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Does Speed of Processing Training Impact Driving Mobility in Older Adults?

Lesley Anne Ross
University of Alabama at Birmingham

DOES SPEED OF PROCESSING TRAINING IMPACT DRIVING MOBILITY IN OLDER ADULTS?

by

LESLEY ANNE ROSS

KARLENE K. BALL, COMMITTEE CHAIR
JERRI D. EDWARDS
DAVID L. ROTH
DAVID E. VANCE
VIRGINIA G. WADLEY

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ABSTRACT

Researchers have documented strong relationships between basic and modifiable cognitive abilities and everyday activities. However, the translation of cognitive training to everyday activities has yielded mixed results. Driving is one everyday activity of great importance to older adults, as evidenced by the variety of negative health, psychological and social effects on persons who have ceased driving. Although it may not be possible for all older persons to remain active drivers into very old age due to increased safety concerns, it may be possible to enhance the abilities already intact in this population in an effort to maintain safe driving, and thus independence and mobility, as long as possible.

One modifiable cognitive ability found to be longitudinally predictive of driving habits is speed of processing. The current study used random-effects modeling to investigate the possible impact of speed of processing training upon later driving behaviors over a five-year period in older adults using data from the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) training study. Results revealed that reasoning training transferred by reducing the amount of reported driving difficulty over five years and on maintaining driving exposure in the total sample. Speed of processing training transferred to maintaining driving mobility, via driving frequency, driving exposure, and reducing driving difficulty in persons with baseline speed of processing impairments. Implications for such findings are discussed.

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CHAPTER 1

INTRODUCTION AND BACKGROUND

Importance of Mobility

Persons ages 65 and older are estimated to encompass nearly 20% of the total US population in the next 23 years (Federal Interagency Forum on Aging-Related Statistics, 2004). As such, questions of mobility, safety and political/social rights to maintain mobility in the light of age-related cognitive decline are increasingly rampant. The fastest growing section of this population, and those at greatest risk of reduced mobility, are 85 and older (2004). Due to the potential social and economic costs associated with this growing population's mobility needs, researchers are increasingly redirected toward translational investigations that may be applied to maintaining everyday activities. One such area is driving, which is classified as an Instrumental Activity of Daily Living (IADL) (Barr, 2002; Fricke & Unsworth, 2001; Owsley et al., 2000; Persson, 1993) and is relied upon by older adults as their primary method of transportation (Barr & Eberhard, 1994; Jette & Branch, 1992).

The importance of driving is illustrated by the host of negative physical, psychological and social ramifications found as a result of both reductions in driving mobility and driving cessation. Persons who have limited their driving are at greater risk of later driving cessation (Dellinger, Sehgal, Sleet, & Barrett-Connor, 2001) and at increased risk of depressive symptoms, even with the availability of alternative transportation via a driving spouse (Fonda, Wallace, & Herzog, 2001). Persons who have already fully stopped driving report feelings of reluctance concerning their cessation decision (Persson, 1993), lower health ratings (Campbell, Bush, & Hale, 1993; Kington, Reuben, Rogowski, & Lillard, 1994), more depressive symptoms (Fonda, Wallace, & Herzog, 2001; Marottoli et al., 1997), decreased out-of home activities (Marottoli et al., 2000), and are at higher risk for entering a long-term care institution (Freeman, Gange, Muñoz, & West, 2006). Additionally, as many of these negative consequences are interrelated, the combined effects are additive in nature. This can be demonstrated by social disengagement, a possible result of driving cessation, which in turn can be linked to further cognitive impairment (Bassuk, Glass, & Berkman, 1999), and thus affect both cognitive well-being and independence.

In addition to the negative consequences of reduced mobility, another reason for concern is older drivers' elevated vehicle crash and resulting mortality rate (Barr, 1991). However, some researchers argue against a general increased crash-risk as a function of age (Langford, Methorst, & Hakamies-Blomqvist, 2006; Tay, 2006), and others argue that the importance of maintaining mobility is a more pressing concern (Burns, 1999). Evans (1991) gave support to this view when he illustrated how older drivers on average pose less of a threat to the public than very young drivers, and that the larger risk to older adults may be reduced mobility rather than vehicular safety. According to Evans, the total number of crash fatalities within the United States, when adjusted for distance driven, has actually declined over 90% between 1921 and 1988. However, this is not the case for very old drivers over the age of eighty (Evans, 2000). Other researchers focused less on age and driving competence and more on functional status as the majority of older drivers who are free from functional impairment remain safe drivers (Ball & Owsley, 2003). As the focus of functional status (e.g., health, capabilities, cognition, etc.) of older adults is becoming of greater interest, so is research targeting functional outcomes, such as everyday activities.

Relationship between Cognition and Everyday Activities

Research has demonstrated a strong link between cognitive abilities and everyday activities, with laboratory-based cognitive measures found to reliably predict functional abilities of older adults (Backman & Hill, 1996). Poorer cognitive functioning, as measured by the Mini-Mental State Exam (MMSE) (Folstein, Folstein, & McHugh, 1975), was the strongest predictor of functional impairment, indicated by both IADLs and Activities of Daily Living (ADL) (such as bathing and toileting activities), in older adults in assisted living facilities (Burdick et al., 2005). Allaire and Marsiske (1999) investigated cognitive abilities, including inductive reasoning, knowledge, declarative memory, working memory, and their relation to everyday performance measures in 174 participants aged 60-92. Like other studies, Allaire and Marsiske found that cognitive factors were strongly related to everyday tasks, such as interpreting a medication interaction table and checking account information.

Other researchers focused more on specific cognitive domains, such as fluid abilities. Using structural equation modeling, Willis and colleagues (1992) found that fluid abilities were a significant longitudinal predictor of everyday tasks accounting for 52% of the variance in everyday tasks, which in turn significantly predicted later selfefficacy in aging beliefs. Processing speed, the focus of the current analyses, is a fluid ability found to predict Timed IADL (TIADL) performance in older adults, such that those with slower processing speed perform more poorly (Owsley, McGwin, Sloane, Stalvey, & Wells, 2001; Owsley, Sloane, McGwin, & Ball, 2002). This relationship was investigated in combination with demographic, medical, memory and reasoning abilities. However, memory and reasoning were not found to be predictive of TIADL performance after adjustment for demographic and medical variables (Owsley, Sloane, McGwin, & Ball, 2002). Given that memory and reasoning skills are needed for everyday tasks, such as remembering where objects (e.g., keys) are located and determining the best method of getting from point A to B during rush-hour (e.g., various interstate routes, back roads, etc.), why may processing speed be an important and predictive measure of these laboratory-based outcome measures?

Speed of Processing Theory

The idea of general age-related slowing of cognitive abilities is credited to Birren (1974). Other researchers have built upon this idea of aging-related cognitive slowing to form several theories. For example, slower speed of processing has been postulated to be an underlying mechanism of many observable difficulties found in cognitive aging. Salthouse (1996) postulated that speed of processing impacts other cognitive processes through two related primary mechanisms, termed the simultaneity and limited time mechanisms. Since processing speed is found to decrease with age (Schaie, 1996), the limited time mechanism acts primarily when there is limited time to perform a function, such as in driving. Due to this mechanism, the amount of time available to perform later functions is decreased, as this time is occupied by performing earlier functions. Put another way, it takes longer to process information which results in less time being available to process subsequent stimuli. The second simultaneity mechanism compounds the limited time mechanism through processing deficits, as the information gained from earlier processing may no longer be available, i.e., lost by the time the later processing is completed. In addition, other researchers have found that speed of processing is one of the first abilities found to decrease in aging (Schaie, 1996). Interestingly, processing speed is also modifiable through targeted cognitive interventions (Ball, Beard, Roenker, Miller, & Griggs, 1988; Ball et al., 2002). Owsley et al. (2000) wrote that "slowed information processing speed has emerged as a promising key in understanding older adults' everyday functional problems, yet it has not received a great deal of attention" (p. 308).

Relationship of Cognition and Driving

Like other activities found in daily life, processing speed is also related to driving outcomes (Ball et al., 2006; Owsley et al., 1998). Other factors commonly found to be related to driving behavior are: increased age (Campbell, Bush, & Hale, 1993; Dellinger, Sehgal, Sleet, & Barrett-Connor, 2001; Marottoli et al., 1993), poorer health (Anstey, Windsor, Luszcz, & Andrews, 2006; Campbell, Bush, & Hale, 1993; Chipman, Payne, & McDonough, 1998; Dellinger, Sehgal, Sleet, & Barrett-Connor, 2001; Hakamies-Blomqvist & Wahlström, 1998; Jette & Branch, 1992; Kington, Reuben, Rogowski, &

Lillard, 1994), and gender (Campbell, Bush, & Hale, 1993; Chipman, Payne, & McDonough, 1998; Hakamies-Blomqvist & Wahlström, 1998). Older drivers who have cognitive impairments avoid more situations (Ball et al., 1998) and reduce driving more often than those without such impairments (Freund & Szinovacz, 2002; Lyman, McGwin, & Sims, 2001). However, there is still some debate concerning the degree of impairment and level of driving habits, as persons with severe cognitive impairment may continue to drive (Freund & Szinovacz, 2002), illustrating a possible lack of awareness concerning increased risk of crashes (Owsley et al., 1998).

Cognitive Training

There is ample evidence documenting cognitive plasticity in aging (Ball et al., 2002; Baltes, 1987; Baltes & Willis, 1982; Kramer & Willis, 2003; Yang, Krampe, & Baltes, 2006). There have been a variety of cognitive training studies, targeted at improving cognitive abilities such as processing speed, memory and reasoning (Ball, Beard, Roenker, Miller, & Griggs, 1988; Ball, Wadley, & Edwards, 2002; Baltes, Kühl, Gutzmann, & Sowarka, 1995; Bond, Wolf-Wilets, Fiedler, & Burr, 2000; Calero & Garcia-Berben, 1997; Calero & García-Berbén, 1997; Hofman, Hock, Kühler, & Müller-Spahn, 1996; Neely & Bäckman, 1995; Saczynski, Willis, & Schaie, 2002; Willis, Blieszner, & Baltes, 1981). The training studies vary greatly in approach, protocol and methodology. It is typically found that cognitive interventions improve their targeted ability; however, transfer to other abilities, such as everyday functioning, has not been consistent. However, processing speed has shown evidence of transfer to other laboratory-based everyday activities, such as TIADL (Edwards, Wadley, Vance, Roenker, & Ball, 2005) and faster complex reaction time on the road-sign test (Roenker, Cissell, Ball, Wadley, & Edwards, 2003). Additionally, persons trained using this speed of processing intervention were found to make fewer dangerous maneuvers on subsequent on-road driving evaluations (Roenker, Cissell, Ball, Wadley, & Edwards, 2003).

Real-world Applications

Given that research has shown a strong relationship between cognitive abilities and everyday activities, the question remains, "why has cognitive training not consistently translated to everyday activities?" Willis and colleagues (1992) discuss one reason researchers may find a strong relationship between everyday tasks and fluid abilities in laboratory-based research is that such tasks are novel. However, many everyday activities encountered in the outside world are not novel, and thus may not require such a high level of fluid abilities. Additionally, many of the tasks to which some fluid-ability training, such as processing speed, transfers are time-dependent, as has been found with speed of processing training transferring to TIADL (Edwards, Wadley, Vance, Roenker, & Ball, 2005) and the road-sign test (Roenker, Cissell, Ball, Wadley, & Edwards, 2003).

However, it is possible to argue that driving is, in fact, one everyday, real-world task that requires a high-level of fluid abilities due to being a novel task. Driving is an activity that requires active physical and cognitive manipulation of a constantly changing environment (Mori & Mizohata, 1995). Driving is a highly interactive task that is variable depending on (a) *external conditions*, such as weather, animals or children running across the road, other vehicles, changing environment, obstructions or distractions within the vehicle, etc. and (b) *internal conditions*, for instance fatigue, medication interactions, medical conditions, sensory difficulties, etc. Drivers must also use previous experience (amount of distance needed to brake), coping mechanisms (avoiding driving at night if one has poor contrast sensitivity), basic crystallized abilities (knowledge of rules of the road), and fluid abilities (process multiple changing stimuli simultaneously).

Rationale Summary

Transportation will increase in need and importance with the growing older population. Although alternative transportation may eventually be necessary for those persons deemed unsafe to drive, methods designed to enhance and maintain safe driving for as long as possible within this population are greatly needed. One such area shown to be predictive of later driving is cognition, specifically, speed of processing. This ability is especially of interest as it may be enhanced and maintained for five-years (Willis et al., 2006) through non-invasive and relatively inexpensive cognitive training. **The purpose of the current study is to determine the impact of speed of processing training upon subsequent driving mobility in older adults.** Driving mobility is operationalized via five outcomes: driving space (physical space driven), driving exposure (specific situations encountered during typical driving), driving frequency (days driven per week), and two driving difficulty (amount of difficulty reported during specific situations) composites. Three Aims have been established to evaluate the impact of speed of processing training upon driving mobility trajectories.

Aim 1

To investigate the impact of speed of processing, reasoning and memory training on later driving behavior trajectories, such as driving space, driving exposure, driving frequency, and driving difficulty habits over a five-year period.

Speed of processing training will impact driving trajectories through maintenance in the amount and areas of travel and less difficulty of challenging driving situations over time, compared to persons without such training who are hypothesized to have a negative slope.

Aim 2

To investigate the dosage effects of speed of processing training on later driving behaviors over time.

It is hypothesized that there will be a significant dosage impact on later driving behaviors, such that those persons receiving the most training (initial and booster) will have the largest effects.

Aim 3

To investigate the impact of training on later driving trajectories in persons who had slower speed of processing at baseline.

Due to possible ceiling effects (e.g., persons who did not have slower processing speed at baseline may have less change in driving over time and have less room for improvement in processing speed), it is hypothesized that persons who had slower speed of processing at baseline, as quantified by baseline Useful Field of View (UFOV®) test performance, but who were trained will have greater differences in driving trajectories over time compared to the slower processing speed control group. Additionally, as booster training has been found to increase speed training from an effect size of .76 (99% CI .62-.90) to .85 (99% CI .61 to 1.09) (Willis et al., 2006), the slower speed of processing persons assigned to booster training will be selected and compared to the slower speed of processing controls. This will increase the likelihood of training transfer effects for the reasons stated above.

CHAPTER 2

METHODS

Data from the randomized, longitudinal, single-blind clinical trial, Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) were analyzed to determine longitudinal effects of speed of processing training on driving habits.

Procedure

Five thousand persons aged 65 and older were contacted via telephone for participation in the study from six sites throughout the United States. Details on participant locations, demographics and eligibility are provided below. Eligible participants who consented to screening came to one of the six sites for two individual and one group baseline assessments of functional, sensory and cognitive abilities. Additionally, detailed information concerning medication use, health, and everyday habits were collected via interviews. These baseline assessments took an average of four to five hours, for which participants were compensated. Of the original 5000 possible participants, 2832 persons meeting all the eligibility requirements were randomized to one of four arms. The first arm was the memory training group (n=711), the second the reasoning training arm (n=705), the third the speed training arm (n=712), and the fourth the no-contact control arm (n=704). However, due to inappropriate randomization, 30 participants were removed from the final sample, resulting in a total sample size of 2802.

Participants in the three intervention arms were trained according to standardized procedures across ten 90-minute sessions, spanning five-weeks. To ensure standardization across the training arms and sites for the annual assessments, data collection, protocol adherence and actual initial and booster training, all trainers and testers attended central training workshops to receive certification. Additionally, quality control procedures were enacted to monitor training and testing of participants. Those persons responsible for testing (pre-, post- and annual) were blind to the type of training participants received.

Depending upon the measures, participants were reassessed on cognitive, health, medication use, everyday habits, sensory, and functional abilities at: post-training (< 10 days) and/or at annuals 1, 2, 3, and 5. Details concerning all assessments and protocols are provided elsewhere (Ball et al., 2002; Jobe et al., 2001; Willis et al., 2006). However, assessments relevant to the proposed analyses are discussed below.

Participants

Beginning in 1998, persons (N=2832) aged 65 and older from Jefferson County, Alabama; metropolitan Detroit, Michigan; Boston, Massachusetts; Indianapolis, Indiana; Pennsylvania; and Cumberland and Baltimore, Maryland were randomized in the study. Exclusionary criteria included: (a) less than 65 years of age at screening, (b) substantial cognitive impairment (MMSE <= 23), (c) substantial functional decline (self-report difficulty with basic ADLs), (d) medical conditions that would likely result in functional decline or mortality prior to two-year follow-up, (e) severe sensory loss, and/or (f) deemed unable to communicate. The sample of 2802 included 75.9% of the sample was female (n=2126); 73.1% was Caucasian (n=2048) and 25.9% was African American (n=726). For the purposes of these analyses, drivers were self-identified and reported driving at least 10 miles per week at baseline. Removal of the non-drivers at baseline resulted in a total sample of 2323, with relatively proportional numbers across the speed of processing (n=577), reasoning (573), memory (n=591) and control (n=582) groups. See Table 1 for the demographic information on each sub-sample analyzed for Aims 1 through 3.

Table 1: Demographic Characteristics for each Sub-sample

	Aim 1: All baseline driving participants	Aim 2: Speed trained and control participants	Aim 3: Slower baseline speed of processing participants in the speed trained and control groups
Age	73 (SD=5.7); range 65-91	73 (SD=5.7); range 65-91	76 (SD=6.1); range 65-91
CESD	4.95 (SD=5.02); range 0-34	4.91 (SD=4.93); range 0-27	5.45 (SD=4.78); range 0-24
Vision	74.10 (SD=11.10); range 31.8- 90	73.88 (SD=11.39); range 31.8-90.0	70.15 (SD=2.00); range 36.8-90.0
Female	1693 (72.9%)	838 (72.3%)	234 (71.8%)
Race			
Caucasian	1757 (75.6%)	876 (75.6%)	235 (72.1%)
African American	542 (23.3%)	270 (23.3%)	90 (27.6%)
Other	18 (0.8%)	9 (0.8%)	0
Years Education	13.77; range 4-20	13.75; range 5-20	13.28; range 5-20

Measures

Driving Habits Questionnaire (DHQ)

Driving habit outcomes were assessed using the self-report DHQ and self-report Life Space Questionnaire (LSQ), which has good test-retest reliability and average reliability coefficients for each domain ranging from 0.60 to .86 (Owsley et al., 1999).

Driving Frequency

Driving frequency was assessed via the reported number the days driven in an average week (0-7). Non-drivers were coded as driving 0 days per week.

Driving Space

This composite was gathered from the LSQ (Stalvey, Owsley, Sloane, & Ball, 1999) and consists of dichotomous questions as to whether or not the participant has driven beyond a certain radius. These areas were asked in relation to either the last seven days (beyond property, beyond neighborhood, or beyond town/community), or the last two months (beyond county/city, beyond state, or beyond region). Items were summed and recoded so that larger numbers (range 0-6) indicate larger driving space.

Driving Difficulty

Participants were asked a series of questions assessing driving difficulty and avoidance during eight typical situations. Difficulty was reported on a scale of 'no difficulty' (1) to 'extreme difficulty' (4), while avoidance was dichotomous and recoded so that higher scores indicated avoidance (yes=1; no=0). Due to the administrative skip pattern of the questionnaire, data for each participant was available on either difficulty or avoidance. In order to use all available data, persons reporting that they purposely avoided particular situations were recoded as having extreme difficulty (4) for that situation, while those reporting they did not avoid that particular situation were recoded as having no difficulty (1). Factor analyses revealed that the eight difficulty questions loaded on two separate factors (see below). As such, two separate composites were created through summing the respective 3-item and 5-item difficulty measures.

3-Item difficulty composite. Difficulty with driving alone, making lane changes, and making left-hand turns across on coming traffic loaded onto one factor. These are rather common situations encountered during driving and may be more difficult to avoid than some others, such as driving at night or in bad weather. This composite ranged from 3 to 12, with higher values indicating greater levels of difficulty.

5-item difficulty composite. Difficulty driving in high traffic, driving at night, driving in the rain, merging with traffic, and driving during rush-hour loaded on the same factor. Compared to the 3-item factor, these situations are more challenging, typically requiring higher levels of visual/cognitive processing. This composite ranged from 5 to 20, with higher values indicating greater levels of difficulty.

Driving Exposure

Participants were asked if they had driven alone, made lane changes, turned left unto oncoming traffic, driven in high traffic, at night, in the rain, merged with traffic, or driven during hour over the last two months. These dichotomous items were recoded and summed such that higher scores as indicating more participation, or exposure, to these eight driving situations (range 0-8).

Demographic

Information on age and gender will be included as covariates as they have been found to be predictive of driving behaviors. Gender was recoded so that female (0) was the reference group.

Health

Self-rated health (SRH) will be used as a covariate as health has been found to be related to driving behaviors. Using the SF-36 (Ware & Sherbourne, 1992), participants were asked to rate their health on a five-point Likert scale (1 = Excellent, 2 = Very Good, 3 = Good, 4 = Fair, 5 = Poor).

Depression

The Center for Epidemiological Studies-Depression-12 (CES-D) (Radloff, 1977) is an assessment of depressive symptomatology. Participants are given 12 statements, such as 'I felt depressed' and 'I had crying spells'. They are then asked to rate how frequently they have experienced such symptoms over the last week. Frequency ratings range from 'never (0)' to '5 to 7 days (3)' with a range of 0 to 36 such that higher scores indicate more depressive symptoms.

Vision

A GoodLite Model 600A light box with the ETDRS chart was used to measure far visual acuity. Each participant was asked to stand 10 feet from the chart and was tested first without corrective lenses then with corrective lenses (if worn). The participants read the chart, which contained nine lines of letters, each line with letters progressively smaller than the previous. Scores were assigned from 0 to 90 based upon how many letters were correctly discriminated (0 is equivalent to Snellen score 20/125; 90 to Snellen score 20/16).

Physical Function

Turn-360 (Steinhagen-Thiessen & Borchelt, 1999) is a measure of lower-limb physical function. Participants are asked to make a 360 degree turn from a standing position. The number of steps taken to complete the turn is recorded with more steps equaling poorer performance. The average of two turns was used in analyses. Higher scores reflect worse performance.

Processing Speed

Visual Processing Speed- The UFOV® test assesses visual processing speed and has been shown to be a valid and reliable predictor of mobility outcomes and vehicle crashes in older adults (Ball et al., 2006; Owsley et al., 1998). The UFOV® test is administered via a personal computer with a touch-screen monitor and consists of four subtests (Edwards et al., 2006; Edwards et al., 2005). Each subtest increases in difficulty level and assesses the display speed (16 to 500 ms) at which participants can accurately complete the task 75% of the time. Participants are instructed to sit approximately 60 cm from the monitor and are presented with tasks with varied display speeds via the double-staircase method and controlled with a white noise backward full-field mask. Subtest 1 requires a central identification of either a car or truck (2 cm by 1.5 cm). Subtest 2 adds a peripheral location task to the central identification task. Subtest 3 is similar to subtest 2 (both identification of central task and localization of peripheral tasks), however, distractors consisting of triangles of the same luminance and size as the targets are added to the screen. The final subtest requires a central discrimination task (were the two central figures the same or different) along with the simultaneous peripheral localization task within the distractor presentation. Scores in ms are given for each subtest, with smaller scores (shorter display duration required to accurately complete each task) representing better performance and faster processing speed.

The UFOV® test will also determine the classification of persons deemed to have slower speed of processing for Aim 3. These classifications, of either faster or slower processing speed, are based upon categories of one through five found in the *UFOV® User's Guide* (Corporation, 1999). These risk categories are and were divided into the slower processing speed group based on risk categories three through five, and the faster processing speed group based on risk categories one and two. These categories correspond and are consistent with current and previous research concerning the UFOV®

and have been found to correspond to higher risk for subsequent vehicle crashing (Owsley et al., 1998).

Training

Although all three training arms were investigated for Aim 1, the primary focus of this study was to investigate the impact of speed of processing training upon driving behavior trajectories. As such, only a brief description of reasoning and memory training will be given. For further details, see (Ball et al., 2002; Jobe et al., 2001; Willis et al., 2006).

Memory Training

Memory training was designed to promote translation of memory strategies, such as mnemonic devices, to everyday activities. Participants were given instruction, practice and feedback on a variety of strategies sought to enhance memory.

Reasoning Training

Reasoning training focused on improving linear thinking skills that would improve everyday problem solving. Participants were given practice and instruction in a variety of reasoning and abstract thinking tasks. Additionally, two levels of reasoning training were utilized that varied on pacing, trainer's modeling, and difficulty of tasks.

Speed of Processing Training

Speed of processing training is a computer-based intervention designed to consist of ten, 90-minute sessions. Training for the ACTIVE protocol was standardized across the three training arms of the study. Participants completed training in groups of 2-4 and were guided by a certified trainer. Each session included 5-10 minutes of discussion about cognitive aging, performance changes, and how processing speed is related to everyday activities. After discussion, participants followed pre-specified practice of tasks for the first five sessions. The last five sessions involved individually customized practice of tasks. Training was accomplished through increasing the difficulty level and speed with which participants process modified versions (same speed of processing goal) of tasks 1 through 4 of the UFOV® test. These modified versions allow trainers to vary options (such as limiting the peripheral target to a particular area, decreasing the illumination of the distractors, etc) in a specified manner to increase the participant's processing speed. Details of the training procedures and effects of training are provided elsewhere (Ball et al., 2002; Ball, Edwards, & Ross, in press; Edwards, Wadley, Vance, Roenker, & Ball, 2005; Jobe et al., 2001).

CHAPTER 3

ANALYSES AND RESULTS

Analyses

Random-effects modeling (Singer & Willett, 2003) was used to investigate Aims one (does training impact driving behaviors), two (dosage effects of speed of processing training on later driving behaviors), and three (does training impact the driving behaviors in persons with slower processing speed at baseline in the trained and control sub-samples). Restricted maximum likelihood estimation with an unstructured covariance structure was used to fit each model with SPSS, version 14.0.2 (2005). This method models both within-individual trajectories and between person differences on trajectory estimates. Additionally, random-effects modeling allows estimations with all participants with two or more waves of data, thus reducing the amount of missing data ignored by most traditional repeated measures analyses.

Baseline predictors of each dependent measure, age, education, SRH, vision, CES-D, and Turn-360 were centered on the grand mean for each respective variable. These centered scores are interpreted as deviations from the mean on each predictor variable. Gender was dummy-coded so that females were equal to zero and males equal to 1. See table 1 (pg. 28) for the correlations among the predictors and the baseline mobility measures. Models were then fit that adjusted for each baseline predictor upon the trajectory of each dependent variable between annual one and five. In addition to the unconditional means models (A) and the unconditional linear growth models (B), separate models were analyzed that included: the baseline outcome measure (C), mean-centered age (D), gender (E), mean-centered education (F), mean-centered Self-rated health (G), mean-centered vision (H), mean-centered CES-D (I), mean-centered turn-360 (J), and the effect of training group membership (K) for each dependent variable. This resulted in over eleven models per outcome. The addition of each predictor resulted in both a main effect and interaction term for that model. Such terms were either kept or removed for subsequent models depending upon model fit and significance. See Appendix A for a complete table of all models and model fit for each outcome variable.

Results

Aim 1: All Participants Driving at Baseline

Eighty-three percent of the total sample (N=2323) used in the analyses for Aim 1 were classified as baseline drivers, had complete baseline data on the variables of interest, and had one or more of the annual follow-up assessments. See Appendix A for the resulting models and fit indices for each driving mobility outcome. The main effects and interactions of the predictors upon each outcome are discussed below. Time for Aim 1 was calculated in months since posttest.

Main Effects

There were main effects of baseline driving space on driving space and baseline driving frequency on subsequent driving frequency, such that higher baseline scores indicated higher driving frequency throughout the five-years. Age was a significant main effect for both driving difficulty composites, such that older persons reported more difficulty with driving situations on average. Additionally, there was a main effect of gender such that men reported less difficulty on both difficulty composites and greater driving exposure. There was only a significant effect of education for driving space, such that persons with more education reported greater driving space. There was also a significant main effect of SRH on all outcomes, such that poorer reported health at baseline indicated larger driving space, more days driven per week, and greater driving exposure over the five years. Poorer baseline SRH scores also indicated greater difficulty for both the 3- and 5-item difficulty composites over the five-years.

Interactions

Time was significant for driving space, driving frequency, 3-item difficulty composite, and driving exposure, such that there were general negative trajectories for these four outcomes. Baseline outcome measures x time interactions were significant for driving exposure and the difficulty composites. The estimates indicated that persons with higher scores on the baseline driving exposure composite had steeper positive slopes; while those with higher rankings of the difficulty composites had negative slopes over time on the difficulty composites. There were significant age x time interactions on driving space, driving frequency, and driving exposure, such that older persons had negative slopes on these three outcomes. There was one significant CES-D x time interaction on the 3-item difficulty composite, such that persons with more depressive symptoms had trajectories indicating more difficulty on these items over time. There was also one significant gender x time interaction on driving frequency, such that females had steeper negative slopes on this outcome. Finally, there were significant time x Turn-360 interactions such that persons performing more poorly compared to the mean performance, had negative slopes on driving space, driving frequency, and driving exposure and experienced more difficulty on the 3-item composite over time.

Training Effects

Training effects were investigated using group membership as a predictor, as well as dummy-coded vectors comparing each intervention group to the control group. There were no main effects or interactions by time of training upon the five outcome measures.

In order to further investigate the possible impact of training main effects upon these outcomes, time was centered four different ways. The average time since post-test was centered on annuals 1, 2, 3, and 5 by subtracting the average time for each respective wave from the time variable. The final models for each outcome with the dummy-coded training vectors were re-run using each centered time variable. Reasoning was found to have a significant main effect on the 5-item driving difficulty at centered annual 2 (est.=.248, SD=.122, p = .043), annual 3 (est.=.295, SD=.128, p =.021), and annual 5 (est. .378, SD=.187, p =.043). Additionally, the reasoning training group had a significant main effect on driving exposure when centered at annual 1 (est.=.143, SD=.072, p=.047).

Aim 2: Speed of Processing Trained and Control Groups

Speed of processing trained and control groups were selected (n=1159) to investigate dosage effects of training upon driving trajectories. The final models for each outcome measure from Aim 1 were utilized. First, the impact of group membership was assessed within each outcome. Second, the total number of sessions was calculated per person by summing the initial training session and the subsequent booster sessions. Participants from the control group were recoded as having zero training sessions. Next, this total number of training sessions was added into each model instead of group membership. These models were analyzed using the raw time measure of months since posttest, and the time measures centered on annuals 3 and 5. No significant effects of group membership or number of training sessions were found.

Aim 3: Slower Speed of Processing Trained and Control Groups

Next, to help account for possible ceiling effects, training was investigated as a function of baseline speed of processing impairment and booster participation through a two-step process in the sample from Aim 2 (speed of processing trained and control groups). First, participants who were not considered slower processing speed according to their baseline UFOV scores (risk category 1 or 2) were removed resulting in a sample of 326 older adults. Each final model from Aim 1 for all five outcome measures were re-analyzed on this sub-sample using group membership for one set of models and number of training sessions for a second set of models. These models were performed using time in months since post-test and time centered at annual 3 and centered at annual 5. No significant training effects were found with group membership. However, there were significant main effects found when using total number of training sessions for driving frequency, driving exposure, and the 3-item driving difficulty. Persons receiving more training sessions reported overall greater driving frequency with time since post-test (est.=.035, SD=.015, p=.024), time centered at annual 1 (est.=.033, SD=.013, p=.017) and time centered at annual 2 (est.=.030, SD=.013, *p*=.027). This effect was reduced to a trend when time was centered at annual 3, and was not significant when time was centered at annual 5, *p*'s > .05. There was also a main effect of number of training sessions on driving exposure with time since post-test (est.=.034, SD=.016, *p*=.036), such that persons with more training sessions reported greater driving exposure overall. Finally, there was also a main effect trend of number of training sessions on 3-item driving difficulty when time was centered at annual 5 (est. -.022, SD=.011, *p*=.049), such that persons with more training sessions reported less difficulty on driving alone, making lane changes, and making left-hand turns across on coming traffic.

Second, the effect of booster on persons with speed of processing impairment was examined. Participants from the speed training group not assigned to receive booster were removed from the analyses, resulting in 259 older adults with baseline speed of processing impairments that were assigned either to the control group (n=166), or were assigned to receive booster training within the speed of processing training group (n=93). Each final model from Aim 1 for all five outcome measures were re-analyzed on this second sub-sample using number of training sessions as an indicator of training effect. These models were calculated using time in months since post-test and time centered at annual 1, centered at annual 2, centered at annual 3 and centered at annual 5. A main effect of number of training sessions was found for driving exposure with time since post-test (est.=.034, SD=.016, *p*=.036), and a main effect trend for driving exposure with time centered at annual 1 (est.= .028, SD=.014, *p*=.046), such that persons with more training reported greater driving exposure. Additionally, a main effect of number of training sessions on the 3-item driving difficulty composite was found when time was centered at annual 5 (est.=-.023, SD=.011, p=.041), such that persons receiving more training reported less difficulty with these driving situations. Lastly, there were also main effects of number of training sessions on driving frequency when time was centered at annual 1 (est.=.036, SD=.014, p=.013) and when time was centered at annual 2 (est=.031, SD=.014, p<.034), indicating persons with more training reported more driving frequency over time.

Table 2: Baseline Correlations

		A	B	C	D	E	F	G	H	I	J	K	L	M
A	Driving Frequency	1												
B	3- Item Driving Difficulty	-.10***	1											
C	5- Item Driving Difficulty	-.26***	.48***	1										
D	Driving Exposure	.34***	-.25***	-.48***	1									
E	Driving Space	.35***	-.15***	-.26***	.42***	1								
D	Age	-.12***	.08***	.17***	-.17***	-.12***	1							
E	Turn 360	-.10***	.10***	.13***	-.13***	-.12***	.30***	1						
F	CES-D	-.06**	.17***	.19***	-.13***	-.11***	.10***	.10***	1					
G	Gender	-.17***	.06**	.18***	-.18***	-.25***	-.08***	-.02	.06**	1				
H	SRH	-.11***	.15***	.20***	-.15***	-.19***	.08***	.14***	.32***	.04*	1			
I	Vision	.13***	-.02	-.12***	.12***	.13***	-.31***	-.13***	-.04	-.04	-.09***	1		
J	Education	.15***	-.05*	-.11***	.21***	.24***	-.03	-.04	-.18***	-.16***	-.20***	.10***	1	
K	UFOV Category	-.10***	.14***	.19***	-.16***	-.16***	.39***	.22***	.14***	.01	.18***	-.24***	-.16***	1

NOTE: all n's > 2315 with range of 2316 to 2323; ****p<.001; **p<.01; *p<.05*

CHAPTER 4

DISCUSSION

The results revealed that driving mobility and reported driving difficulty can be modified from their general negative slopes with cognitive training. Specifically, memory training translated to the general population in this sample, with those trained reporting less driving difficulty on the 5-item difficulty composite and reported greater driving exposure over the five-years. Speed of processing training in persons who had slower processing speed at baseline translated to greater driving frequency, greater driving exposure and less driving difficulty on the 3-item driving difficulty composite in persons who received more training sessions. Although such results need to be replicated and should be interpreted with some caution, the translation of cognitive training to actual real-world everyday activities is exciting.

In addition to the training, other significant predictors of restricted driving mobility from Aim 1 were baseline increased age, more depressive symptoms, being female, less education, poorer SRH, and poorer Turn-360. There were significant time effects for driving space, driving frequency, driving exposure and the 3-item driving difficulty items, indicating a significant general decline in driving over time on each of these outcomes.

The negative effects of increased age and time on the five outcomes were not surprising. Although there was not a significant effect of time on the 5-item driving difficulty composite, this model was further investigated as suggested by Singer and Willet (2003), yielding significant main effects of reasoning training when time was centered. Additionally, there were general negative slopes over time associated with increased age for driving space, driving frequency, and driving exposure. This is in agreement with much of the research on driving cessation, indicating that age is associated with declines in driving mobility (Campbell, Bush, & Hale, 1993; Marottoli et al., 1993).

The findings for depressive symptomology, gender, education, and turn-360 were not as consistent with prior research. Although correlated with driving outcomes and other baseline measures, reported depressive symptoms were significant with an interaction by time only on the 3-item difficulty measure. However, it is important to note that the majority of the sample expressed very few depressive symptoms, as indicated by more than 50% indicating a score of four or less. Thus suggesting a small range of depressive symptoms within this sample.

As has been reported in the literature (Campbell, Bush, & Hale, 1993), females reported less driving mobility, via exposure, and greater driving difficulty for both the 3-item and 5-item difficulty composites. However, some researchers have failed to find a gender effect (Dellinger, Sehgal, Sleet, & Barrett-Connor, 2001), as was the case in these analyses for driving space and frequency. Additionally, other researchers have warned that gender findings may be due to cohort effects or societal differences (Hakamies-Blomqvist & Siren, 2003). There was a main effect of education on driving space, such that persons with more education indicated greater driving space throughout the five years. This was not surprising as less education or lower income, often highly correlated with education, have been related to driving cessation (Burns, 1999; Jette & Branch, 1992; Marottoli et al., 1993; O'Neill et al., 2000).

Two health/physical functioning predictors that were significant for several of the outcomes were SRH and Turn-360. There were main effects of SRH across all the outcomes, with persons who rated their health as worse had less driving mobility and more driving difficulty over time. These results are similar to Anstey and colleagues (2006) who found self-rated health to be predictive of subsequent driving cessation. Turn-360 also emerged as a relatively stable predictor of driving space, driving frequency, driving exposure, and the 3-item difficulty composite trajectories (slopes), such that persons performing poorly on this measure had less driving mobility and greater driving difficulty. This is consistent with Edwards et al. (submitted) where turn-360 was found to predict driving cessation over a five-year period. The SRH main effects and turn-360 interactions are interesting effects as they are easily and freely administered and may be of use to clinicians concerned about persons at risk for reduced mobility. These results bring to question whether physical interventions that enhance balance, such as Tai Chi, may also impact mobility over time (Li et al., 2005).

There were not significant differences between persons trained on speed of processing and the control group in the total sample over the five years on driving mobility outcomes. However, there were significant main effects of reasoning training on driving exposure and the 3-item driving difficulty composites. This finding is interesting considering recent longitudinal research that identified cognitive reasoning as a predictor of driving cessation (Anstey et al., 2006). Although reasoning training was not an original focus point of the current analyses, reasoning and speed of processing constructs are closely related as both are fluid abilities.

In order to address Aim 2, the final models from Aim 1 were re-analyzed with only the speed of processing training group and the control group. In addition to group membership, number of training sessions was analyzed as predictors of longitudinal driving mobility trajectories. However, no significant effects of group membership or number of training sessions were found. As this was considered a possibility given that stronger training effects are typically found in persons with initial speed of processing impairment, Aim 3 was addressed.

This final Aim sought to address both ceiling effects of persons with good processing speed at baseline by removing those persons from the analyses. Additionally, the second part of Aim 3 also addressed issues of greater training effects found in the booster groups (Willis et al., 2006). Greater amounts of speed of processing training were found to have a positive effect on driving frequency, driving exposure and a trend on the 3-item driving difficulty composite. The second part of this Aim repeated the same models and centering techniques while selecting for persons who had slower baseline speed of processing (trained and control groups) and who had been assigned to booster (trained group). Again, positive main effects were found on driving frequency, driving exposure, and the 3-item difficulty composite. It is interesting to note that main effects were significant at earlier time points (annuals 1 and 2) for the driving mobility (frequency and exposure); however, it was not until annual 5 that an effect is found for driving difficulty. This may have to do with the sensitivity of the measures, slower transfer to difficulty items (such that trained persons maintain their driving skills or confidence compared to the controls), or a combination of such factors.

Implications

The present results indicate that although speed of processing training did not significantly impact subsequent driving mobility in the total sample, reasoning training did. These findings, coupled with prior research provide evidence of basic-level cognitive transfer to real-world functional behaviors. The finding that speed did not significantly impact driving mobility in the total sample does not preclude the notion that processing speed is an underlying mechanism of cognitive aging. The fact that reasoning training significantly impacted driving in the total sample, but speed of processing training did not, considered along with the wealth of research that links processing speed to driving, suggests that there may be a mediational relationship between speed, reasoning and driving abilities. Research in the developmental cognitive trajectories of children have noticed a partial mediation among speed, working memory and reasoning as a function of age (Fry & Hale, 1996; Kail, 2007; Kail & Hall, 1999). As such, it is feasible that the two training protocols are taping some of the same underlying cognitive constructs or abilities.

Finally, it is clear that processing speed training translates positively to driving mobility trajectories in older adults with slower basline speed of processing. It is this same group that are at greater risk for subsequent at-fault crashes (Ball et al., 2006), and reductions in mobility over time (Owsley & McGwin, 2004). Many researchers are arguing for the investigation of impaired or at-risk sub-samples of older adults rather than focusing on all older adults as a group.

This is logical given the great heterogeneity found within this unique population. Additionally, the speed of processing training protocol is non-invasive, cost-effective

(Viamonte, Ball, & Kilgore, 2006), and is useable in a variety of training formats (Wadley et al., 2006). As such, given the translation of speed training to driving mobility within persons with slower baseline speed of processing, and the general translation of reasoning training to the sample as a whole, it would be interesting to investigate a combination of speed and reasoning training on everyday activities.

Limitations

There are several limitations to this study. Firstly, driving habits are measured via self-report and should not be confused with driving skills or possible improvement of driving skills. Secondly, this sample is fairly well educated and generally in good cognitive health. Although education does not directly impact the potential benefit of processing speed training, (Ball, Edwards & Ross, in press) persons with more education tend to remain active drivers for longer periods of time, thus possibly reducing the amount of change in driving habits over time. This is also compounded by the good baseline cognitive functioning found in this sample at baseline. Persons with lower (slower) cognitive functioning at baseline have more room for improvement during cognitive training and will likely show greater training effects. As this sample is generally well educated (thus more likely to have less reduction in driving habits) and in good cognitive functioning at baseline (thus less room for improvement in processing speed and less likely to reduce driving), there may be a reduction in translation of training effects to driving. Aim 3 (investigating the driving trajectories of the training and controlled participants with poorer processing speed at baseline) attempted to lessen this risk.

Finally, upon examining the residuals throughout the models, it is clear that there is significant level-1 variation that still needs to be addressed. Such variation indicates that there is significant within-individual variation that requires the inclusion of time-varying predictors to address such variation and within-individual change on the outcome trajectories. Such predictors should be included in future analyses.

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APPENDIX A

AIM 1 MODELS FOR DRIVING FREQUENCY, DRIVING EXPOSURE, DRIVING SPACE, 3-ITEM DRIVING DIFFICULTY, AND 5-ITEM DRIVING DIFFICULTY

Driving Frequency with non-centered time since posttest

Models:	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**Training**
Fixed Effects, Initial status, π_{0i}											
Intercept	5.40***	5.79***	5.79***	5.79***	5.755**	5.759***	5.753***	5.75***	5.75***	5.75***	5.74***
	(.039)	(.045)	(.034)	(.034)	*	(.039)	(.039)	(.040)	(.039)	(.040)	(.071)
					(.039)						
Baseline			.75***	.722***	.711***	.706***	.704***	.701***	.702***	.698***	.698***
Days			(.020)	(.016)	(.016)	(.017)	(.016)	(.016)	(.016)	(.017)	(.017)
Age				-.015*	-.016**	-.016*	-.014*	-.011	-.014*	-.016*	-.016*
				(.006)	(.006)	(.006)	(.006)	(.006)	(.006)	(.007)	(.007)
Gender					.142	.121	.140	.128	.143	.144	.146
0=female					(.078)	(.079)	(.078)	(.078)	(.078)	(.078)	(.078)
Education						.022					
						(.013)					
SRH							-.144***	-.174***	-.169***	-.163***	-.161***
							(.040)	(.032)	(.033)	(.032)	(.032)
								.004			
Vision								(.003)			
									.005		
CESD									(.007)		
										.017	.017
T360										(.021)	(.021)
Memory											-.001
Reasoning											-.073
Speed											.117
											p's>.20
Rate of Change, π_{1i}											
Intercept		-013***	-014***	-015***	-	-.016***	-.016***	-.016***	-.016***	-.016***	-.016***
		(.001)	(.001)	(.001)	.016***	(.001)	(.001)	(.001)	(.001)	(.001)	(.002)
					(.001)						
Baseline			-.001								
Days			(.001)								

Driving Frequency with non-centered time since posttest (Cont'd)

	Age				-001*** (.0001)	-.001*** (.0001)	-.001*** (.0001)	-.001*** (.0002)	-.001*** (.0002)	-.001*** (.0002)	-.001*** (.0002)	-.001*** (.0002)
	Gender 0=female					.005* (.002)	.005* (.002)	.005* (.002)	.005* (.002)	.005* (.002)	.005* (.002)	.005* (.002)
	Education						-4.3E-005 (.0004)					
	SRH							-.002 (.001)				
	Vision								2.11E-005 (9.80E-005)			
	CESD									-.0004 (.0002)		
	T360										-.003*** (.001)	-.003 (.001)
	Memory											-.0007
	Reasoning											.0041
	Speed											-.0013 *p's*>.20
Variance Components												
L 1	W/I person	1.183 (0.025)	.832*** (.022)	.833*** (.022)	.834*** (.022)	.834*** (.022)	.834*** (.022)	.833*** (.022)	.833*** (.022)	.832*** (.022)	.823*** (.022)	.823*** (.022)
L 2	In initial status	2.578 (0.097)	2.550*** (.127)	.954*** (.077)	.942*** (.075)	.941*** (.075)	.940*** (.075)	.937*** (.076)	.937*** (.076)	.929*** (.075)	.932*** (.075)	.931*** (.075)
	In rate of change		.0007*** (6.38E-005)	.001*** (6.30E-005)	.001*** (6.16E-005)	.001*** (6.15E-005)	.0007*** (6.16E-005)	.0007*** (6.20E-005)	.0007*** (6.21E-005)	.0007*** (6.19E-005)	.0007*** (6.07E-005)	.0007*** (6.08E-005)
	UN(2,1)		-008*** (.002)	-.006** (.002)	-.006** (.002)	-.006*** (.002)	-.006*** (.002)	-.007*** (.002)	-.007*** (.002)	-.007*** (.002)	-.006*** (.002)	-.006 (.002)
	-2LL	23171	22157	20777	20700	20693	20700	20508	20522	20469	20101	20137
	AIC	23175	22165	20785	20708	20701	20708	20516	20530	20477	20109	20145
	BIC	23189	22192	20812	20735	20728	20735	20543	20557	20504	20136	20171

Model Key: A: Unconditional means model; B: Unconditional linear growth model; C: Addition of baseline driving frequency; D: Addition of mean-centered age; E: Addition of gender; F: Addition of mean-centered education; G: Addition of mean-centered SRH; H: Addition of mean-centered vision; I: Addition of mean-centered CES-D; J: Addition of mean-centered Turn-360; K: Addition of training effects; ****p<.001; **p<.01; *p<.05*

Driving Exposure with non-centered time since posttest

Models	A	B	C	D	E	F	G	H	I	J	Training
Fixed Effects, Initial status, π_{0i}											
Intercept	7.13***	7.48***	7.46***	7.46***	7.42***	7.41***	7.40***	7.40***	7.40***	7.40***	7.34***
	(.034)	(.035)	(.031)	(.031)	(.036)	(.035)	(.035)	(.035)	(.035)	(.035)	(.064)
Baseline			.637***	.625***	.612***	.603***	.592***	.589***	.589***	.575***	576***
exposure			(.028)	(.028)	(.029)	(.029)	(.029)	(.030)	(.029)	(.030)	(.030)
Age				-.013*	-.015*	-.015*	-.014*	-.013*	-.016**	-.016**	-.015*
				(.006)	(006)	(.006)	(.006)	(.006)	(.006)	(.006)	(.006)
Gender					.168*	.219***	.228***	.222***	.229***	.225***	.224***
0=female					(.073)	(.057)	(.057)	(.057)	(.057)	(.056)	(.056)
Education						.010					
						(.012)					
SRH							-.100**	-125***	-.124***	-.107***	-.109***
							(.038)	(.029)	(.031)	(.029)	(.029)
								.001			
Vision								(.003)			
									.005		
CESD									(.007)		
										-.0005	-7.7E-005
T360										(.019)	(.019)
Memory											.05
Reasoning											.15
Speed											.05
											p's>.09
Rate of Change, π_{1i}											
Intercept		-012***	-012***	-013***	-014***	-013***	-014***	-013***	-.013***	-.013***	-.013***
		(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.002)
Baseline			.007***	.006***	.006***	.006***	.006***	.006***	.006***	.006***	.006***
Exposure			(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
				-001***	-001***	-001***	-.001**	-001***	-.001***	-.001***	-.001***
Age				(.002)	(.0002)	(.0002)	*(.0002)	(.0002)	(.0002)	(.0002)	(.0002)
Gender					.003						
0=female					(.002)						

Driving Exposure with non-centered time since posttest (Cont'd.)

	Education						7.04E-005 (.0004)					
	SRH							-.002 (.001)				
	Vision								.0001 (9.99E-005)			
	CESD									-.0003 (.0002)		
	T360										-.003** *(.001)	-.003*** (.001)
	Memory											-.0004
	Reasoning											-.0006
	Speed											-.0004 *p's*>.8
Variance Components												
L 1	W/I person	1.14 (.024)	.732*** (.020)	.738*** (.020)	.740*** (.020)	.740*** (.020)	.740*** (.020)	.744*** (.020)	.745*** (.020)	.744*** (.020)	.735*** (.020)	.735*** (.020)
L 2	In initial status	1.87 (.075)	1.288*** (.083)	.765*** (.065)	.753*** (.065)	.749*** (.065)	.750*** (.065)	.750*** (.065)	.749*** (.065)	.742*** (.065)	.727*** (.065)	.727*** (.065)
	In rate of change		.001*** (6.94E-005)	.001*** (6.66E-005)	.001*** (6.42E-005)	.001*** (6.42E-005)	.001*** (3.43E-005)	.001*** (6.49E-005)	.001*** (6.49E-005)	.001*** (6.46E-005)	.001*** (6.17E-005)	.001*** (6.19E-005)
	UN(2,1)		-.002 (.002)	-008*** (.002)	-008*** (.002)	-008*** (.002)	-008*** (.002)	-008*** (.002)	-008*** (.002)	-.008*** (.002)	-.008*** (.002)	-.008*** (.002)
Goodness of Fit												
	-2LL	22415	21113	20174	20075	20071	20075	19921	19932	19887	19437	19475
	AIC	22479	21121	20182	20083	20079	20083	19930	19940	19895	19445	19483
	BIC	22492	21148	20209	20110	20106	20110	19956	19967	19922	19472	19509

Model Key: A: Unconditional means model; B: Unconditional linear growth model; C: Addition of baseline driving exposure; D: Addition of mean-centered age; E: Addition of gender; F: Addition of mean-centered education; G: Addition of mean-centered SRH; H: Addition of mean-centered vision; I: Addition of mean-centered CES-D; J: Addition of mean-centered Turn-360; K: Addition of training effects; ****p<.001; **p<.01; *p<.05*

Driving Space with non-centered time since posttest

Models	A:	B:	C	D	E	F	G	H	I	J	Training
Fixed Effects, Initial status, π_{0i}											
Intercept	3.35*** (.027)	3.53*** (.035)	3.51*** (.031)	3.52*** (.031)	3.39*** (.036)	3.40*** (.033)	3.40*** (.033)	3.40*** (.033)	3.40*** (.033)	3.40*** (.034)	3.39*** (.063)
Baseline space			.548*** (.025)	.529*** (.017)	.485*** (.017)	.466*** (.017)	.450*** (.018)	.448*** (.018)	.450*** (.018)	.445*** (.018)	.445*** (.018)
Age				-.004 (.006)	-.008 (.006)	-.007 (.006)	-.006 (.006)	-.005 (.006)	-.007 (.006)	-.005 (.006)	-.005 (.006)
Gender 0=female					.500*** (.071)	.457*** (.050)	.463*** (.049)	.458*** (.050)	.461*** (.050)	.472*** (.050)	.471*** (.050)
Education						.042*** (.012)	.036*** (.008)	.035*** (.008)	.036*** (.008)	.036*** (.008)	.037*** (.008)
SRH							-.144*** (.037)	-.154*** (.025)	-.151*** (.026)	-.146*** (.026)	-.147*** (.025)
Vision								.002 (.003)			
CESD									.0003 (.006)		
T360										-.009 (.019)	-.009 (.019)
Memory											-.03
Reasoning											.06
Speed											.01
											p's>.51
Rate of Change, π_{1i}											
Intercept		-.006*** (.001)	-.006*** (.001)	-.007*** (.001)	-.007*** (.001)	-.007*** (.001)	-.007*** (.001)	-007*** (.001)	-.007*** (.0008)	-.008*** (.0008)	-.008*** (.002)
Baseline space			-3.2E-005 (.001)								
AGE				-.001*** (.0001)	-.001*** (.0002)	-.001*** (.0002)	-.001*** (.0002)	-001*** (.0002)	-.001*** (.0002)	-.001*** (.0002)	-.001*** (.0002)
Gender 0=female					-.0003 (.002)						
Education						9.80E-005 (.0003)					

Driving Space with non-centered time since posttest (Cont'd.)

	SRH							-.0004 (.001)				
	Vision								6.41E-005 (7.83E- 005)			
	Cesd									-.0001 (.0002)		
	T360										-.001* (.0005)	-.001* (.0005)
	Memory											.0005
	Reasoning											-.0004
	Speed											-.0005 *p's*>.80
L 1	W/I person	.926* (.020)	.815*** (.022)	.818*** (.022)	.817***	.817*** (.022)	.818*** (.022)	.815*** (.022)	.815*** (.022)	.815*** (.022)	.815*** (.022)	.815*** (.022)
L 2	In initial status	-.0001 (.002)	1.168*** (.080)	.684*** (.065)	.676*** (.065)	.637*** (.063)	.626*** (.063)	.620*** (.063)	.620*** (.063)	.619*** (.063)	.626*** (.063)	.628*** (.063)
	In rate of change		.0003*** (4.41E- 005)	.0003*** (4.38E- 005)	.0002*** (4.25E- 005)	.0002*** (4.25E- 005)	.0002*** 4.26E-005	.0002*** (4.26E- 005)	.0002*** (4.26E- 005)	.0002*** (4.26E- 005)	.0002*** (4.25E- 005)	.0002*** (4.26E- 005)
	UN(2,1)		-.005** (.002)	-.005** (.001)	-.005** (.001)	-.005** (.001)	-.005** (.002)	-.005** (.001)	-.005** (.001)	-.005** (.001)	-.005** (.001)	-.005** (.001)
	-2LL	20602	20097	19273	19172	19092	19063	18852	18865	18832	18529	18571
	AIC	20606	20106	19281	19180	19100	19071	18860	18873	18840	18537	18579
	BIC	20619	20132	19308	19207	19127	19098	18887	18899	18867	18564	18606

Model Key: A: Unconditional means model; B: Unconditional linear growth model; C: Addition of baseline driving space; D: Addition of mean-centered age; E: Addition of gender; F: Addition of mean-centered education; G: Addition of mean-centered SRH; H: Addition of mean-centered vision; I: Addition of mean-centered CES-D; J: Addition of mean-centered Turn-360; K: Addition of training effects; ****p<.001; **p<.01; *p<.05*

3-item Driving Difficulty with non-centered time since posttest

Models	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**Training**
Fixed Effects, Initial status, π_{0i}											
Intercept	3.413*** (.0168)	3.429*** (.0244)	3.432*** (.0226)	3.433*** (.0226)	3.470*** (.0261)	3.468*** (.0242)	3.470*** (.0242)	3.470*** (.0242)	3.468*** (.0242)	3.460*** (.0241)	3.445*** (.0457)
Baseline Difficulty			.389*** (.0224)	.384*** (.0223)	.379*** (.0223)	.380*** (.0223)	.374*** (.0225)	.372*** (.0224)	.3727*** (.0226)	.3776*** (.0226)	.3770*** (.0227)
Age				.015*** (.0041)	.021*** (.0027)	.021*** (.0027)	.020*** (.0028)	.020*** (.0029)	.0197*** (.0028)	.0195*** (.0029)	.0195*** (.0029)
Gender 0=female					-.131* (.0517)	-.126*** (.0348)	-.125*** (.0343)	-125*** (.0344)	-.120*** (.0343)	-.116** (.0343)	-.116** (.0344)
Education						.004 (.0085)					
SRH							.054* (.0269)	.066*** (.0180)	.047* (.0188)	.047* (.0189)	.047* (.0189)
Vision								.0009 (.0021)			
CESD									.0023 (.0048)	.0020 (.0047)	.0020 (.0047)
T360										-.0217 (.0133)	-.0215 (.0134)
Memory											-.02
Reasoning											.06
Speed											.02
											p's>.40
Rate of Change, π_{1i}											
Intercept		-.0007 (.0006)	-.0007 (.0006)	-.0004 (.0006)	-.0006 (.0007)	-.0005 (.0006)	-.0005 (.0006)	-.0005 (.0006)	-.0005 (.0006)	-.0003 (.0006)	8.94E-005 (.0012)
Baseline Difficulty			-.003*** (.0006)	-.003*** (.0006)	-004*** (.0006)	-.003*** (.0006)	-.003*** (.0005)	-.003*** (.0006)	-.003*** (.0006)	-.003*** (.0006)	-.003*** (.0006)
Age				.0002 (.0001)							
Gender					.0002 (.0013)						

3-item Driving Difficulty with non-centered time since posttest (Cont'd.)

	Education						-.0003 (.0002)					
	SRH							.0004 (.0007)				
	Vision								-3.5E-005 (5.33E-005)			
	CESD									.0003* (.0001)	.0003* (.0001)	.0003* (.0001)
	T360										.0007* (.0003)	.0007* (.0003)
	Memory											.001
	Reasoning											-.001
	Speed											-.001 *p's*>.50
L 1	W/I person	.001 (-4.2E-005)	.494*** (.0129)	.494*** (.0129)	.494*** (.0129)	494*** (.0129)	.493*** (.0129)	.491*** (.0129)	.491*** (.0129)	.491*** (.0129)	.490*** (.0130)	.490*** (.0130)
L 2	In initial status	-4.2E-005 (.0003)	.451*** (.0396)	.296*** (.0349)	.289*** (.0346)	.287*** (.0346)	.290*** (.0347)	.281*** (.0345)	.280*** (.0345)	.278*** (.0344)	.252*** (.0340)	.253*** (.0340)
	In rate of change		4.67E-005* (2.23E-005)	4.21E-005 (2.22E-005	4.17E-005 (2.21E-005)	4.30E-005 (2.22E-005)	4.30E-005 (2.21E-005)	4.14E-005 (2.21E-005)	4.09E-005 (2.21E-005)	4.03E-005 (2.21E-005)	3.20E-005 (2.20E-005)	3.22E-005 (2.20E-005)
	UN(2,1)		-.002* (.0008)	-.001 (.0008)	-.001 (.0008)	-.001 (.0008)	-.001 (.0008)	-.0010 (.0008)	-.0010 (.0008)	-.0010 (.0008)	-.0005 (.0008)	-.0005 (.0008)
	-2LL	16255	15847	15455	15425	15414	15389	15248	15265	15224	14944	14990
	AIC	16259	15855	15.463	15433	15422	15397	15256	15273	15232	14952	14998
	BIC	16273	15882	15490	15460	15449	15424	15283	15300	15259	14979	15025

Model Key: A: Unconditional means model; B: Unconditional linear growth model; C: Addition of baseline 3-item driving difficulty; D: Addition of mean-centered age; E: Addition of gender; F: Addition of mean-centered education; G: Addition of mean-centered SRH; H: Addition of mean-centered vision; I: Addition of mean-centered CES-D; J: Addition of mean-centered Turn-360; K: Addition of training effects; ****p<.001; **p<.01; *p<.05*

5-item Driving Difficulty with non-centered time since posttest

Models	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**Training**
Fixed Effects, Initial status, π_{0i}											
Intercept	7.421**	7.502***	7.511***	7.520***	7.654***	7.634***	7.646***	7.658***	7.650***	7.633***	7.560***
	(.056)	(.073)	(.061)	(.061)	(.071)	(.066)	(.067)	(.067)	(.067)	(.067)	(.126)
Baseline			.634***	.620***	.604***	.604***	.659***	.593***	.592***	.587***	.593***
Difficulty			(.022)	(.023)	(.023)	(.023)	(.023)	(.023)	(.023)	(.023)	(.023)
Age				.040***	.045***	.044***	.043***	..042***	.044***	.045***	.044***
				(.011)	(.008)	(.008)	(.008)	(.008)	(.008)	(.008)	(.008)
Gender					-.521***	-.438***	-.443***	-.438***	-.446***	-.447***	-.443***
0=female					(.412)	(.101)	(.099)	(.100)	(.100)	(.100)	(.100)
Education						-.021					
						(.023)					
SRH							.149*	.191***	.203***	.197***	.192***
							(.074)	(.051)	(.054)	(.052)	(.051)
								-.003			
Vision								(.006)			
									.001		
CESD									(.013)		
										.010	
T360										(.037)	
Memory											.023
Reasoning											.156
Speed											.184
											p's > .30
Rate of Change, π_{1i}											
Intercept		-.003	-.003	-.002	-.003	-.003	-.003	-.003	-.003	-.002	-.004
		(.002)	(.022)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)
Baseline			-.002***	-.002***	-.002***	-.002***	-.002***	-.002***	-.002***	-.002***	-.002***
Difficulty			(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
				2.86E-005							
Age				(.0003)							
					.003						
Gender					(.004)						
						.0006					
Education						(.0006)					

5-item Driving Difficulty with non-centered time since posttest (Cont'd.)

								.002				
	SRH							(.002)				
	Vision								-1.6E-005			
									(.0002)			
	CESD									-.0003		
										(.0003)		
	T360										-.0006	
											(.001)	
	Memory											.003
	Reasoning											.004
	Speed											.001
												p's>.40
L	W/I	3.473	3.067***	3.075***	3.072***	3.073***	3.069***	3.090***	3.090***	3.090***	3.058***	3.087***
1	person	(.074)	(.082)	(.082)	(.082)	(.082)	(.082)	(.083)	(.083)	(.083)	(.083)	(.083)
L	In initial	4.908	5.893***	2.837***	2.798***	2.748***	2.755***	2.730***	2.730***	2.740***	2.621***	2.738***
2	status	(.198)	(.348)	(.254)	(.253)	(.251)	(.251)	(.253)	(.253)	(.253)	(.249)	(.253)
	In rate of		.001***	.001***	.001***	.001***	.001***	.001***	.001***	.001***	.001***	.001***
	change		(.0002)	(.0002)	(.0002)	(.0002)	(.0002)	(.0002)	(.0002)	(.0002)	(.0002)	(.0002)
	UN(2,1)		-.032***	-.022***	-.022***	-.022***	-.022***	-.022***	-.022***	-.022***	-.022***	-.022***
			(.007)	(.006)	(.006)	(.006)	(.006)	(.006)	(.006)	(.006)	(.006)	(.006)
	-2LL	29301	28694	27694	27689	27667	27656	27444	27459	27414	26919	27463
	AIC	29305	28702	27702	27697	27675	27664	27452	27467	27422	26927	27471
	BIC	29319	28729	27729	27724	27702	27691	27479	27494	27449	26953	27498

Model Key: A: Unconditional means model; B: Unconditional linear growth model; C: Addition of baseline 5-item driving difficulty; D: Addition of mean-centered age; E: Addition of gender; F: Addition of mean-centered education; G: Addition of mean-centered SRH; H: Addition of mean-centered vision; I: Addition of mean-centered CES-D; J: Addition of mean-centered Turn-360; K: Addition of training effects; ****p<.001; **p<.01; *p<.05*

APPENDIX B

IRB PROJECT REVISION/AMENDMENT FORM

/11/'04

UAB Project Revision/Amendment Form irb

(Rev. 4/7/2004)

(PLEASE TYPE: In MS Word, highlight the shaded, underlined box and replace with your text; double-click checkboxes to check/uncheck.)

Link: Project Revision/Amendment Form

Federal regulations require IRB approval before implementing proposed changes.
Please complete this form and attach the changed research documents. Change means any change, in content or form, to the protocol, consent form, or any supportive materials (such as the Investigator's Brochure, questionnaires, surveys, advertisements, etc.)

Principal Investigator: *Karlene Ball* Date: *11/05/2004*
Contact: *Kathy McConnell* Phone #: *934-2610* Fax #: *975-2295* E-mail: *kmcconn@uab.edu*
Campus Address: *109 HMB (2100)*
Study/Protocol Title: *ACTIVE Phase II: UAB Field Site*
IRB Protocol #: *X960401003*

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Current Status of Project: (check only one)

☒ Currently in Progress (# participants entered: _____)
☐ Study has not yet begun (no participants entered)
☐ Closed to participant enrollment (remains active); # participants on therapy/intervention_____; # participants in long-term follow-up only *462*

This submission changes the status of this study in the following manner: (check all that apply)

☐ Protocol Revision ☐ Revised Consent Form
☒ Protocol Amendment ☐ Addendum (new) consent form
☐ Study Closed to participant entry ☐ Enrollment temporarily suspended by sponsor
☐ Study Terminated ☒ Other, (specify) *add investigators*

1. Briefly describe, and explain the reason for, the revision or amendment. Include a copy of supportive documents with changes highlighted. Please highlight changes/revisions/additions to the consent form, protocol, research questionnaire, etc.
Lesley Ross, a doctoral student in Developmental Psychology, will be added to this study as investigators. She has completed training in human subjects protection. Updated training 2/4/04. Walker 11/09/04

2. Does this revision/amendment revise or add a genetic or storage of samples component?
☐ Yes ☒ No
If yes, please see the Guidebook to assist you in revising or preparing your submission documents or call the IRB office at 4-3789.

3. Does the change affect subject participation (e.g. procedures, risks, costs, etc.)?
☐ Yes ☒ No

4. Does the change affect the consent document? ☐ Yes ☒ No
If yes, briefly discuss the changes. _____

Include the revised consent form with the changes highlighted.
Will any participants need to be reconsented as a result of the changes? ☐ Yes ☒ No
If yes, when will participants be reconsented?_____

Signature of Principal Investigator *Karlene Ball* Date *11-5-2004*

FOR IRB USE ONLY

APPROVED Marilyn Doss 11/10/04
MARILYN DOSS, M.A.
Vice Chair – IRB

Rev DOLA 9/1/04