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Distractibility and Aging: Relationship of Scores on the Useful Field of View Across Age and Mini Mental Status Exam

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Research indicates that age is not a reliable predictor of driving safety; therefore it is important to understand the relationship between cognitive difficulties and driving risk. Distractibility has been shown to increase in the aging population. The purpose of this study was to understand how age and diagnosis of PD, AD, and MCI impacts visual distractibility on the Useful Field of View (UFOV) test. Further, the researcher was seeking to understand how distractibility impacts driving risk as determined by the Drivewise® assessment. The data analyzed in this study was obtained from the records of the neurobehavioral unit of a teaching hospital in a large northeastern US city. Of a larger research database 236 participants were entered into the study due to the availability of UFOV test scores. Statistical analyses were conducted to investigate the relationship between age, MMSE, and diagnosis across performances on UFOV 1, UFOV 2, and distractibility (UFOV 2 – UFOV 1). The results indicated that age had a slight positive correlation with UFOV 2 and distractibility (UFOV 2 – UFOV 1). Participants with impaired mental status (< 24) were significantly more likely to perform in the "slow" category (> 350) on UFOV 2 and the high distractibility category (> 208) than normal MMSE participants. There were significant diagnostic group differences for UFOV 2 and distractibility. The results also revealed that low distractibility participants were significantly more likely to pass the driving evaluation than high distractibility participants.

Keywords: distractibility; aging; driving; Parkinson's disease; Alzheimer's disease; neuropsychology

Introduction

The ability to safely operate a vehicle tends to regress as cognitive functions decline (Anderson, Campbell, Amer, Grady, Hasher, 2014; Goode, Ball, Sloane, Roenker, Myers, Owsley, 1998; Reger, Welsh, Watson, Cholerton, Baker, & Craft, 2004; Zook, Bennet, & Lane, 2009). Given that various neural systems contribute to the cognitive functions required to drive, examining the impact of impairments in a given cognitive domain can be important for understanding driving safety (Anderson, Rizzo, Shi, Uc, & Dawson, 2005; Anderson et al., 2014). In addition to understanding the impact of cognitive impairment on driving, it is important to understand

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how the cognitive decline associated with aging is related to driving safety. Maintaining independence, including driving ability, as people age is important to overall well being and quality of life and helps the individual to feel connected with the mainstream social world (Eisenhandler, 1990). Research indicates that age and diagnosis alone do not predict an individual’s ability to drive safely. Understanding the impact of cognitive decline on driving ability, as it relates to age and diagnosis, will help to create effective assessments. Proper assessment measures can assist in evaluating and regulating driving to provide a safe environment for all drivers and pedestrians.

Distractibility and Aging

Several studies have examined the impact of aging on attentional control and distractibility (Berti, Grunwald & Schroger, 2013; Campbell, Grady, Ng, & Hasher, 2012; Gazzaley, Clapp, Kelley, McEvoy, Knight, & D’Esposito, 2008; Healey, Campbell & Hasher, 2008; Wascher, Schneider, Hoffman, Beste, & Sanger, 2012; Weeks & Hasher, 2014). Research has tended to indicate that overall, older adults do not experience significant declines in simple attention (Washer et al., 2012).Distractibility may be related to the older adults difficulty processing information quickly enough to manage the distracting stimuli in time. It is postulated that these individuals are often able to compensate for distractibility with sufficient processing time (Wascher et al., 2012). Gazzaley et al. (2008) examined the relationship between the inhibitory and processing speed hypotheses using EEG and a selective attention task. The results indicated the ability to suppress was delayed for older adults, thus a decline in processing speed occurs which delays the inhibition of irrelevant information. Further, Gazzaley et al. found that the impaired suppression of distractors early in processing is associated with poorer memory of task-relevant information.

Berti, Grunwald, and Schroger (2013) examined the distractibility during an auditory discrimination task in aging adults. The results indicated that there were no significant differences in the age groups (18-27, 39-45, and 59-66) and that the ability to process irrelevant changes while maintaining focus on task-relevant information is effective until at least the 60s.

Wascher et al. (2012) examined the ability of older adults to compensate for slowing when presented with distraction in early perceptual processing. Participants were asked to detect changes of luminance or orientation in a fast sequence of visual stimuli. Results indicated that older participants showed a reduced performance when luminance and orientation changes were presented simultaneously at separate locations. Additionally, older adults showed a delayed event-related potential (ERP)-correlates of fronto-central control mechanisms in the conflict condition indicating that they are unable to compensate for perceptual conflicts.

Campbell et al. (2012) examined age differences in distractibility. This research endeavor sought to understand the neural underpinnings of distractibility using fMRI imaging. Results indicated that older adults were more distracted by the overlapping words than younger adults on a 1-back task. During conditions that required inhibition of attention, the younger adults showed greater activation of the rostral pre-frontal cortex and inferior parietal cortex, while the older adults showed reduced functional connectivity within the fronto-parietal network.

Darowski, Helder, Zacks, Hasher, and Hambrick (2008) examined the effect of distractibility on working memory and reasoning tasks. To examine distractibility the researchers utilized a reading-with-distraction task, while employing computerized sentence span, operation span, and rotation span to measure working memory. Raven's Advanced Progressive Matrices were utilized as a reasoning task. The results confirmed the hypothesis, which is consistent with Hasher and Zacks' (1988) inhibitory control and distraction hypothesis. Although this difficulty inhibit a response to distracting, irrelevant information is generally considered a hindrance on related cognitive abilities, such as memory. Healey, Campbell and Hasher (2008) and Weeks and Hasher (2014) note that older adults show an increase in ability to later recall the distracting stimuli in comparison to younger adults that effectively inhibited their attention.

Aging and Driving

The ability of older adults to operate a motor vehicle safely is a concern of the public, from other drivers to lawmakers. This concern arises from the increase in traffic accidents among the aging population (Ball & Owsley, 1993). Although this concern is present, it is important to consider the factors that increase the risk of accidents, as the majority of older adults are safe drivers (Ball & Owsley, 2003). Cognitive decline can impair driving ability, despite age; therefore age is not a reliable indicator of driving ability. Because older adults are at increased risk of certain cognitive declines, it is important to understand how to best measure cognitive declines associated driving ability in this population.

Distractibility

Useful Field of View. A large number of studies have examined the utility of UFOV and it is well established as an effective tool to assess for driving risk (Myers, Ball, Kalina, Roth & Goode, 2000; Ball & Rebok, 1994; Ball, Owsley, Sloane, Roenker & Bruni, 1993; Clay et al., 2005; Goode et al., 1998; Ishimatsu, Miura & Shinohara, 2010). A meta-analysis of the relationship between UFOV and driving performance in older adults conducted by Clay et al. (2005) indicated that poorer UFOV performance is associated with negative driving outcomes and indicated that it was a valid and reliable measure of driving performance and safety. The current literature is lacking in its differentiation between diagnostic categories including early Alzheimer's disease and Parkinson's disease and tends to focus either on general aging or those that have neurological impairments that have already progressed to dementia.

Ball et al. (1993) examined the size of the UFOV and its ability to predict vehicular accidents in older individuals. The researchers found the size of the useful field of view had sensitivity (89%) and specificity (81%) in predicting which older drivers had a history of accidents. This study did not examine the use of the UFOV test or visual distractibility; however, it was important in establishing that age-related reduction in the size of the visual field (caused by attending to focal stimuli) impacts driving ability.

Other studies have examined performance on the UFOV test, which examines visual attention and processing speed on various tasks, and its relationship to driving ability. Owsley et al. (1991) found individuals with poorer performance on visual attention (UFOV) and mental status had 3-4 more accidents of any type and 15 times more intersection accidents on a driving test. Goode et al. (1998) found that UFOV alone reliably distinguished between crashers and non-crashers with 86.3% sensitivity and 84.3% specificity. Additionally, the results indicated that differentiation of crashers and non-crashers using only UFOV was not significantly different than using UFOV with the addition of other neuropsychological measures (MMSE, Trails, WMS, Rey-O Copy). Bowers, Anastasio, Sheldon, O'Connor, Hollis, Howe, and Horowitz (2013) found that UFOV subtest 2 was the single best predictor of at-risk drivers on an on-road driving evaluation (AUC = 0.84).

Additionally, the results indicated four subtests (MMSE, UFOV subtest 2, visual acuity, and contrast sensitivity) were able to identify at-risk drivers with 95% specificity and 80% sensitivity (AUC = 0.91).

Myers et al. (2000) examined the relationship between UFOV and ability to pass a road test and found that seven tests (visual tracking, visual acuity, reaction time, pegs missed, Hooper Visual Organization Test and UFOV) were significantly correlated with driving risk. Further UFOV was the single best predictor of road test outcome. Ishimatsu et al. (2010) found that UFOV reaction times provides an independent indicator of accident risk for younger participants (M = 22.8 years); while UFOV prediction of older participants' (M = 75.4 years) accident risk was not significant. The researchers suggest that self-regulation and self-assessment of driving behaviors may have impacted the results, as almost all of the accident-free participants reported regulating their driving (avoiding situations that required higher levels of driving skills such as driving at night) due to insight that their driving competence had declined; whereas, the accident-involved participants did not.

Processing Speed

Among the various cognitive abilities that allow for safe driving, the ability to respond and react quickly to information is essential (Leverson, Hopkins, & Sigmundsson, 2013). Leverson et al. (2013) examined the impact of processing speed in a driving simulation task with varying demands on visual processing and reaction time. The results indicated that the older group (65+ years) was 27% slower on the condition that required a choice reaction than the younger group (35-45 years). Additionally, this older group was 46% slower on a reaction time task with increased visual complexity. Although several studies (Dobbs & Shergill, 2013; Hollis et al., 2013; Vaucher et al., 2014) have indicated that processing speed as determined by Trails A is correlated with driving-risk outcome, the power of TMT-A to identify patients whose cognition has declined to an unsafe level is only moderate and not useful as a sole predictor (Dobbs & Shergill, 2013).

Alzheimer's Disease and Driving

Duchek et al. (1997) examined the role of selective attention in driving and dementia of the Alzheimer's type. Results indicated that error rate and reaction time of visual search were the best predictors of driving performance in healthy normal aging adults, those with very mild and mild Alzheimer's type dementia. Further, selective attention and global cognitive status were predators of driving ability, even in the earlier stages of Alzheimer's type dementia. Reger et al. (2004) conducted a meta-analysis of driving ability in this population utilizing studies that involved neuropsychological measures, caregiver reports of driving skills, and on road assessments. The results indicated that measures of mental status and visuospatial skills correlated with caregiver reports. Additionally, the results supported a moderate correlation between visuospatial skills and on-road measures. The benefit of caregiver reports in this study, as well as in practice settings is that it is often readily available and thought to be more accurate than patient reports. In contrast, it is not objective and may not correlate with road test outcome. Caregiver reports have the potential to be biased due to personal factors that may change the caregiver's motivation for the patient to drive.

Dawson et al. (2009) sought to understand the predictors of driving safety in early Alzheimer's disease (AD) (mean MMSE score = 26.5) utilizing neuropsychological measures and a 35-mile urban and suburban driving assessment. The AD group committed more safety errors (mean = 42.0, SD = 12.8) than elderly drivers without AD (mean = 33.2, SD = 12.2) which was a statistically significant difference ($p < 0.0001$). A composite cognitive score was calculated for each participant and was a significant predictor of safety concerns for participants with AD. Additionally, those with AD obtained poorer scores on a visual memory tests, Trails A and the Functional Reach Test. The limitations of this study include the experimental setting that may impact the natural driving environment of the subjects and the lack of control for family members that were present during the driving evaluation. Additionally, this study lacks some generalizability in that it only included 7 women.

Parkinson's Disease and Driving

Cubo et al. (2010) sought to examine the clinical predictors of driving safety in this population by comparing PD patients who drive with those that are unable to drive. The results indicated that the most valuable predictors of driving safety in PD patients are older age ($p < 0.0001$), ability to perform activities of daily living ($p = 0.002$), and motor problems ($p = 0.002$). Beyond these factors, overall cognitive dysfunction predicted driving ability ($p = 0.004$). Specifically, participants with memory ($p = 0.007$) and attention-executive dysfunction ($p = 0.015$) difficulties were at risk. Radford, Lincoln and Lennox (2004) found that cognitive abilities were not reliable discriminators of safe and unsafe PD drivers. This finding may be related to sample size and reduced range of cognitive abilities among the participants.

Purpose and Research Questions

The purpose of this study is to understand how age and diagnosis impacts visual distractibility on the Useful Field of View test. Further, the researcher is seeking to understand how distractibility impacts driving risk as determined by the Drivewise® assessment.

Does age correlate with distractibility on UFOV Trial 2?

Do drivers that are vulnerable to distraction on UFOV Trial 2 perform slower on Trial 1?

Does mental status of dementia (MMSE < 24) reduce performance on UFOV Trial 2?

Are there group differences of UFOV performance and driving risk between subjects diagnosed with Parkinson's disease, Alzheimer's disease, and Mild Cognitive Impairment?

Does test performance correlate with driving safety as determined by Drivewise® outcome?

Methods

An archival, correlational design was used to assess the relationship between the predictor, moderating and criterion variables. Age, scores on the UFOV and TMT served as predictor variables and Drivewise® Assessment as the criterion variable with diagnostic category as the moderator. Data was gathered from the records of the neurobehavioral unit of a teaching hospital in a large northeastern US city.

Participants

Data for this study were obtained from the patient records at an urban teaching hospital as part of a larger research study. The subjects selected for participation in this study were referred for a driving assessment through the Drivewise® program between January 2010 and January 2015. Drivewise® is a program aimed at providing objective evaluations of driving safety. All participants underwent a comprehensive neuropsychological evaluation. Participants were selected based upon their completion of the UFOV test. Six participants were excluded due to age (<40 years).

Measures

Demographics. Demographic information was collected from the subject file within the research database. Data included age, gender, years of education, and diagnosis.

Useful Field of View. The Useful Field of View (UFOV) is a computer-based measure of complex visual attention and predicts the ability to detect and discriminate visual information. The purpose of the instrument is to predict on-road driving performance and is often used as a screening measure to predict driving risk. The UFOV is comprised of three subtests. Part 1 measures central vision and processing speed and requires the identification of a small, centrally located picture as either a truck or car. Part 2 measures divided attention and requires the identification of the same picture as Part 1 with the additional task of simultaneously identifying where a second car was located in one of eight locations surrounding the center box. Part 3 measures selective attention and is the same task as Part 2 with the addition of distractor symbols that create the need to inhibit attention and direct it elsewhere. Parts 1 and 2 were used for this study.

Mini Mental State Examination, 2nd Edition. The Mini-Mental State Examination, 2nd Edition (MMSE-2: M. F. Folstein, S. E. Folstein, White, & Messer, 2010) is utilized as a screening measure for cognitive impairment. It is an 11-question measure that examines five areas of cognitive function: orientation, registration, attention and calculation, recall, and language. The total score on this measure was used for his study.

Trail Making Test. The Trail Making Test (TMT) is a visual motor test of scanning, tracking, divided attention and cognitive flexibility. It is comprised of two parts. Part A requires the subject to draw a line connecting consecutively numbered circles on one work sheet. This task measures speed and accuracy of scanning and visual attention. Part B requires the subject to connect consecutively numbered and lettered circles while alternating between number and letters. This part measures speed and accuracy of divided attention and cognitive flexibility, or multitasking (Lezak, Howieson, Bigler & Tranel, 2012). The speed of Trails parts A will was used for this study.

DriveWise® Assessment Outcome. The DriveWise® Evaluation at Beth Israel Deaconess Medical Center involves social work, occupational therapy, cognitive and on-road assessments (O'Connor, Kapust, & Hollis, 2008). This comprehensive evaluation yields a judgment regarding competence and ability to drive and corresponding recommendations to support that individual. This study used the outcome of the subjects' DriveWise® evaluation which consists of a pass or fail.

Procedures

Participants' age, gender, education, DSM IV diagnosis, and scores on the MMSE, UFOV and TMT, DriveWise® Assessment score were extracted from archival evaluation records by research staff of the cognitive neurology unit. This data was sanitized of names, dates of birth, medical record numbers, and phone numbers. The data set was stored electronically in an encrypted and password protected file on a password-protected computer. To determine the relationship between predictor and the criterion variable, the role of diagnostic category as a moderator of these relationships, a step-wise multiple regression analysis was conducted.

Results

Data Treatment

Two hundred and thirty-six (236) participants were initially entered into the study database based on completing of neuropsychological evaluations between January 2010 and January 2015that included the UFOV.

Six participants were removed due to age (< 40 years), resulting in a total of 230 participants. A "distractibility" score was calculated by subtracting the UFOV 1 score from the UFOV 2 score (UFOV2-UFOV1). UFOV 2 was divided into normal (< 350) and slowed (≥ 350) performance. Distractibility scores were divided by median into low distractibility (< 207) and high distractibility (> 208) groups. Participants who were unable to complete UFOV 1 or UFOV 2 were not included in parametric data analyses but were coded as "slow" for non-parametric analyses because they failed the test. MMSE scores were divided into normal (> 26) and impaired (< 24) performance. The participants scoring a 25 were excluded from the normal and impaired MMSE groups to control for the standard error of measurement. Age was split into high and low at the mean at age 75. Sixty-five participants were extracted to complete three diagnostic groups: Alzheimer's disease, Parkinson's disease, and Mild Cognitive Impairment (MCI).

Sample Demographics

Descriptive statistics for the sample and each diagnostic group (Parkinson's, Alzheimer's, and Mild Cognitive Impairment). This included: sex, age, and education (see Tables 1 and 2). This study included 230 participants including 99 females and 131 males. The participants ranged in age from 46 to 95 with a mean age of 75.6 years with a standard deviation of 10.7. The average education of the sample was 15.96 years with a standard deviation of 2.83. Sixty-five participants were extracted to complete three diagnostic groups: Alzheimer's disease, Parkinson's disease, and Mild Cognitive Impairment (MCI). The remaining 165 participants carried various medical, neurological, and psychiatric diagnoses (n = 6) such as anxiety or depression.

The Alzheimer's disease group consisted of 31 participants with a mean age of 73.2 and a standard deviation of 10.6. Seventeen of the participants in this group were males. The mean education of the Alzheimer's group was 15.43 with a standard deviation of 3.01. The Parkinson's disease group consisted of 23 participants with a mean age of 72.3 and a standard deviation of 7.09. Twenty-one of the participants in this group were males. The mean education of the Parkinson's group was 17.35 with a standard deviation of 3.07. The MCI group consisted of 21 participants with a mean age of 75.86 and a standard deviation of 9.18. Nine of the participants in this group were males. The mean education of the MCI group was 16.14 with a standard deviation of 2.43. The results indicated that the Alzheimer's group scored significantly lower than the MCI and Parkinson's groups on the MMSE (see Table 16). There were no significant differences for age and education.

Table 1

Demographic Characteristics of the Sample and Diagnostic Groups

Group	*N*	Gender		Age *M* (SD)	Education *M* (SD)	MMSE	
		Male	Female			*M* (SD)	% Impaired
Sample	230	131 (57%)	99 (43%)	75.6 (10.7)	15.96 (2.83)	26 (4.45)	24.7
Alz.	31	17 (54.8%)	14 (45.2%)	73.2 (10.6)	15.43 (3.01)	22.71 (5.37)	54.8
Park.	23	21 (91.3%)	2 (8.7%)	72.3 (7.09)	17.35 (3.07)	27.91 (2.29)	9.1
MCI	21	9 (42.9%)	12 (57.1%)	75.86 (9.18)	16.14 (2.43)	25.62 (3.43)	33.3

Note. Alz. = Alzhiemer's Disease, Park. = Parkinson's Disease, MCI = Mild Cognitive Impairment, N = number of participants, M = mean, SD = standard deviation.

Descriptive Statistics of test scores were completed for each subtest completed by the participants (see Table 2). The mean score of the MMSE was 26 with a standard deviation of 4.45. The mean time on Trails A was 57.99 seconds with a standard deviation of 38.88. The mean score on UFOV 1 was 73.16 (seconds) with a standard deviation of 89.72. The mean score of UFOV 2 was 266.09 (seconds) with a standard deviation of 155.42. A "distractibility" score was calculated by calculating the difference score between UFOV 1 and UFOV 2 (UFOV2-UFOV1). The mean score on this variable was 213.67 with a standard deviation of 138.44.

Table 2

Descriptive Statistics of the Individual Test Scores

Test	Mean (SD)	Min.	Max.	Skewness (SE)	Kurtosis (SE)
MMSE	26 (4.45)	0	30	-3.006 (0.162)	13.906 (0.322)
Trails A(in seconds)	57.99 (38.88)	14	287	2.848 (0.161)	10.381 (0.321)
UFOV 1	73.16 (89.72)	17	500	2.268 (0.162)	5.327 (0.322)
UFOV 2	266.09 (155.42)	17	500	0.165 (0.175)	-1.162 (0.348)
Distractibility	213.67 (138.44)	0	483	0.260 (0.175)	-0.919 (0.348)

Note. M = mean, SD = standard deviation, SE = standard error.

Research Question 1

Does Age Correlate with Distractibility on UFOV Trial 2?

To determine whether age correlated with UFOV Trial 2 performance across the entire sample, a Pearson product moment correlation coefficient was computed (see Table 4). This analysis indicated that age had a slight positive correlation with performance on this measure ($r = 0.147$, $p < 0.05$). A correlational analysis (see Table 3) was also performed to determine whether age was associated with increased distractibility score (UFOV 2 – UFOV 1) across the entire sample. The results indicated that age had a positive correlation with distractibility ($r = 0.118$, $p < 0.05$). The coefficient of determination was 0.012 indicating that approximately one percent of the variance in distractibility is explained by age.

Table 3

Pearson Product Moment Correlation of Age, UFOV 2, and Distractibility

		Age	UFOV 2	Distractibility
Age	Pearson Correlation	1	0.147*	0.118*
	Sig. (1-tailed)		0.021	0.05
	N	230	193	193

Note. *N* = Number of Participants. $^{*}p < 0.05$ (one-tailed).

A chi-square analysis (see Tables 4 and 5) was performed to determine whether individuals older than 75 were more likely to perform in the "slowed" category on UFOV 2 and it revealed that age was not significantly related to UFOV 2 performance.

Table 4

Crosstabs of Age and UFOV 2

			UFOV 2		Total
			Normal	Slowed	
Age	Under 75	Count	60	44	104
		% within UFOV2	47.2%	42.7%	45.2%
	Over 75	Count	67	59	126
		% within UFOV2	52.8%	57.3%	54.8%
Total		Count	127	103	230
		% within UFOV 2	100.0%	100.0%	100.0%

Table 5

Chi-Square Analysis of Age and UFOV 2

	Value	df	Asymp.Sig.††	Exact Sig. ††	Exact Sig. †
Pearson Chi-Square	0.470	1	0.493		
Continuity Correction	0.305	1	0.591		
Likelihood Ratio	0.471	1	0.493		
Fisher's Exact Test				0.508	0.290
Linear-by-Linear Association	0.468	1	0.494		
N of Valid Cases	230				

Note. †= One-Tailed, ††= Two-Tailed.

A chi-square analysis (see Tables 6 and 7) was also performed to determine if individuals younger than 75 were more likely to perform in the Low Distractibility group and it revealed that age below 75 group was not significantly related to distractibility.

Table 6

Crosstabs of Age and Distractibility

			Distractibility		Total
			Low	High	
Age	Under 75	Count	48	42	90
		% within UFOV2	49.5%	43.8%	46.6%
	Over 75	Count	49	54	103
		% within UFOV2	50.5%	55.3%	53.4%
Total		Count	97	54	193
		% within UFOV 2	100.0%	100.0%	100.0%

Table 7

Chi-Square Analysis of Age and Distractibility

	Value	df	Asymp.Sig.††	Exact Sig. ††	Exact Sig. †
Pearson Chi-Square	0.638	1	0.425		
Continuity Correction	0.428	1	0.513		

(Table 7 continued)

	Value	df	Asymp.Sig.††	Exact Sig. ††	Exact Sig. †
Likelihood Ratio	0.638	1	0.424		
Fisher's Exact Test				0.472	0.247
Linear-by-Linear Association	0.634	1	0.426		
N of Valid Cases	193				

Note. † = One-Tailed, †† = Two-Tailed.

Research Question 2

Does mental status of dementia (MMSE < 24) reduce performance on UFOV Trial 2?

The sample was divided into impaired MMSE (< 24) and normal MMSE (26+) groups to determine if these groups correlated with normal (< 350) or slowed (> 350) performance on UFOV 2. A chi-square analysis was performed (see Tables 8 and 9) and it revealed that impaired MMSE participants were significantly more likely to perform in the slow category on UFOV Trial 2 than normal MMSE participants X^2 (1, N = 227) = 45.685, p = 0.000.

Table 8

Crosstabs of MMSE and UFOV 2

			UFOV 2 Normal	Slowed	Total
MMSE	Impaired	Count	9	47	56
		% within UFOV2	7.2%	46.1%	24.7%
	Normal	Count	116	55	171
		% within UFOV2	92.8%	53.9%	75.3%
Total		Count	125	102	227
		% within UFOV 2	100.0%	100.0%	100.0%

Table 9

Chi-Square Analysis of MMSE and UFOV 2

	Value	df	Asymp.Sig.††	Exact Sig. ††	Exact Sig. †
Pearson Chi-Square	45.685	1	0.000		
Continuity Correction	43.616	1	0.000		
Likelihood Ratio	48.170	1	0.000		
Fisher's Exact Test				0.000	0.000
Linear-by-Linear Association	45.483	1	0.000		
N of Valid Cases	227				

Note. † = One-Tailed, †† = Two-Tailed.

A chi-square analysis (see Tables 10 and 11) was performed to determine if the impaired MMSE group correlated with higher levels of distractibility. The results indicated that impaired MMSE participants were more likely to perform in the high distractibility (> 208) category than the low distractibility category (< 207) X^2 (1, N = 192) = 11.008, p < 0.001.

Table 10
Crosstabs of MMSE and Distractibility

		Distractibility		Total
		Low Distractibility	High Distractibility	
MMSE	Impaired	8	25	33
	Normal	89	70	159
Total		97	95	192

Table 11
Chi-Square Analysis of MMSE and Distractibility

	Value	df	Asymp.Sig.††	Exact Sig. ††	Exact Sig. †
Pearson Chi-Square	11.008	1	.001		
Continuity Correction	9.776	1	.003		
Likelihood Ratio	11.448	1	.001		
Fisher's Exact Test				.001	.001
Linear-by-Linear Association	10.951	1	.001		
N of Valid Cases	192				

Note. †= One-Tailed, ††= Two-Tailed.

Research Question 3

Are there group differences of UFOV performance and driving risk between subjects diagnosed with Parkinson's disease, Alzheimer's disease, and Mild Cognitive Impairment?

To determine if there were group differences in UFOV performance across diagnoses of Alzheimer's disease, Parkinson's disease, and Mild Cognitive Impairment, a one-way Anova with Tukey's-B post hoc analysis was calculated (see Table 12). The results indicated that there were no significant differences between groups on the UFOV 1 (see Table 13).

Table 12
Anova of Diagnosis, UFOV 1, UFOV 2, and Distractibility

		Sum of Squares	df	M Square	F	Sig.
UFOV 1	Between Groups	1952.070	2	978.035	0.102	0.903
	Within Groups	651763.113	68	9584.752		
	Total	653715.183	70			
UFOV 2	Between Groups	298839.721	2	1494919.860	5.968	0.004
	Within Groups	1427138.68	57	25037.521		
	Total	1725978.40	59			
Distractibility	Between Groups	171916.027	2	85958.014	3.930	0.25
	Within Groups	1268706.20	58	21874.245		
	Total	1440622.23	60			

Note. M = Mean, df = Degrees of Freedom.

Table 13

Post-hoc (Tukey's-B) Analysis of UFOV 1 and Diagnosis

Diagnosis	N	Subset for alpha = 0.05
		1
Mild Cognitive Impairment	20	76.7000
Parkinson's Disease	23	85.7826
Alzheimer's Disease	28	89.5000

Note. Means for groups in homogenous subtests are displayed.

The analysis indicated that the Alzheimer's and MCI groups were significantly slower on UFOV 2 than the Parkinson's group (F (2, 1) = 5.958, p = 0.004) (see Table 14).

Table 14

Post-hoc (Tukey's-B) Analysis of UFOV 2 and Diagnosis

Diagnosis	N	Subset for alpha = 0.05	
		1	2
Parkinson's Disease	20	213.5500	
Mild Cognitive Impairment	19		324.2105
Alzheimer's Disease	21		382.1429

Note. Means for groups in homogenous subtests are displayed.

The results also indicated that the Alzheimer's group was impacted significantly more by distractibility than the Parkinson's group (F (2, 1) = 1.770, p = 0.025); however, the MCI group was not significantly different from either the Alzheimer's or Parkinson's groups (see Table 15).

Table 15

Post-hoc (Tukey's-B) Analysis of Distractibility and Diagnosis

Diagnosis	N	Subset for alpha = 0.05	
		1	2
Parkinson's Disease	19	175.7368	
Mild Cognitive Impairment	20	244.8000	244.8000
Alzheimer's Disease	22		305.5909

Note. Means for groups in homogenous subtests are displayed.

Because the frequency statistics indicated that the mean MMSE score for the Alzheimer's disease group was lower than for the MCI and Parkinson's groups, and some age and education differences were present, a one-way Anova with Tukey's-B post hoc analysis was calculated (see Tables 16 and 17) to determine if thesewere statistically significant differences. The results indicated that the Alzheimer's group scored significantly lower than the MCI and Parkinson's groups on the MMSE (F (2, 1) = 5.958, p = 0.004. There were no significant differences for age and education

Table 16

Anova of Age, Education, MMSE and Diagnosis

		Sum of Squares	df	M Square	F	Sig.
Age	Between Groups	150.387	2	75.193	0.877	0.421
	Within Groups	6176.28	72	85.782		
	Total	6326.67	74			
Education	Between Groups	44.132	2	22.066	2.677	0.076
	Within Groups	560.488	68	8.242		
	Total	604.620	70			
MMSE	Between Groups	352.356	2	178.178	10.445	0.000
	Within Groups	1211.158	71	17.059		
	Total	1567.514	73			

Note. M = Mean, df = Degrees of Freedom.

Table 17

Post-hoc (Tukey's-B) Analysis of Diagnosis and MMSE Scores

Diagnosis	N	Subset for alpha = 0.05	
		1	2
Parkinson's Disease	19	22.7097	
Mild Cognitive Impairment	20		25.6194
Alzheimer's Disease	22		27.9091

Note. Means for groups in homogenous subtests are displayed.

To determine if there were group differences in UFOV performance across diagnoses while controlling for the effect of mental status, an ANCOVA was calculated (see Table 18). The results indicated that when accounting for mental status the relationship was not as strong between diagnosis and UFOV 2 is significant, (F (2, 55) = 3.137, p = 0.05) or distractibility, F (2, 55) = 3.206, p = 0.48). There was still no significant relationship between diagnosis and UFOV 1.

Table 18

Anccova Comparisons of Diagnosis, MMSE, UFOV 1, UFOV 2, and Distractibility

	Sum of Squares	df	Mean Square	F	Sig.
UFOV 1	2810.918	2	1405.459	0.403	0.671
UFOV 2	157155.244	2	78577.622	3.137	0.051
Distractibility	128037.578	2	64018.789	3.206	0.048

Research Question 4

Does test performance correlate with driving safety as determined by Drivewise® outcome?

The results of a stepwise linear regression (see Table 19) revealed that none of the variables were significantly correlated with Drivewise® outcome. Because there were no significant bivariate correlations, the linear regression was never conducted.

Table 19

Bivariate Correlations of Drivewise Outcome and Age, Education, MMSE, TATime, UFOV1, UFOV2 and Distractibility.

		Age	Edu.	MMSE	TATime	UFOV 1	UFOV 2	Distract.
Pearson Correlation	Drivewise Outcome	0.118	0.133	0.120	0.066	0.078	0.078	0.052
	Sig. †	0.065	0.053	0.062	0.197	0.159	0.157	0.252

Note. †One-Tailed.

The sample was divided into high distractibility (> 208) and low distractibility (< 207) groups to determine if these groups correlated with the result of the Drivewise® evaluation. A chi-square analysis was performed (see Tables 20 and 21) and it revealed that low distractibility participants were significantly more likely to pass the driving evaluation than high distractibility participants X^2 (1, N = 187) = 5.854, $p < 0.05$

Table 20

Crosstabs of Distractibility and Drivewise® Outcome

			Result		Total
			Pass	Fail	
Distractibility	Low	Count	57	36	93
		% within Result	58.2%	40.4%	49.7%
	High	Count	41	53	94
		% within Result	41.8%	59.6%	50.3%
Total		Count	98	53	187
		% within Result	100.0%	100.0%	100.0%

Table 21

Chi-Square Analysis of Distractibility and Drivewise® Outcome

	Value	df	Asymp.Sig.††	Exact Sig. ††	Exact Sig. †
Pearson Chi-Square	5.854	1	0.016		
Continuity Correction	5.167	1	0.023		
Likelihood Ratio	5.886	1	0.015		
Fisher's Exact Test				0.019	0.011
Linear-by-Linear Assoc.	10.951	1	0.016		
N of Valid Cases	187				

Note. †= One-Tailed,††= Two-Tailed.

Discussion

Aging, UFOV 2, and Distractibility

Results indicated that age correlated with a measure of divided attention (UFOV 2) performance and a measure of distractibility (UFOV 2 – UFOV 1), which controls for visual response time. Although these correlations were significant, it suggested that the variance in performance on these measures is most accounted for by factors other than age. These results are consistent with prior research indicating that individuals are more vulnerable to distractibility on this measure as they age. Other factors that may impact performance on these measures are the effects of brain changes that are not typical of normal aging, pre-existing cognitive vulnerabilities that may not have resulted in a diagnosis, psychiatric diagnoses that have cognitive correlates, or decline in mental status.

The lack of a strong correlation in this study may be related to several factors including the skewness of the data and floor and ceiling effects of this particular test. Possible test scores range from 17ms to 500ms. These limits formed clusters of participants scoring at the floor (500ms) rather than creating an even distribution. This caused the data to be skewed, with more participants scoring at the slower end on UFOV 2. The skewness of the data may have impacted the strength of the relationships because statistical analyses assume a normally distributed sample.

Mental Status and Distractibility

The results of a chi-square analysis revealed that participants with an impaired MMSE (< 24) were more likely to perform in the "slow" category (> 350) on UFOV 2 as well as the "high distractibility" group. This supports the hypothesis that impaired and normal MMSE groups are significantly different in their level of divided attention and distractibility. Five of the possible thirty points on the MMSE are in the domain of attention. It is possible that fewer points earned in the attention domain contributed to the relationship between distractibility and MMSE. Distractibility is an attentional problem, so it is logical to assume that people who are distractible may perform poorly on simple attention tasks; however specific domain scores were not obtained for this study.

Hoffman (2013) indicated that attention, working memory, language, learning, and visual-spatial skills are all impacted by frontal network systems. Additionally, Wierenga et al. (2006) found that naming objects activates a larger frontal network in older individuals than younger individuals (two points on the MMSE are related to object naming). Many of the tasks in the MMSE are mediated by frontal-network function. Subsequently, it makes sense that a frontal network task (distractibility) would correlate with performance on this measure.

Diagnosis and UFOV

The results indicated that there were group differences in performance on UFOV 2 and the distractibility score, but not for UFOV 1. On UFOV 2 the Alzheimer's and MCI groups were significantly slower than the Parkinson's group. Additionally, the Alzheimer's group was more distractible than the Parkinson's group; however, the MCI group was not significantly different than either of these groups on this measure. This is consistent with the findings of Baddeley et al. (2001) that indicate Alzheimer's disease patients are susceptible to visual distraction and impairment in duel task performance. Although the group differences were statistically different, it is important to consider the severity of the disorder as well.

An analysis of MMSE scores for each diagnostic group revealed that the Alzheimer's disease group scored significantly lower on the MMSE than the Parkinson's or MCI group. This suggested that the difference may be accounted for by the progression of dementia rather than the cognitive impact of the specific disorder. Further statistical analyses indicated that when controlling for MMSE scores, there were still significant differences between the diagnostic groups; however, the relationship was not as strong. Diagnosis of

Alzheimer's disease appears to be at least partially responsible for visual distractibility but is moderated by the severity of cognitive difficulties (i.e. progression of dementia).

Test Performance and Drivewise® Outcome

The results indicated that none of the variables (age, education, MMSE, Trails A time, UFOV 1 & 2, and distractibility) were significantly correlated with Drivewise® outcome when a stepwise linear regression was computed. The lack of correlation between age and Drivewise® outcome is consistent with previous research (Ball & Owsley, 2003) that indicates that age is not a reliable indicator of driving ability. It was hypothesized that poorer performance on Trails, UFOV 2, and distractibility would correlate with negative Drivewise outcome. The lack of significant correlation is likely in part related to the skewness of the data and floor and ceiling effects of the UFOV test scores.

To compensate for the skewness of distractibility scores, a second analysis was completed to determine if high distractibility and low distractibility groups correlated with the result of the Drivewise® evaluation. The analysis revealed that low distractibility participants were significantly more likely to pass the driving evaluation than high distractibility participants. This suggests that a cutoff score of 207 on the distractibility score (UFOV 2 – UFOV 1) may be useful when conducting driving evaluations.

Limitations of the Study

The UFOV subtest is a valid and reliable measure of visual attention and predictor of driving safety (Myers et al., 2000; Ball & Rebok, 1994; Ball et al., 1993; Clay et al., 2005; Goode et al., 1998; Ishimatsu et al., 2010). Though this test is often used in research settings, it posed a difficulty for the current study due to the ceiling and floor effects. The "fastest" score an individual can obtain is 17ms and the slowest is 500ms. Though this does not pose a problem for evaluating driving safety, it may when utilizing the test for measuring visual distractibility. These limits formed clusters of participants scoring at either end of the spectrum, rather than creating an even distribution. The skewness of the data may have impacted the strength of the relationships.

Additionally, the relatively small sample size, particularly in regard to diagnostic groups, limits the generalizability of these results. Although the diagnostic groups were small, this is the first study known to this author to have examined the differences in distractibility and driving performance among these diagnostic categories.

Recommendations for Future Research

As discussed, the present study lacked a sufficient number of participants to understand the impact of diagnosis while controlling for severity of the illness, or progression of dementia. Future research may elect to focus more specifically on the relationship between severity of illness and visual distractibility. Measures of severity may include self-report or symptom scales, as well as controlling for MMSE performance.

The UFOV's lack of sensitivity at either end of abilities may limit its ability to understand the impact of aging on distractibility. Future researchers may consider utilizing the UFOV 3 subtest to examine selective attention across age and diagnosis. The increase in difficulty between UFOV 2 and UFOV 3 may assist in obtaining a more evenly distributed sample size in regard to test performance. Additionally, alternate measures of distractibility or creation of a similar measure with a wider range of stimulus presentation length may improve the ability to examine distractibility, aging and driving risk.

Clinical Implications

The findings of this study suggest that a single measure to determine driving risk is insufficient. This is consistent with previous research that indicates that driving risk evaluations are most sensitive and specific when they include the UFOV test in conjunction with other neuropsychological measures (Owsley et al., 1991). These results are also consistent with Ball and Owsley's (2003) report that age is not a reliable predictor of driving risk, as many older adults are able to continue driving safely. It is important to assess the various cognitive functions that relate to driving ability as individuals get older, rather than generating presumptions based upon age.

References

Anderson, J. A. E., Campbell, K. L., Amer, T., Grady C. L., & Hasher, L. (2014). Timing is everything: Age differences in the cognitive control network are modulated by time of day. *Psychology and Aging*. *29*(3), 648-657.

Anderson, S.W., Rizzo, M., Shi, Q., Uc, E. Y., & Dawson, J. D. (2005). Cognitive abilities related to driving performance in a simulator and crashing on the road. In Proceedings of *The Third International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design* (pp. 286-292). University of Iowa.

Baddeley, A. D., Baddeley, H. A., Bucks, R. S., & Wilcock, G. K. (2001). Attentional control in Alzheimer's disease. *Brain, 124*, 1492-1508.

Ball, Karlene, & Owsley, C. (1993). The useful field of view test: A new technique for evaluating age-related declines in visual function. *Journal of American Optometric Association, 64*(1), 71-79.

Ball, K., Owsley, C., Sloane, M. E., Roenker, D. L., & Bruni, J. R. (1993). Visual attention problems as a predictor of vehicle crashes in older drivers. *Investigative Opthalmology& Visual Science, 34*(11), 3110-3123.

Ball, K., & Owsley, C. (2003). Driving competence: It's not a matter of age. *Journal of the American Geriatrics Society, 51*(10), 1499-1501.

Ball, K., & Rebok, G. (1994). Evaluating the driving ability of older drivers. *The Journal of Applied Gerontology, 13*(1), 20-38.

Ball, K. K., Vance, D. E., Edwards, J. D., & Wadley, V. G. (2004). Aging and the Brain. *Principles and Practice of Behavioral Neurology and Neuropsychology,* 796-809.

Berti, S., Grunwald, M., & Schroger, E. (2013). Age dependent changes of distractibility and reorienting of attention revisited: An event-related potential study. *Brain Research, 1491*, 156-166.

Bowers, A.R., Anastasio, R. J., Sheldon, S. S., O'Connor, M. G., Hollis, A. M., Howe, P.D., & Horowitz, T. S. (2013). Can we improve clinical prediction of at-risk older drivers? *Accident Analysis and Prevention*, *59*, 537-547.

Campbell, K., L., Grady, C. L., Ng, C., & Hasher, L., (2012). Age differences in the frontoparietal cognitive control network: Implications for distractibility. *Journal of Neuropsychologia,* http://dx.doi.org/0.1016/j.neuropsychologia.2012.05.025.

Clay, O. J., Wadley, V. G., Edwards, J. D., Roth, D. L., Roenker, D., L., & Ball, K. K. (2005). Cumulative Meta-analysis of the relationship between Useful Field of View and driving performance in older adults: Current and future implications. *Optometry and Visual Science, 82*(8), 724-731.

Darowski, E. S., Helder, E., Zacks, R. T., Hasher, L., & Hambrick, D. Z. (2008). Age-related differences in cognition: The role of distraction control. *Neuropsychology,* 22(5), 638-644.

Dawson, J. D., Anderson, S. W., Uc, E. Y., Dastrup, E., & Rizzo, M. (2009). Predictors of driving safety in early Alzheimer's disease. *Neurology, 72*, 521-527.

Dobbs, B. M., & Shergill, S. S. (2013). How effective is the Trail Making Test (Parts A & B) in identifying cognitively impaired drivers? *Age and Ageing, 42*, 577-581.

Duchek, J. M., Hunt, L., Ball, K., Buckles, V., & Morris, J. C. (1997). The role of selective attention in driving and dementia of the Alzheimer type. *Alzheimer's Disease and Associated Disorders, 11*(1), 48-56.

Eisenhandler, S. A. (1990). The asphalt identikit; Old age and the driver's license. *The International Journal of Aging & Human Development, 30*(1), 1-14.

Folstein, M. F., Folstein, S. E., White, T., & Messer, M. A. (2010). *Mini-mental state examination* (2nd ed.).

Gazzaley A., Clapp, W., Kelley, J., McEvoy, K., Knight, R. T., & D'Esposito, M. (2008). Age-related top-down suppression deficit in the early stages of cortical visual memory processing. *Proceedings of the National Academy of Sciences, 105*(35), 13122-13126.

Goode, K. T., Ball, K. K., Sloane, M., Roenker, D. L., Myers, R. S., Owsley, C. (1998). Useful Field of View and other neurocognitive indicators of crash risk in older adults. *Journal of Clinical Psychology in Medical Settings, 5*(4), 425-439.

Cubo, E., Martin, P. M., Gonzalez, M., Bergareche, A., Campos, V., Fernández, J. M., … Rodriguez, B. (2010). What contributes to driving ability in Parkinson's disease? *Disability and Rehabilitation,* 32(5), 374-378.

Hasher, L., & Zacks, R. T. (1988). Working memory, compensation, and aging: A review and a new view. *The Psychology of Learning and Motivation, 22*, 193-225.

Healey, M. K., Campbell, K. L., & Hasher, L. (2008). Cognitive aging and increased distractibility: costs and potential benefits. *Progress in Brain Research, 169*, 353-363.

Hoffmann, M (2013). The human frontal lobes and frontal network systems: An evolutionary, clinical, and treatment perspective. *ISRN Neurology*.

Hollis, A. M., Lee, A. K., Kapust, L. R., Phillips, L. K., Wolking, J., & O'Connor, M. G. (2013). The Driving Competence of 90-year-old drivers: From a hospital-based driving clinic. *Traffic Injury Prevention, 14*(8), 782-790.

Ishimatsu, K., Miura, T., & Shinohara, K. (2010). Age influences visual attention characteristics among accident-free and accident-involved drivers. *Japanese Psychological Research, 52*(3), 186-200.

Leverson, J. S., Hopkins, B., & Sigmundsson, H. (2013). Ageing and driving: Examining the effects of visual processing demands. *Transportation Research, 17*, 1-4.

Lezak M. D., Howieson D. B., Bigler, E. D., & Tranel, D. (2012). *Neuropsychological assessment* (5th ed.). *New York: Oxford University Press.*

Myers, R. S., Ball, K. K., Kalina, T. D., Roth, D. L., & Goode, K. T. (2000). Relation of the useful field of view and other screening tests to on-road driving performance. *Perceptual and Motor Skills, 91*, 279-290.

O'Connor, M. G., Kapust, L. R., & Hollis A. M. (2008). Drivewise: An interdisciplinary hospital-based driving assessment program. *Gerontology & Geriatrics Education, 29*(4), 351-362.

Owsley, C., Ball, K., Sloane, M. E., Roenker, D. L., & Bruni J. R. (1991). Visual/Cognitive correlates of vehicle accidents in older drivers. *Psychology and Aging, 5*(3), 403-413.

Radford, K. A., Lincoln, N. B., & Lennox, G. (2004). The effects of cognitive abilities on driving in people with Parkinson's disease. *Disability and Rehabilitation, 26*(2), 65-70.

Reger, M. A., Welsh, R. K., Watson, G. S., Cholerton, B., Baker, L. D., & Craft, S. (2004). The relationship between neuropsychological functioning and driving ability in dementia: A meta-analysis. *Neuropsychology, 18*(1), 85-93.

Vaucher, P., Herzig, D., Cardoso, I., Herzog, M. H., Mangin, P., & Favrat, B. (2014). The trail making test as a screening instrument for driving performance in older drivers; a translational research. *BioMed Geriatrics, 14*(123).

Wascher, E., Schneider, D., Hoffman, S., Beste, C., & Sanger, J. (2012). When compensation fails: Attentional deficits in healthy ageing caused by visual distraction. *Neuropsychologia, 50*, 3185-3192.

Wierenga, C. E., Benjamin, M., Gopinath, K., Perlstein, W. M., Leonard, C. M., Rothi, L. J, … Crosson, B. (2008). Age-related changes in word retrieval: role of bilateral frontal and subcortical networks. *Neurobiology of Aging, 29*(3), 436-451.

Weeks, J. C., & Hasher, L. (2014). The disruptive and beneficial effects of distraction on older adults' cognitive performance. *Frontiers in Psychology, 5*(133), 1-6.

Zook, N. A., Bennet, T. L., & Lane, M. (2009). Identifying at-risk older adult community-dwelling drivers through neuropsychological evaluation. *Applied Neuropsychology, 16*, 281-297.