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ATTENTION FACTORS COMPARED TO OTHER PREDICTORS OF SIMULATED DRIVING PERFORMANCE ACROSS AGE GROUPS

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Summary: Groups of young, middle-aged, and older adults performed a battery of computer-based attention tasks, the UFOV® and neuropsychological tests, and simulated low-speed driving in a suburban scenario. Results from the attention tasks were submitted to Maximum Likelihood factor analysis and 6 factors were extracted that explained more than 57% of the task variance. The factors were labeled speed, switching, visual search, executive, sustained, and divided attention in descending order of amount of task variance explained. The factor scores were used to predict simulated driving performance. Step-wise regressions were computed with driving performance as the criterion, and age, sex and the factor scores, the UFOV® scores, or the neuropsychological test scores as predictors. Results showed that the perceptual-motor speed and divided attention measures from the UFOV® and attention battery were more likely to explain driving performance variance than the neuropsychological tests.

INTRODUCTION

Many experts have predicted that assessment of driving ability is likely to be necessary as the baby boom generation approaches retirement age (e.g., Eby et al., 2009). The goal of older driver assessment is to identify those who already have, or are expected to soon, become a danger to themselves or to other road users (Korner-Bitensky et al., 2005). However, assessments that are triggered solely on the basis of age are neither a good use of resources, nor likely to be accepted by policy makers and the general public (Ball & Owsley, 2003). Instead, low-cost screening tools are needed to identify older drivers whose cognitive status indicates that they need to have further, driving-specific (e.g., on-road or simulated driving) evaluation. Numerous screening tools have been suggested, and some (e.g., Useful Field of View, UFOV®) have shown promise in identifying high risk drivers (Ball, 1997).

However, many different professionals are consulted by the public for help with driving assessment (e.g., occupational therapists, driver rehabilitation specialists, neuropsychologists, physicians, etc.). Each discipline has different approaches to the problem and familiarity with different screening tools. For example, Dougall (2003) surveyed neuropsychologists in the U.S. and Canada and asked them to identify tools that they have used or would use for evaluating driving competency and total of 100 different tests were listed. Unfortunately, many of these screening tools may have little validity and reliability in predicting driving ability.

The present study reports on our third revision of a comprehensive visual attention test battery that can be used for any age group, but that is sensitive to the areas of concern for the aging driver as well as for individuals of any age with attention dysfunction. Our approach is similar to the Assessment Software for Attention Profiles (Washburn & Putney, 1997) in that we use multiple basic attention tasks that require speeded reactions to visual stimuli, the results of which are submitted to factor analysis. We believe that this approach has several advantages over individual tests, such as common method variance is extracted in the first factor, and the extraction method we use creates statistically independent factors. We compared the ability of our attention factors to predict simulated driving performance during a low-speed suburban scenario to other screening tools that have been identified in the literature to predict simulated driving of older adults (e.g., Mathias & Lucas, 2009; Shanmugaratnam et al., 2010).

METHOD

Participants

One hundred seventeen individuals participated in the study. Participants were recruited from the Central Michigan University psychology subject pool and from the Mount Pleasant, MI community through fliers placed at local organizations. Students were given course credit, whereas, community members were paid $28 per hour for their participation. Participants were recruited in three age groups: The younger group consisted of 40 participants (24 females, 16 males; *M* age = 21 years, *SD*=2). The middle-aged group consisted of 40 participants (25 females, 15 males; *M* age= 46 years, *SD*= 9). The older group consisted of 37 participants (24 females, 13 males; *M* age = 70 years, *SD* = 8). The ethnicity of the three groups was 80.0, 87.5, and 94.5 percent Caucasian for the young, middle, and old groups, respectively.

Procedure

The study consisted of two sessions conducted on different days: one for computer-based attention and neuropsychological testing, and the other for simulated driving in a number of scenarios designed to test driving performance. The order of sessions was counterbalanced and there was always one day between sessions. Driving data collection was done using a DriveSafety DS-600c driving simulator (DriveSafety Corp.), which is the front passenger cabin of a Ford Focus with a 180 degree field-of-view. The driving simulator is equipped with a motion base which provides motion cues in pitch. Driving performance data were recorded at 60 Hz. Computer test battery data were collected on a standard PC using E-Prime software (Psychology Software Tools, Inc.).

The cognitive session consisted of a battery of attention tasks and neuropsychological tests that lasted about 1.5 hrs. The battery involved completing the following attention tasks: a two-choice RT task (RT-2), pedal reaction time, a two color version of the Stroop task (Stroop, 1935), the attention network task (ANT, Fan et al., 2002), a visual search task (Neisser, 1963), Trail Making Test Parts A and B (Reitan, 1958), continuous go/no-go RT performance task (CPT), and a dual-task of single axis compensatory tracking and two-choice RT task (DT). Neuropsychological tests were the WAIS Digit Span, Mini-Mental State Exam (MMSE; Folstein et al., 1975), Clock Drawing (scored using the abbreviated system proposed by Freund et al., 2005), and the Wisconsin Card Sort Test (WCST; Heaton, 1981). The Useful Field of View (UFOV®; Ball, 1997) was also administered.

In the driving session participants drove multiple scenarios that were preceded by a simulator adaptation protocol. The scenario reported here presented four events (Table 1) in a suburban environment with a speed limit of 25 mph (40.2 kph). The drive covered approximately 1.3 km and took approximately 3 min.

Table 1. Driving scenario events

Driving Event	Description
Pullout	A sedan pulls out from an obscured position in front of a panel truck and enters the roadway in front of the participant.
Bicycle	At a four-way stop intersection, a bicyclist crosses the intersection in front of the participant from left to right.
Dog	A dog darts out toward the road from between parked cars, stops short of the travel lane and pauses, then turns around and leaves the roadway.
Emergency Vehicles	A group of emergency vehicles with emergency lights activated is parked on the opposite side of the road.

RESULTS AND DISCUSSION

Driving Performance

Four driving performance measures were calculated around the events in the scenario: RMS lane position (in m from lane center), *SD* steering (in degrees of rotation from steering wheel center), *M* and *SD* speed (in m per s). As can be seen in Table 2, driving performance differed across age groups only for a subset of measures in the pullout and bicycle events, where the old group differed from the young group and the middle group did not differ from the other two.

Attention factors

Based upon our previous work (Nelson et al., 2007; Tuttle et al., 2009), we simplified the set of variables from the computerized attention task battery to 16. Maximum likelihood (ML) factor analysis was performed for all groups combined (n=105 subjects had no missing data) to find an overall factor structure of the attention task variables. After reduction to six factors, orthogonal varimax rotation with Kaiser normalization was conducted to preserve the statistical independence of the factor scores. A total of 57.5 percent of the total variance was explained by the six factors (Table 3). The six factors were interpreted as representing perceptual-motor processing speed (Factor 1), switching (Factor 2), visual search (Factor 3), executive (Factor 4), sustained (Factor 5), and divided (Factor 6) visual attention functions based upon the pattern of the rotated factor loadings shown in Table 4.

Step-wise regressions

We conducted three step-wise regression analyses using different sets of predictors for each driving performance measure within a scenario event. Participant age and sex were used in all regressions. The first step-wise regression (UFOV) used the refresh rate (in ms) for each of the three UFOV tests: perceptual speed (PS), divided attention (DA), and selective attention (SA) as predictors. The second regression (Neuropsychological) used the clock drawing task (CDT) score, the scaled WAIS Digit Span score, and all of the WCST measures as predictors. The final regression (Factors) used the six factor scores as predictors. All predictors were entered step-wise using $p<.05$ to enter and $p>.10$ to remove. Table 5 presents the results for driving performance measures in each event. Shown in Table 5 is the total R^2 if any of the predictors were entered and the order in which the predictors were entered. Note that the sample size differed across the three regressions because we used case-wise deletion. The effect of the different *n*s for the analyses was that age and/or sex may have been significant in one analysis but not in another (e.g., age for RMS lane position in the pullout event).

Table 2. Driving performance mean (*SD*) by age group for the four events in the scenario

	Age Group				
	Young (n=35)	Middle (n=36)	Old (n=32)	*F*	*p*
Pullout					
RMS Lane Position (m)	0.14 (0.07)	0.15 (0.08)	0.17 (0.10)	1.29	0.28
SD Steering (degrees)	1.54 (0.71)	2.05 (1.20)	3.12 (1.54)	15.38	0.00
M Speed ($m*s^{-1}$)	7.08 (0.89)	6.96 (1.20)	6.22 (1.27)	5.68	0.01
SD Speed ($m*s^{-1}$)	2.67 (0.78)	2.85 (0.95)	2.93 (0.80)	0.89	0.41
Bicycle					
RMS Lane Position (m)	0.15 (0.10)	0.16 (0.11)	0.32 (0.19)	15.21	0.00
SD Steering (degrees)	0.87 (0.89)	0.93 (0.97)	2.79 (3.32)	9.61	0.00
M Speed ($m*s^{-1}$)	2.30 (0.91)	1.60 (0.64)	2.54 (2.36)	2.10	0.13
SD Speed ($m*s^{-1}$)	1.44 (0.70)	1.16 (0.94)	1.37 (1.02)	0.93	0.40
Dog					
RMS Lane Position (m)	0.22 (0.13)	0.28 (0.21)	0.21 (0.12)	1.95	0.15
SD Steering (degrees)	4.54 (3.26)	4.04 (3.16)	3.31 (2.88)	1.33	0.27
M Speed ($m*s^{-1}$)	4.32 (2.21)	5.18 (2.56)	4.02 (2.03)	2.37	0.10
SD Speed ($m*s^{-1}$)	2.59 (0.80)	2.18 (1.01)	2.54 (0.77)	2.32	0.10
Emergency Vehicles					
RMS Lane Position (m)	0.51 (0.24)	0.45 (0.22)	0.52 (0.26)	0.89	0.41
SD Steering (degrees)	2.06 (0.93)	3.15 (5.26)	3.67 (4.83)	1.32	0.27
M Speed ($m*s^{-1}$)	10.44 (2.00)	9.65 (2.55)	9.25 (3.24)	1.78	0.17
SD Speed ($m*s^{-1}$)	1.00 (0.66)	1.48 (1.09)	1.58 (1.33)	2.96	0.06

Note: Significant values in bold

As can be seen in Table 5, age tended to be a significant predictor when the age groups differed on a particular driving performance measure in Table 2. However, there was not a complete agreement between the ANOVAs for age as a grouping factor and for participants' age in years. For example, age group was not significant in the ANOVA for RMS lane position in the pullout event, but participant age was significant for this performance measure in the UFOV regression. Of more interest for the present study were the instances where age group was significant in the ANOVA, but was replaced by a predictor variable that explained more variance in driving performance in the regressions. For example, perceptual-motor speed (Factor 1) explained more variance than participant age for *SD* speed in the bicycle event.

Of most interest for the present study are the instances when the regressions for different predictor sets associated (e.g., RMS lane position for the pullout event) and when they dissociated (e.g., RMS lane position for the bicycle event). In general, the UFOV® and the attention factor predictor sets were more similar to each other than either set was to the neuropsychological set. Although there were instances where the UFOV® and the attention factors provided similar predictive and diagnostic utility, there were more instances when the attention factors were both more predictive of driving performance and more diagnostic overall. On the other hand, the neuropsychological tests were as predictive as the attention factors, but were not nearly as consistent. That is, the divided attention factor (Factor 6) often explained significant driving performance variability, but the specific neuropsychological test result that explained significant driving performance variability differed from event-to-event where only WCST categories completed occurred more than once.

Table 3. Total Variance Explained from ML Factor Analysis

	Extraction Sums of Squared Loadings			Rotated Sums of Squared Loadings		
Factor	Eigen Value	% of Variance	Cumulative %	Eigen Value	% of Variance	Cumulative %
1 (Speed)	3.012	18.826	18.826	2.801	17.505	17.505
2 (Switching)	1.123	7.017	25.842	1.923	12.017	29.522
3 (Visual Search)	2.597	16.231	42.073	1.476	9.228	38.750
4 (Executive)	1.137	7.108	49.181	1.042	6.515	45.265
5 (Sustained)	.643	4.021	53.202	1.021	6.379	51.644
6 (Divided)	.690	4.313	57.515	.939	5.871	57.515

Table 4. Varimax Rotated ML Factor Matrix

	Factor					
	1 (Speed)	2 (Switching)	3 (Vis. Search)	4 (Executive)	5 (Sustained)	6 (Divided)
RT-2	.613	.109	.317	-.042	-.133	.154
Dual-Task RMS Error	.356	.247	.192	.205	-.227	.557
Dual-Task error rate	-.017	.108	-.087	.037	.027	.594
Dual-Task RT-2	.567	.199	.155	.171	-.074	.243
Trail Making Part A	.060	.933	.012	.054	.037	.096
Trail Making Part B	.225	.933	.126	.103	-.049	.221
Feature Visual Search Slope	.085	-.021	.713	.058	-.142	-.088
Pop-out Visual Search Slope	.369	.082	-.027	.181	-.081	-.069
Distracter Visual Search Slope	.159	.115	.584	.047	-.120	-.053
ANT Alerting	-.005	.064	-.125	.034	.399	.023
ANT Orienting	.084	-.124	-.142	-.032	.353	-.130
ANT Executive	.198	.128	.242	.925	.050	.166
Stroop Incongruency Loss	.148	.023	.378	.183	-.014	.186
CPT Block 1RT	.625	.035	.406	-.041	*.607*	.198
CPT Block 2 RT	.810	.004	.166	-.061	*.381*	.013
CPT Block 3 RT	.799	.014	.116	.144	*.318*	-.037

Note: Values in bold = primary loading; values in bold italics = secondary loading

Conclusion

The current study extended our previous research using attention factors to predict simulated driving (Nelson et al., 2007; Tuttle et al., 2009). The attention factors in the current study generally support the factor structure obtained in our previous studies. Further, we believe that the attention factor set was overall more predictive, diagnostic, and consistent than either the UFOV® or the neuropsychological set. Of course, there are many qualifications that must be made regarding this conclusion, some of the most important of which are that we examined high-functioning participants who were doing simulated driving at low speed. We also did not have any drivers who would have been classified as high risk. Thus, the comparative utility of the various predictors for identifying high risk drivers on the road must still be examined. However, we believe that the current results show promise for the development of a computerized test battery that anyone can administer, the results of which can be used to predict driving performance.

Table 5. Significant predictors from regression analyses of driving performance for each event in the scenario

		Predictor Set		
		UFOV (n=102)	Neuro-psychological (n=83)	Factors (n=96)
Pullout				
RMS Lane Position (m)	R^2	.15	-	.08
	Predictor Order	1-Age, 2-SA 3-DA	-	1-Divided
SD Steering (degrees)	R^2	.23	.29	.24
	Predictor Order	1-Age	1-Age	1-Age
M Speed ($m*s^{-1}$)	R^2	.14	.19	.10
	Predictor Order	1-Age, 2-DA	1-Age, 2-MMSE	1-Age
SD Speed ($m*s^{-1}$)	R^2	-	.06	.08
	Predictor Order	-	1-Failure to maintain	1-Executive
Bicycle				
RMS Lane Position (m)	R^2	.19	.13	.20
	Predictor Order	1-Age, 2-PS	1-Age	1-Age 2-Divided
SD Steering (degrees)	R^2	.15	.36	.22
	Predictor Order	1-Age	1-Categories completed 2-% conceptual response 3-Learning to learn	1-Speed, 2-Age
M Speed ($m*s^{-1}$)	R^2	-	.06	-
	Predictor Order	-	1-Nonperseverative errors	-
SD Speed ($m*s^{-1}$)	R^2	-	-	.06
	Predictor Order	-	-	1-Divided
Dog				
SD Steering (degrees)	R^2	-	.07	.10
	Predictor Order	-	1-Categories completed	1-Speed 2-Visual search
Emergency Vehicles				
SD Steering (degrees)	R^2	-	.07	.07
	Predictor Order	-	1-CDT	1-Executive
SD Speed ($m*s^{-1}$)	R^2	-	.10	.04
	Predictor Order	-	1-Age, 2-Learning to learn	1-Age

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