz et al., 2017), we sought to examine how MoCA might be used by practitioners to predict abnormal FTD road test performance. Specifically, does the literature-based MoCA cutoff reflect normal and abnormal driving performance in this study population? Could MoCA be used to differentiate groups needing (or not needing) FTD evaluations? Among groups with varying MoCA scores, do predictors of FTD performance differ?

2. Methods

2.1. Design and participants

This observational study recruited older drivers from three primary care clinics associated with an urban, academic hospital (Betz et al., 2017). To be eligible, participants had to: be ≥ 65 years old, have driven a car in the past month, speak English, and have a score ≥4 on the Six-Item Screener (SIS), a test that considers cognitive level and that was used to rule out potential participants who may not be able to comprehend the study (Callahan et al., 2002). In total, 315 older drivers enrolled (65% participation rate) and 266 completed the FTD session (Betz et al., 2017). This study was approved by the Colorado Multitple Institutional Review Board.

2.2. Procedures

At enrollment, participants completed a survey considering health characteristics and driving ability; the research assistant then administered the MoCA. Participants were then referred to DriveSafe, a state-certified driving school overseeing FTD tests in Colorado. Participants were evaluated based on standardized FTD protocols considering key driving skills (Justiss et al., 2006). Participants completing both the baseline survey and DriveSafe FTD session received $25.

2.3. Variables

"Abnormal" FTD test scores comprised "fail" (unsafe to drive/irremediable) or "conditional pass" (unsafe to drive, but remediable/safe to drive with restrictions and recommendations) ratings to identify those drivers most in need of FTD test referral. For the MoCA, participants could score 0–30 points; scores < 26 denote MCI and scores ≥26 represent normal cognitive function according to literature (Nasreddine et al., 2005). Other baseline variables included self-reported demographic and health characteristics and functional measures including the Timed Up and Go test ("Timed Up and Go (TUG) Test (with normative reference values),"), Rapid Pace Walk (RPW) (Marshall et al., 2013), and the 4-m walk gait speed (4MGS) test ("NIH Toolbox: 4-Meter Walk Gait Speed Test,"). Finally, participants self-reported current health status through fair, good, very good, and excellent ratings. Fair and good ratings were combined into one category for analyses.

2.4. Analysis

The primary outcome was an "abnormal" rating on the FTD test. FTD scores were compared to baseline MoCA scores and participants who did not complete FTD tests were excluded (n = 50). MoCA scores range from zero to 30 (best); for analysis, participants were initially dichotomized into two groups: MoCA scores < 26 and ≥ 26. For each group, we first performed univariate regression to consider associations between FTD score and other variables. Here, we utilized conservative inclusion criteria ($p < 0.05$), accounting for potential multiple comparison issues. Then we performed full Type III ANOVA models utilizing Likelihood Ratio tests, including all significant variables. Finally, we included statistically significant variables from the previous models (alpha < 0.05) in final Type III ANOVA models, again examining FTD test score relationships.

Additionally, we performed a sensitivity analysis to determine a MoCA cutoff based on our data. We determined this cutoff by

Table 1
Demographic characteristics and fitness to drive test ratings.

	Total		Fitness to Drive Test Rating			
	All	**%**	**Abnormal**	**%**	**Normal**	**%**
Total	264	-	219	83.3	45	16.7
Age[a] (median, IQR)	73	(68,78)	74	(69,79)	69	(67,74)
Gender[a]						
Male	143	54.2	111	50.7	32	71.1
Female	121	45.8	108	49.3	13	28.9
Race						
White	234	88.6	196	89.5	38	84.4
Black	22	8.3	18	8.2	4	8.9
Asian	2	0.8	1	0.5	1	2.2
American Indian	0	0.0	0	0.0	0	0.0
Pacific Islander	0	0.0	0	0.0	0	0.0
Other	6	2.3	4	1.8	2	4.4
Marital Status						
Never Married	8	3.0	6	2.7	2	4.4
Married	162	61.4	132	60.3	30	66.7
Widowed	50	18.9	45	20.5	5	11.1
Divorced	41	15.5	34	15.5	7	15.6
Other	3	1.1	2	0.9	1	2.2
Living Situation						
With Spouse	169	64.0	139	63.5	30	66.7
With Friend	4	1.5	2	0.9	1	2.2
With Children	12	4.5	9	4.1	3	6.7
Other Family	7	2.7	7	3.2	0	0.0
Alone	73	27.7	62	28.3	11	24.4
Education Level						
High school or less	25	9.5	21	9.6	4	8.9
Vocation/tech/some college	61	23.1	50	22.8	11	24.4
College degree or higher	176	66.7	146	66.7	30	66.7
Health Rating						
Excellent	48	18.2	34	15.5	14	31.1
Very good	102	38.6	88	40.2	14	31.1
Good/Fair	114	43.1	97	44.2	17	37.8
MoCA (literature-based)						
< 26	151	57.2	129	58.9	22	48.9
≥26	113	42.8	90	41.1	23	51.1
MoCA (sensitivity analysis-based)						
< 28	214	81.1	185	84.5	29	64.4
≥28	50	18.9	34	15.5	16	35.6

[a] Indicates $p < 0.05$; MoCA = Montreal Cognitive Assessment.

evaluating the area under the receiving operating characteristic curve (AUC) to consider MoCA score specificity-sensitivity for predicting normal versus abnormal FTD score and by identifying the highest AUC. We then utilized this cutoff in the regression analysis detailed above to compare it with the literature standard.

3. Results

Overall, 264 participants completed both the MoCA and FTD session. The median age was 73 (range: 65 to 93) and a majority were White (89%; Table 1). Half of participants were male (54%) and self-reported very good or excellent health status (57%); two-thirds were married (61%), lived with someone (72%), and had college degrees or higher (67%). Regarding measures, the range of MoCA scores was 10–30 points. The median score was 25. Overall, 44% had abnormal cognitive function through literature-based MoCA (< 26), 81% had an abnormal MoCA score based on the cutoff determined through sensitivity analysis, and 83% received abnormal FTD test scores. Participants with abnormal literature-based MoCA scores were more likely to have abnormal FTD test scores (Fig. 1).

For participants with abnormal MoCA scores (< 26), the TUG test ($p = 0.01$), 4MGS test ($p = 0.003$), and age ($p = 0.04$) were significant through univariate logistic regressions compared to FTD scores (data not shown). Because the TUG and 4MGS tests are highly correlated with each other, we decided to only include 4MGS for its associations with cognition in this study. Through full model analysis, both 4MGS ($p = 0.02$) and age ($p = 0.04$) remained statistically significant (Table 2). In the final model among those with abnormal MoCA scores (< 26), participants were more likely to have an abnormal FTD score with every meter/second increase in 4MGS score ($p = 0.02$) and every one-year increase in age ($p = 0.04$).

For participants with normal MoCA scores (≥ 26), gender ($p = 0.04$), health status ($p = 0.02$) and MoCA score ($p = 0.02$) were all significantly associated with FTD test score through univariate logistic regression (data not shown). In the ANOVA model, health status ($p = 0.02$) and gender ($p = 0.04$) were found to be statistically significant, while MoCA was insignificant ($p = 0.17$). In the final model, health status ($p = 0.02$) and gender ($p = 0.04$) remained significant in predicting FTD score for those with normal MoCA scores (≥ 26) (Table 2). After adjusting for gender, participants reporting excellent health status were less likely to have abnormal FTD scores compared to those reporting very good ($p = 0.01$) or good/fair ($0 = 0.07$) health status ($p = 0.07$);. After adjusting for health status, females were more likely to have abnormal FTD scores than males ($p = 0.04$).

Utilizing sensitivity analysis, we identified a MoCA cutoff score of 28 with an AUC of 0.60 for this population (Fig. 2). For participants with abnormal MoCA scores < 28, age ($p = 0.03$) and the TUG test ($p = 0.02$) were both significant in univariate logistic

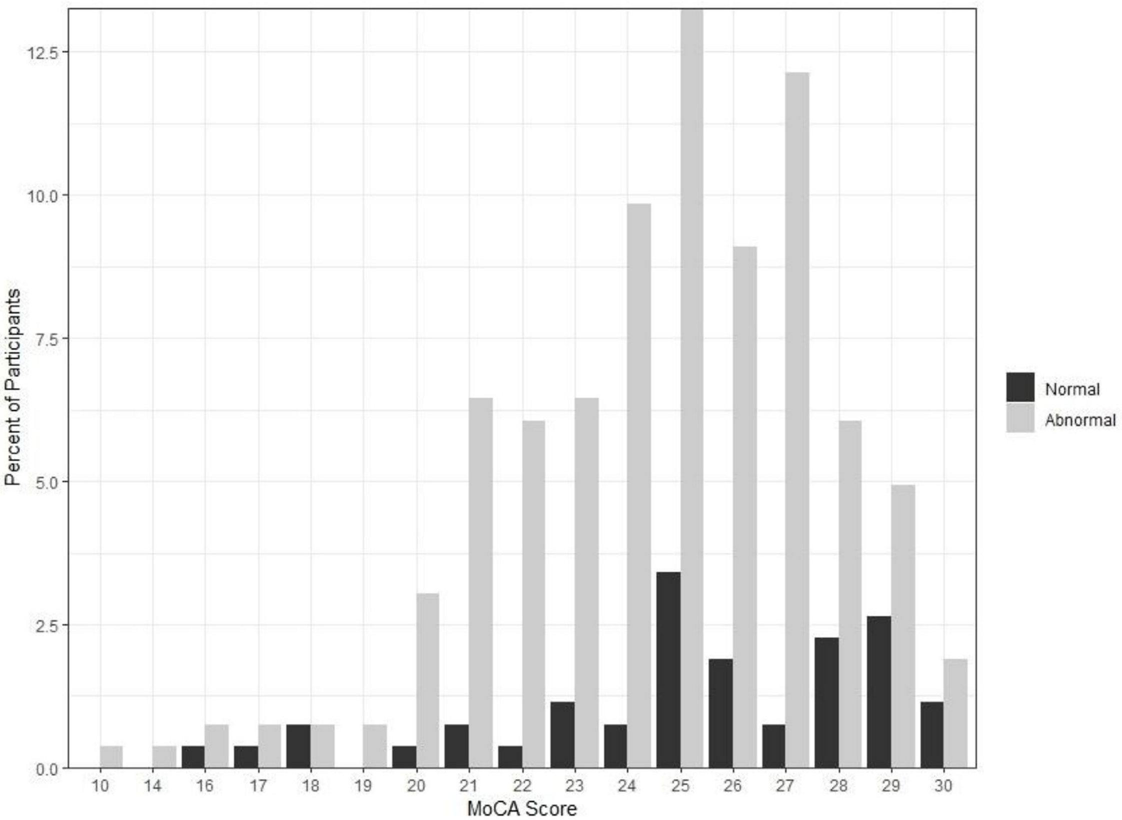
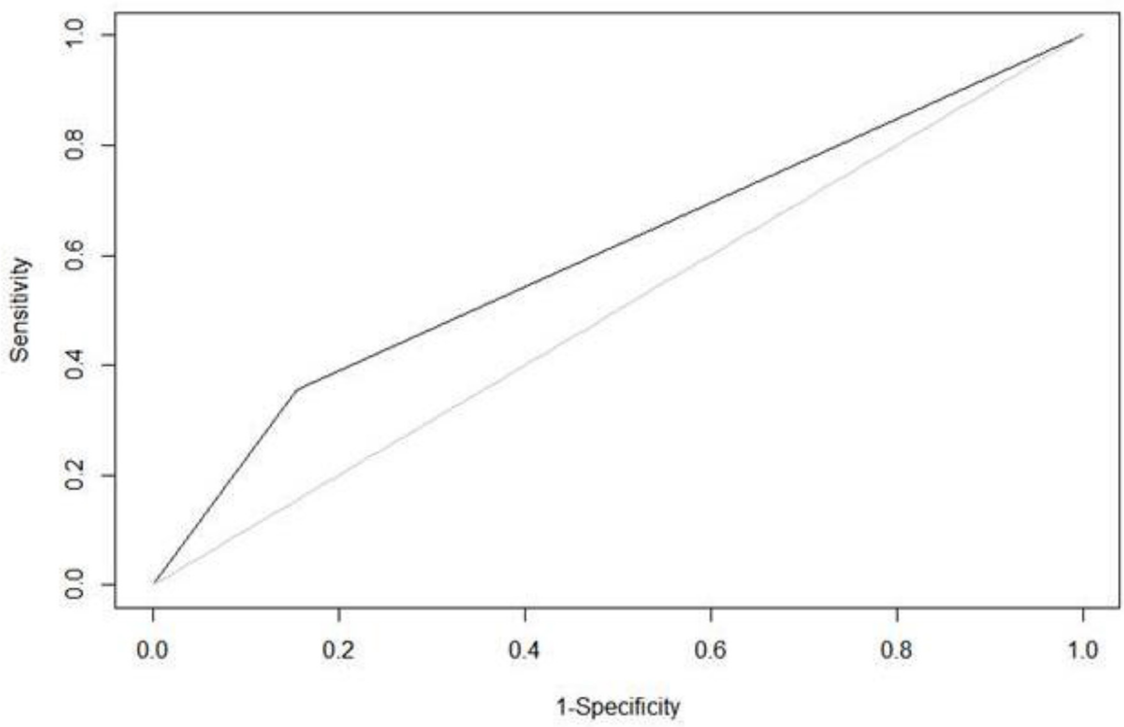


Fig. 1. Distribution of MoCA score for participants with normal and abnormal Fitness to Drive (FTD) scores.

Table 2
Regression models of factors associated with abnormal FTD score, for stratified MoCA score analysis (cutoff: 26 points).

	Abnormal MoCA Score (< 26)		
	Estimate	Std. Error	p value
Intercept	91.9	19.75	0.13
Age	1.05	1.04	0.04
4 Meter Gait Speed	11.81	3.04	0.02
	Normal MoCA Score (≥ 26)		
Intercept	1.03	1.57	0.95
Health			0.02
Very Good vs Good/Fair	1.67	1.895	0.42
Excellent vs Good/Fair	0.33	1.83	0.07
Excellent vs Very Good	0.19	1.82	0.01
Female	2.93	1.687	0.04



Area under the curve = 0.6.

Fig. 2. Receiver operating characteristics curve associated with MoCA score cutoff of 28 for predicting normal versus abnormal FTD score. Area under the curve = 0.6.

Table 3
Regression models of factors associated with abnormal FTD score, for stratified MoCA score analysis (cutoff: 28 points).

Abnormal MoCA Score (< 28)			
	Estimate	Std. Error	p value
Intercept	31.5	13.01	0.18
Age	1.07	1.036	0.03
Normal MoCA Score (≥ 28)			
Intercept	0.64	1.53	0.30
Ability to Follow Road Signs	0.12	2.70	0.02
Female	4.97	2.10	0.02

regressions. In the full model, the TUG test became insignificant when included with age ($p = 0.16$). For participants with a MoCA score < 28, the best predictor of a passing FTD test score was older age ($p = 0.03$; Table 3).

For participants with MoCA scores ≥28, gender ($p = 0.02$), ability to follow information from road signs while driving ($p = 0.02$), and RPW ($p = 0.02$) were significant through univariate logistic regression. RPW ($p = 0.12$) became insignificant in the full model in the presence of all other variables and was excluded from continued analysis. In the final model, among those with normal MoCA scores (≥28), females were more likely to have an abnormal FTD test score than males ($p = 0.02$), while those who could easily interpret information from road signs were less likely to have an abnormal FTD test score. ($p = 0.02$; Table 3).

4. Discussion

4.1. Summary of findings

This study examined predictors of FTD driving test scores based on MoCA score groupings and also performed a sensitivity analysis to consider a MoCA score cutoff especially relevant to this population. The MoCA may be a valuable first screening tool in determining whether older adults need further FTD testing. In our models, older adults with abnormal MoCA screens were more likely to have abnormal FTD test ratings if they were older and had slower gait scores; those with normal MoCA screens were more likely to have abnormal FTD test scores based on health status and if they were female. For the 28-point MoCA cutoff determined through sensitivity analysis, those with abnormal scores MoCA were more likely to have abnormal FTD scores when older, while those with normal scores had higher likelihood of abnormal FTD scores when they had difficulty following road signs and when they were female.

As a cognitive measure, MoCA may play a valuable part in determining a need for FTD testing (American Geriatrics Society and Pomidor, 2016). Supported by prior work, our results show that participants receiving abnormal MoCA scores often had abnormal FTD test scores (Esser et al., 2016). For participants with abnormal literature-based cognitive screens, 4MGS scores were associated with abnormal FTD tests. Previous research correlates balance – a key component of gait speed - with driving ability (American Geriatrics Society and Pomidor, 2016). For example, older adults at risk of falling are more likely to experience a motor vehicle crash and may be more likely to reduce or restrict driving (Foley et al., 2000; Scott et al., 2017). Interestingly, TUG and RPW were not strongly correlated with FTD, though both have been associated with cognition and driving ability (American Geriatrics Society and Pomidor, 2016). In contrast, little research exists on the relationship between 4MGS and cognition or driving. Ultimately, considering the associations between balance, cognition, and driving, patients with poor 4MGS scores may need referrals not only for driving tests, but also for physical therapy, which may in turn improve driving performance (Marmeleira et al., 2009).

For both the original and analysis-based MoCA cutoffs, participants with abnormal MoCA scores were more likely to have an abnormal FTD score with increasing age. Previous research considering the use of MoCA in testing driving performance have found similar relationships with age (Bowers et al., 2013). In general, age-related physical changes, such as slowed reaction time, may affect driving ability (Musselwhite and Haddad, 2007). Practitioners should always factor patient age into their decisions to refer them for further FTD testing and especially in those cases where cognitive problems are also present.

For participants with normal cognitive screens, female gender strongly predicted abnormal FTD tests for both cutoffs. Research has found that confidence may play a part in driving performance (Charlton et al., 2006). For women, low confidence may reflect the ability to depend on others – those living alone may have more driving confidence (D'Ambrosio et al., 2008). Similarly, males may aim to sustain driving ability to maintain the traditional role of supporting their families (Marottoli et al., 1993). Another consideration is unconscious bias on the part of FTD instructors, such that they were more likely to give women low driving scores. Such psychological and social characteristics may affect FTD test performance and should be considered in the administration and interpretation of FTD tests. For participants with normal MoCA test scores based on the 26-point cutoff, self-reported health status played a role on FTD test scores, depending on what they rated themselves. All participants rated themselves to be in good health, whether they felt it was fair/good, very good, or excellent. Considering that the population was mostly well-educated, this trend makes sense based on past research (Wagner and Short, 2014). Interestingly, those who felt their health was very good were more likely to have abnormal FTD scores compared to those who only rated their health as fair/good. In contrast, those who rated themselves to have excellent health were much less likely to have abnormal FTD scores in comparison with those with fair/good health. Research has shown that among those who fit into the "very old" category (87–97 years old), some may begin to experience a dissonance between their perceived health status and their actual health status, based on functional ability (Wettstein et al., 2016); this dissonance may relate, in some case, to lack of insight caused by ADRD. Future research should consider the role of perceptions of health status on common functions such as driving and whether the old and very old populations is getting the driving counseling they may need.

4.2. Limitations

Study limitations include a lack of other cognitive tests to refine cognitive diagnoses. Our study population was also fairly uniform, being mostly White, aged 65 to 93, and having decent health status. Our population also had a high proportion of abnormal FTD test scores, which affected our power and the predictive strength of variables. Finally, previous research has shown that combining MoCA with other cognitive measures may better predict FTD testing need – research should consider whether multiple tests, and what combination of tests, may more accurately identify those who may benefit from FTD testing.

5. Conclusion

The MoCA – a tool commonly used in geriatric clinical practice - may be a valuable tool for determining need for FTD assessment in older adults. Beyond cognitive function, health practitioners should consider the role of other factors that may influence FTD scores. Practitioners might use the MoCA and patient demographic factors, along with gait speed, to complement or stratify use of tools like the Clinician's Guide to Assessing and Counseling Drivers (American Geriatrics Society and Pomidor, 2016) in evaluating need for FTD testing. Future research should examine variables like balance, gender, and age in FTD test performance and how these factors may affect FTD testing referral. Implementation research related to how to best incorporate older driver screening and assessment into routine practice will also be important.

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