Only Subtest 2 and 3 of the Useful Field of View Test Predict Timed Instrumental Activities of Daily Living

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The Useful Field of View test (UFOV®, Visual Awareness, Inc., Chicago, IL) is a measure of older adults cognitive functional level. In the past 20 years, UFOV has aroused conciderable interest because performance on the test predicts older adults' ability to perform a range of everyday activities. UFOV is best known for its ability to predict driving performance (Clay et al., 2005) and at-fault motor vehicle collisions in older adults (e.g., Ball, Owsley, Sloane, Roenker, & Bruni, 1993; Goode et al., 1998; Owsley et al., 1998; Rubin et al., 2007). In their meta-analysis of eight studies with a total of 712 older drivers, Clay et al. (2005) found an average correlation between UFOV and driving performance of and a large difference in driving performance between drivers with a 40% reduction of the useful field of view or greater and drivers with a reuction of less than 40%, . Using the established 40%-criterion, Ball et al. (1993) reported a sensitivity of 89% and a specificity of 81% when using UFOV to identify drivers with a history of one or more at-fault motor vehicle crashes in the previous five years. These results were later confirmed in an independent study by Goode et al. (1998), who reported a sensitivity of 86.3% and a specificity of 84.3%. It is because of these qualities that UFOV is widely used as cognitive driving test and serves as a proxy for driving ability in many studies (e.g., Weaver, Bédard, McAuliffe, & Parkkari, 2009, more citations needed, maybe training studies?). Performance on UFOV, furthermore, is related to older adults' performance of other everyday tasks such as the Timed Instrumental Tasks of Daily Living (TIADL, Owsley, Sloane, McGwin, & Ball, 2002) Can you point me to other studies that report correlations between the two measures, so I can characterize the size of the effect here?. The TIADL test consists of five tasks intended to assess functional abilities in the domains of telephone communication, finances, nutrition, shopping, and medication usage. **Add an example here** Notably, improvements in UFOV performance through training are associated with improvements in the untrained TIADL (Edwards et al., 2005a, 2002). Some studies, moreover, suggest that older adults with an impaired useful field of view have a higher risk of falling than unimpaired adults (Vance et al., 2006). I had a look at the papers that I often see cited for falls (Stalvey et al., 1999, Sims, McGwin, et al., 2001, Sims, Owsley et al., 1998, and Vance et al., 2006). I was unable to obtain Sims et al. (1998) but from the abstract it sounds as though the following may apply to this paper as well. If I'm not mistaken the papers never actually assess the association of UFOV and the risk of falls, do they? The analyses by Stavlvey et al. (1999) and Sims (2001) show that UFOV and falls are both independently related to at-fault accidents but no relationship between UFOV and falls is reported. In Vance (2006) the relationship is assessed in SEM as a mixture of different measures, but the correlations in table 2 only show a very small association between subtest 2 and falls. I've tried to predict the risk of falls in SKILL and ACTIVE using UFOV subtests 1-4 as individual predictors in a logistic regression with mixed success. In SKILL subtest 3 and maybe 1 (need to check for influential cases still, as the exclusion of cases with falls > 20 makes subtest 1 obsolete) are predictive, but no test is predictive of falling in ACTIVE (same inclusion criteria). Do you think it is worth reporting these analyes to further support the claim that subtests 1 and 4 don't contribute much to the prediction of everyday activities? Would this make a stronger case?

Since it was first conceived (Ball, Beard, Roenker, Miller, & Griggs, 1988; Sekuler & Ball, 1986) several variants of the the UFOV paradigm have been proposed (for an overview see Edwards et al., 2005a). In its current form, the UFOV test consists of four subtests in which particpants view brief presentations of white stimuli on a black background (Figure ). Trials start with a central square fixation box () that is presented for x ms. In subtest 1, a pictogram of a car or truck () is displayed within the fixation box for a duration varying between 16.67 ms and 500 ms in steps of 16.67 ms (1 frame on a 60 Hz computer screen). The entire screen is then masked by a random dot pattern for x ms. At the end of a trial participants give a non-speeded repsonse identifying the briefly presented object as either car or truck. Subtest 2 follows the same general procedure as subtest 1; in addition to the object in the fixation box, a second pictogram () is presented simultaneously at one of eight radial positions at 11.7 eccentricity. Following the identification of the central object, participants indicate at which of the eight locations the second object was displayed, irrespective of its identity. In subtest 3, 47 downward pointing triangular distractors of the same size, contrast, and luminance as the targets are added to the display at x, y, and 11.7 eccentricities sourrounding the central fixation box. Do you know the exact eccentricities of the other distractors? I haven't found any information on this. Subtest 4 is a variant of subtest 3 where *two* pictograms () are displayed in the central fixation box. Do you know the exact size of these? I haven't found any information on this. Participants indicate whether the two central objects are the same or different and locate the simultaneously presented object in the periphery. Each subtest is scored as the display duration at which the test taker performs with an accuracy of 75% as determined by a double-staircase procedure. Responses are collected either by mouse or touch screen. Depending on the method of response collection and the retest interval the reliability of the subtests has been reported to be - for subtest 1, - for subtest 2, and - for subtest 3 (Edwards et al., 2005a). **Add information on the reliability of the complete test** No estimates of the test-retest reliability of subtest 4 are available.

## Validity of UFOV subtests

UFOV outcomes are usually reported and analyzed as sum score of all subtests but there are reasons to doubt that UFOV subtests contribute equally to the prediction of everyday activities, such as TIADL and driving. One conceptualization of UFOV is that it measures processing speed, but only few studies have assessed the validity of UFOV subtests individually. Edwards et al. (2006) found UFOV subtests 2 and 3 correlate most strongly with the Wechsler Adult Intelligence Scale Digit Symbol Substitution test (WAIS-R DSS, Wechsler, 1981) and the Road Sign Test (Ball et al., 2002; RST, Edwards et al., 2002)---two measures that have been used repeatedly to asses the concurrent validity of UFOV as a measure of processing speed. In a longitudinal study, Lunsman et al. (2008) found that UFOV and DSS performance developed similarly across a five-year period. The omission of subtest 4 from the sum score did not affect the association of UFOV and DSS throughout the nine measurement occasions suggesting that it captures little unique variance related to processing speed. In fact, subtest 2 alone exhibited a longitudinal association with DSS similar to the sum score of all four tests. These studies indicate that UFOV subtests 2 and 3 contribute most of the variance that UFOV shares with other measures of processing speed.

Research on the association of UFOV subtests and the risk of motor vehicle crashes is less consistent. Owsley et al. (1998) analyzed older adults' relative risk of motor vehicle collisions depending on their performance on UFOV subtests 1-3. Their analyses suggest that only subtest 2 is indicative of the relative risk traffic accidents: Older adults who exhibited impaired performance had a 2.3-fold risk of motor vehicle collision involvement compared to those with unimpaired performance. The cut-off values used to distinguish high from low performers were selected ad-hoc for each subtest "based on their distributions" (p. 1086, Owsley et al., 1998). In a prospective study, Rubin et al. (2007) found that both subtest 1 and 2 were individually related to motor vehicle crashes in older adults. Ball et al. (2006) administered only subtest 2 and reported a 2.02-fold increase in therisk of at-fault motor vehicle crashes for drivers with impaired performance compared to unimpaired drivers in the 5-year period following testing; again the 352 ms cut-off (80th percentile) was chosen ad-hoc. UFOV subtest 2 remained predictive of at-fault accidents even when controlling for age, sex, and milage driven. Based on these findings, some researchers have used subtest 2 alone as a short version of UFOV (e.g., Anstey, Horswill, Wood, & Hatherly, 2012; Owsley, McGwin, & Searcey, 2012; Vance et al., 2006). In a recent study Friedman, McGwin, Ball, & Owsley (2013) replicated the findings by Ball et al. (2006) in a sample of 2000 older drivers. Using a 350 ms cut-off, impaired drivers exhibited a 2.33-fold increased risk of at-fault motor vehicle crashes compared to drivers with particularly good scores (< 150 ms). Note, however that this association did not hold when the authors controlled for potentially confounding variables such as age, sex, education, and visual functions. Is this an analysis that we should add? I think we have all variables that were controlled for in this study. To summarize, the results regarding the association UFOV performance and motor vehicle crashes are mixed but suggest that subtest 2 may be of particular importance to the prediction of motor vehicle crashes. All of the studies described here administred the three-subtest version of UFOV, that is, no research on the incremental validity of subtest 4 is available.

One possible reason for the differences between subtests is the variance of performance on each. A majority of older adults obtain the lowest possible score of 16 ms on subtest 1. The normative data by Edwards et al. (2006) give a mean score of 30.66 ms, which is well below the second fastest presentation time of 33.34 ms. The small variance in subtest 1 scores is likely to limit its predictive value. For this reason, some researchers calculate the sum score excluding subtest 1 for their analyses (e.g., Ball et al., 2002). Subtest 4 is the latest addition to the protocol (Jobe et al., 2001) and reduces the right skew of the sum scores of subtests 1-3. However, Edwards et al. (2006) report a correlation of between the three- and four-subtest sum scores, suggesting that subtest 4 adds little unique variance. Thus, based on their distributional properties we hypothesized that subtest 2 and 3 contribute most to the prediction of everyday activities.

Another explanation for the varied perdictive qualities of UFOV subtests could be that each subtest is related to different psychological and visual abilities. Two recent studies have looked more closely at the individual subtests. Anstey et al. (2012) related subtest 2 to cognitive and visual factors extracted from a range of tests. They found that an executive speed factor, chracterized by high loadings of, e.g., visual search, number comparison, and a digit symbol matching task, explained a large portion of the variance in subtest 2 performance. Spatial abilities, characterized by high loadings of mental rotation tasks and Trail-Making-Test B, and working memory (e.g., Wechsler Adult Intelligence Scale-III Digit Span task, **???**) were also related to subtest 2. These three factors explained 37% of the overall variance and 85% of age related variance captured by subtest 2. Should we replicate this analysis with the SKILL data? Matas, Nettelbeck, & Burns (2014) explored the association of subtest 1-3 to visual abilities, cognitive and memory impairment assessed by the Mini Mental State Exam (M. F. Folstein, Folstein, & McHugh, 1975), inspection time, and change detection among other things. In this study, subtest 1 was related to related to change detection, visual functions, and executive functions. Subtest 2 was associated with change detection, cognitive impariment and additionally with age, and subtest 3 was related to crowding, contrast sensitivity, cognitive impairment and inspection time. Although these results may not give a complete picture they serve to illustrate that UFOV subtests relate to a wide range of visual and cognitive abilities, some of which may be more important to older adults' functional abilities than others.

Research into the incremental validity of UFOV subtests will help to identify cognitive abilities that are essential to a range of everyday activities. We are unaware of any studies investigating the association of individual UFOV subtests with TIADL or the risk of falls. To close this gap, we conducted an investigation into the incremental validity of UFOV subtests for the prediction of TIADL.

This last paragraph needs some work.

# Cognitive training based on the UFOV paradigm

This is, where I thought we could add a bit about the benefits of UFOV training leading to the argument, that omission of tasks that are unrelated to everyday activities from the training protocol could yield a more effective intervention. Of course this would have to be verified in training studies.

UFOV performance can be improved by training (e.g., Ball et al., 2002; Wolinsky, Vander Weg, Howren, Jones, & Dotson, 2013). What is more, several large scale clinical trials have demonstrated that UFOV training (also known as speed of processing training, SOPT) has a lasting positive effect on performance of TIADL and driving (Ball, Edwards, Ross, & McGwin, 2010; Edwards et al., 2005b) and effects on UFOV performance that last for up to 2 years (Ball, Edwards, & Ross, 2007; Vance et al., 2007).

Jerry, in your talk in Dortmund you had a nice overview of effect sizes. Do you think you could add these here?

Edwards, Ruva, O’Brien, Haley, & Lister (2013): TIADL improvements are largely mediated by UFOV performance (91%) and particularly by performance on subtest 2.

Furthermore, an investigation of UFOV subtests is important because new commercial versions of speed of processing training called Double Decision (formerly known as Road Tour; Posit Science Corporation, San Francisco, California) only implement variants of subtest 3 (Wolinsky et al., 2011).

To better understand the cognitive processes that benefit from UFOV training, it is important to determine the constructs measured by the UFOV test and how the four subtests contribute to this measurement. Parallel to the argument in the previous section.

# The current study

The aim of the present study was to investigate the individual contributions of UFOV subtests to the prediction of TIADL. As outlined above, a detailed investigation of the association between UFOV and TIADL will (1) help to identify cognitive abilities that are essential to everyday tasks, (2) possibly suggest a shortend or---by repeating retained tasks---a more reliable version of the testing protocol, and (3) inform the development of more targeted cognitive intervetions that focus on the most relevant tasks. We analysed two large samples from the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE, Jobe et al., 2001) and the Staying Keen In Later Life (SKILL, Edwards et al., 2005b) studies. Both studies adminstered UFOV and TIADL to large samples of older adults, and provide a good basis to test our hypothesis and perform a direct replication of our results in an independent dataset. We tested the incremental validity of each subtest in a simultaneous regression analysis predicting TIADL performance as a measure of everyday activitiesand expected subtests 1 and 4 to possess limited incremental validity. Furthermore, the wide range of neuropsychological tests used in the SKILL study enabled us to explore the contribution of UFOV subtests 1 and 4 to the measurement of visual and cognitive abilities.

# Method

## Sample

For the present study, we analyzed the data from the baseline phase SKILL and ACTIVE. Prior to all analyses, we excluded participants who exhibited cognitive decline, as indicated by Mini Mental State Examinations scores of 24 or less (M. F. Folstein et al., 1975), and participants with UFOV scores of 2000 ms, to ensure good understanding of the study protocol. Participants with corrected near vision of less than 20/80 were excluded because TIADL depend on intact near vision (Owsley et al., 2002).

### SKILL study

The SKILL study examined the relationship of cognitive, sensory and functional abilities among older adults. 1052 community-dwelling older adults from Bowling Green, Kentucky, Birmingham, Alabama, and surrounding areas were screened for inclusion (Clay et al., 2009; K. M. Wood et al., 2005); Edwards et al. (2005b) provide a detailed description of the SKILL study protocol. To participate in baseline assessment, participants were required to complete a screening visit and have a corrected visual acuity of 20/80 or better. 894 participants completed the baseline visit.

The analysed dataset consisted of 877 cases with complete data for all UFOV subtests and TIADL. After exclusion of participants with a MMSE score less than 25 (), a near visual acuity less than 20/80 (), and a maximum score of 500 ms on every UFOV subtest (), the analysed sample consisted of 836 participants. The mean age of the analyzed sample was 73.27 years (, range = 62.00, 95.92) and consisted of 89.95% Caucasians and 9.33% African Americans. 58.37% of participants were female, 92.82% completed high school, and 67.70% had college education.

### ACTIVE study

**ADD DESCRIPTION** Ball et al. (2002)

Jobe et al. (2001) provide a detailed description of the ACTIVE study protocol. Inclusion: 20/50 ... The data was retrieved from the public repository of the Inter-university Consortium for Political and Social Research (<http://www.icpsr.umich.edu/icpsrweb/ICPSR/studies/4248>).

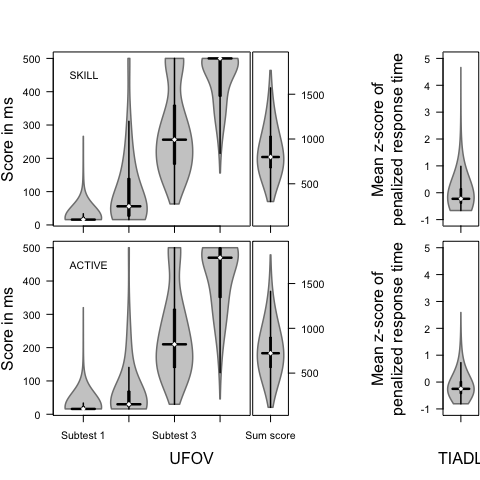
The baseline dataset consisted of 1358 cases with complete data for all UFOV subtests and TIADL. To obtain a sample comparable to the SKILL dataset, we again excluded participants with a MMSE scores of 24 or less (), a near visual acuity less than 20/80 (), and a maximum score of 500 ms on every UFOV subtest (). The analysed sample consisted of 1237 participants with mean age of 72.93 years (, range = 65.00, 93.00), 77.61% were Caucasian and 21.02% African Americans. 77.20% of participants were female, 92.32% completed high school, and 65.08% had college education.

## Measures

**PROVIDE DESCRIPTIONS OF MEASURES** From ACTIVE TIADL, UFOV and falls (?); additionally from SKILL: Letter comparison, Pattern comparison, SCS RT, WAIS-R DSS, TMT-A, TMT-B, Stroop accuracy, WMS-III Digit span, WMS-III Spatial span, WASI Matrix reasoning, WASI Vocabulary, Far acuity, Near acuity (logMAR), Contrast sensitivity

## Data analysis

Due to deviation from normality of TIADL scores (SKILL: skweness , kurtosis , ACTIVE: skweness , kurtosis , Figure ) and heteroscedasticity (SKILL: , , ACTIVE: , ; studentized Breusch-Pagan test) in ordinary least squares regression, we performed non-parametric bootstrap linear regression analyses based on 10.000 bootstrap samples and computed bias-corrected and accelerated (BCa) 95%-confidence intervals and report them in brackets. We inspected jackknife-after-bootstrap plots (Efron, 1992) and identified one influential case in the SKILL dataset (0.12% of the analysed sample) and two in the ACTIVE dataset (0.16% of the analysed sample). We report the results excluding these participant; see the electronic supplementary material for the jackknife-after-bootstrap plots and results from the analysis of the complete datasets. The data were analysed using R (3.0.1, R Core Team, 2013) and the R-package *psych* (Revelle, 2014) (**add others**). R-script for all analyses are available at ...



# Results

## Prediction of Instrumental Activities of Daily Living

### Analysis of the SKILL dataset

As Figure shows, the distribution of sum scores of all four UFOV subtests approximated a normal distribution, skweness = , kurtosis = . The distributions of individual subtest scores, however, deviated substantially from normality, skweness = - , kurtosis = - . Furthermore, inspection of the distributions revealed substantial range restriction in the scores of subtest 1 and 2, with 90.67% and 31.58% of scores falling below 32 ms; subtest 4 scores amassed at the upper boundary between 484 and 500 ms, 54.19%. Subtest 3 exhibited the least range restriction with 0% and 20.81% of scores at the lower and upper boundary, respectively.

The results of the bootstrap regression analysis are given in Table . In line with our hypotheses, UFOV subtests 1 and 4 did not contribute to the prediction of TIADL. Subtest 2, , and subtest 3 were predictive of TIADL performance, . Variance inflation factors indicated unproblematic levels of multicollinearity (all ).

### Analysis of the ACITVE dataset

The distributions of UFOV and TIADL scores in the ACTIVE study closely correspond to those in the SKILL study. The distribution of UFOV sum scores approximated a normal distribution, skweness = , kurtosis = , but again the distributions of individual subtest scores deviated from normality, skweness = - , kurtosis = - , Figure . Scores of subtest 1 and 2 were restricted in range, with 91.35% and 52.95% of scores falling below 32 ms, while subtest 4 scores amassed at the upper boundary between 484 and 500 ms, 45.76%. Subtest 3 exhibited the least range restriction with 0.08% and 14.87% of scores at the lower and upper boundary, respectively. Refere to Table for correlations of UFOV subtests, sum score and TIADL in SKILL and ACTIVE.

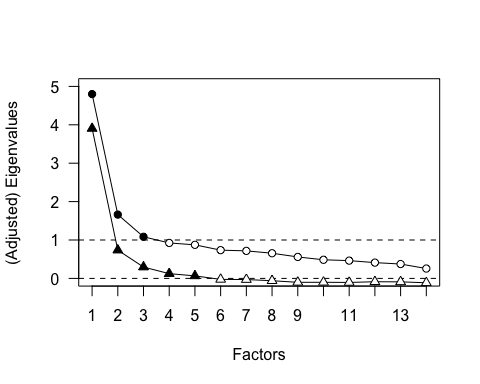
The exact replication of our previous analysis in the ACTIVE dataset again confirmed our hypotheses. UFOV subtests 1 and 4 did not contribute to the prediction of TIADL, Table . Only subtest 2, , and subtest 3, , were predictive of TIADL performance. Variance inflation factors indicated multicollinearity was no cause for concern (all ).

## UFOV constructs

(K. M. Wood et al., 2005)

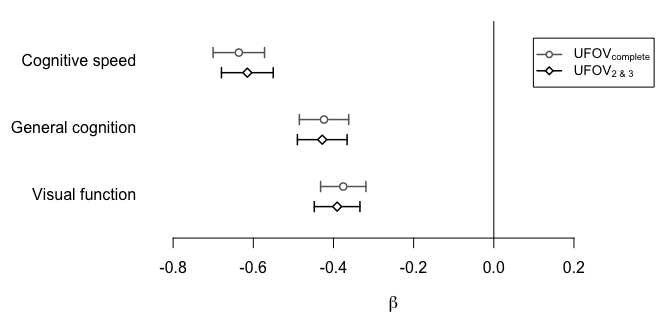
To further explore if omitting UFOV subtests 1 and 4 from the testing protocol changes the assessed constructs, we performed a factor analysis with oblimin-rotation on a subset of neuropsychological tests administred in the SKILL study, Table . We replaced missing data in eight variables with median values and reversed scores of measures where lower scores represented better performance prior to all analyses. The resulting data were suitable for factor analysis, Kaiser-Meyer-Olkin , , , .

**CHECK DESCRIPTIVES OF VARIABLES!**



We consulted several indicators of the number of factors to extract. The scree plot and the Kaiser-Guttman-criterion suggested three factors and Very Simple Structure criteria [citation needed] yielded two (complexity 1 and 2) or three factors (complexity 3). A modified parallel analysis (Glorfeld, 1995; Horn, 1965), using the 99th percentile to estimate bias, yielded five meaningful factors. As parallel analysis is partially sensitve to sample size and the fourth and fifth factor appeared to be method specific we decided to retain three factors for further analysis (see K. M. Wood et al., 2005 for a similar factor solution for the SKILL dataset, Table ). We report the results of the following analyses with a five factor solution in the electronic supplementary material.

Overall, the three extracted factors explained 43.56% of the variance in the selected subset of neuropsychological tests. Measures of processing speed, such as pattern comparison, SCS, or DSS, loaded on the first factor and largely exhibited negligible loadings on the other factors; only DSS additionally loaded on the second factor. We, thus, interpreted the first factor, which explained 20.32% of the variance, as representing cognitive speed. The second factor accounted for 13.56% of the variance and was characterized by loadings of WASI Matrix reasoning and Vocabulary, working memory tasks, and measures of executive control, such as the Stroop task and TMT-B. Because most of these tasks require little speeded cognition, we interpreted the second factor as general non-speed cognitive ability. Only accuracy in the Stroop task and TMT-B also loaded on the first factor reflecting the speed components in these tasks. The third factor explained 9.67% of the variance in the analysed measures and clearly represented basic visual functions: It was only correlated with near and far visual acuity and contrast sensitivity.



We used factor scores of of all three factors, derived using the regression method, to predict the sum score of UFOV subtests 1-4 and the shortend UFOV protocol consisting of subtests 2 and 3, Figure . UFOV performance was related to all three extracted factors. Cognitive speed was the strongest predictor of the UFOV sum score, , , ; general non-speeded cognition, , , , and basic visual functions, , , , also predicted UFOV performance, albeit the association was weaker. Overall, the three factors explained 36.52% of variance in UFOV performance, , . Variance inflation factors indicated that the correlation between the three factors was unproblematic (all ). As apparent from Figure , omission of subtests 1 and 4 did not affect the association of UFOV to the three factors. Cognitive speed still was most strongly associated with UFOV subtests 2 and 3, , , ; general non-speeded cognition, , , , and basic visual functions, , , exhibited a weaker association. The three factors explained 35.75% of variance in UFOV performance, , (all ). Note the close correspondance of all estimates.

An efficient test administration is important in applied settings, such as the Department of Motor Vehicles (Ball et al., 2006). The 15-minute duration of UFOV makes it an interesting candidate for standard driving assessment. From an applied perspective, the investigation of each subtests' predictive value may yield an even shorter version of the testing protocol. The time saved could be used to administer subtests repeatedly to improve the reliability of test scores or to adminster additional measures.

**SPEARMAN-BROWN-PROPHECY**

## Age-related variance

## [1] 0.4116

## [1] 0.4085

## Analysis of Variance Table  
##   
## Model 1: scale(ufov\_total) ~ scale(Factor1) + scale(Factor2) + scale(Factor3)  
## Model 2: scale(ufov\_total) ~ scale(Factor1) + scale(Factor2) + scale(Factor3) +   
## scale(age)  
## Res.Df RSS Df Sum of Sq F Pr(>F)   
## 1 776 447   
## 2 775 414 1 32.6 61 1.8e-14 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

The results were virtually identical for the shortend version of the UFOV protocol (s. ESM).

# Discussion

The discussion is still a collection of notes rather than a real draft. Sorry about that.

Normative data of UFOV suggest that performance on subtests 1 and 4 may contribute little unique variance to UFOV sum scores (Edwards et al., 2006) and previous studies have identified subtests 2 and 3 as having the strongest relation to other measures of processing speed (Edwards et al., 2006; Lunsman et al., 2008). To test the association of each subtest with TIADL, we analysed two large samples from the SKILL (Edwards et al., 2005b) and ACTIVE (Jobe et al., 2001) studies. Our results support the aprior proposed hypotheses: UFOV subtests 1 and 4 posses little or no incremental validity in the prediction of TIADL. Further exploratory analyses suggest that ommission of subtests 1 and 4 does not change the psychological constructs assessed by UFOV. Previous studies have found that subtest 2 is of particular importance to the prediction of at-fault motor vehicle crashes in older adults (Owsley et al., 1998). We demonstrated that these findings don't generalize to the prediction of other everyday activities; both subtests 2 and 3 are independently associated with TIADL performance. Taken together with previous investigations of at-fault traffic accident prediction, our findings suggest that it may be feasible to omit subtests 1 and 4 from the testing protocol.

We want to emphasize, that more work on the incremental validity of UFOV subtests for the predicition of at-fault accidents is neccesary. Furthermore, our analyses provide only week evidence regarding the effects of shortening the testing protocol on the prediction of other everyday activities in older adults, such as driving and falls. Finally, we excluded participants with severe cognitive decline from our analyses to ensure proper understanding of the UFOV protocol and all other neuropsychological tests. Thus, our findings cannot be assumed to generalize to other populations, such as older adults suffering from MCI, Alzheimer's disease or HIV [citations needed].

"Visual acuity and contrast sensitivity, the vision tests included in the present study, have typically been reported to have small or no correlation with crash outcomes or driving performance (Wood, 2002; Anstey et al., 2005; Rubin et al., 2007; Owsley and McGwin, 2010)." (Matas et al., 2014)

## Relevant abilities that benefit from training

Our findings are also relevant to the investigation of cognitive interventions for older adults.

* UFOV training effects unlike many other trainings generalizes to everyday activities
* which "basic" abilities improve through UFOV training?

A recent analysis of the training gains in the SKILL study found that performance improvements in subtest 2 fully mediate training effects on TIADL (Edwards et al., 2013).

According to their analyses, subtest 1 is related to visual acuity and contrast sensitivity, subtest 2 is related to change detection and processing speed, and subtest 3 is related to crowding and contrast sensitivity but also processing speed (Matas et al., 2014). -> It's not visual acuity, which has been established before (e.g., Ball et al., 1993)

Maybe discuss relation of UFOV to DSS and the findings by Lynn Hasher (consulting editor of psych and aging) that DSS measures selective attention etc.

More effective training by focusing on tasks 2 and 3

## Conclusions

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