UFOV®

UFOV® User's Guide®
Version 6.1.4

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Customer Support/Software Technical Assistance

Please have the following information available before calling Technical Assistance:
A description of the problem, what you were doing when it occurred, and the exact wording of any messages you may have received.

Software/Hardware Technical Assistance-859-523-8007
Or email Dan Roenker at droenker@visualawareness.com

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I. Introduction

Brief Description of UFOV®

This manual describes the development, operation, and utility of the Useful Field of View (UFOV®) test. It is a computer-administered and computer-scored test of functional vision and visual attention, which can be predictive of ability to perform many everyday activities, such as driving a vehicle. The test can be administered in about 15 minutes and is recommended for use as a screening measure in conjunction with a clinical examination of cognitive functioning or fitness to drive. It is recommended for people who are age 55 years old or older, who have suffered health problems that can cause deficits in thinking abilities (e.g., stroke, Alzheimer's Disease, head injury), who are concerned about their driving ability, and who have had multiple vehicle crashes.

UFOV® consists of three subtests, or parts, which assess speed of visual processing under increasingly complex task demands. Using both eyes, the examinee must detect, identify, and localize briefly presented targets. In the first subtest, the examinee identifies a target presented in a centrally located fixation box that is presented for varying lengths of time. In the second subtest, the examinee identifies a target, but must also localize a simultaneously presented target displayed on in the periphery of the computer monitor. The third subtest is identical to the second, except that the target displayed on in the periphery is embedded in distractors, making the examinee's task more difficult.

An interpretive report provides scores for each part of UFOV® and assigns the examinee to one of five levels, or categories, of risk.

II. Recommended Users

UFOV® may be used to estimate risk by helping users predict the degree to which an examinee may perform everyday activities safely, such as driving a motor vehicle. UFOV® should be viewed as one source of information that may aid in forming opinions about an examinee's ability to drive safely. Information other than UFOV®, such as driving habits, driving record, medical conditions, and other relevant factors, should always be taken into account before determining an individual's ability to drive safely.

Health Care Professionals.

UFOV® may be used to aid in making professional judgments about individuals' fitness to drive. UFOV® may also be used as part of a battery of cognitive tests for purposes of assessing cognitive functioning.

Employers.
UFOV® may be used to assess potential or current employees□ driving skills. UFOV® is also sensitive to temporary conditions, such as medication side effects, and may assist employers in determining □fitness to drive.

Departments of Motor Vehicles.
UFOV® may serve as a measure for screening applicants for driver's licenses.

Insurers.
UFOV® may aid in measuring and managing risk.

III. Getting Started

Note: The Windows version of the software is both touch and mouse compatible. For many applications (e.g., older adults) a touch screen is recommended. Only a limited set of touch monitors is compatible with the software. For more information on touch monitors contact VAI. In the instructions that follow it is assumed that touch monitor is being used. If mouse input is being used, then when the instructions refer to touching a place on the screen, move the mouse cursor to that location and click the left mouse button.

Accessing the Software: The installation of the software should automatically produce a shortcut icon on the desktop. To access the software simply click the UFOV® icon. If no icon is present, the software may be found in the UFOV® menu in the Program Files menu. It is important that all other applications be terminated prior to starting the UFOV® software. The UFOV®software must carefully control the length of time that an image is available on the monitor. The presence of other applications, even if minimized, will interfere with this process and produce excessive timing errors. For more information on timing errors, see the section label Timing Errors.

When the icon is activated the software will first determine and report the refresh rate of the monitor. If possible the software will attempt to set the refresh rate of the monitor to 60 HZ. All measurements are made in terms of the refresh rate of the monitor and thus this step is critical for the correct functioning of the software. If the software is unable to set the refresh rate to 60 HZ, it will determine and set the refresh rate to a value closest to 60 HZ . The results of this operation are reported on the screen. Touch the continue button to proceed. The main or home UFOV®screen should then appear. All functions of the software are accessed through the pull down menus at the top of the screen. The first step in using the software is to identify a CLIENT.

Entering a Client's Identification Information: From the Client Info menu, select either the Browse Clients or New Client options. If the Browse Client option is selected an alphabetized list of previous Clients is provided (the number in parentheses behind their name is their Client ID number). Highlight the appropriate name and double click with the left mouse button. If a new client is being tested select the New Client option. A window will appear requesting information about that client. It is necessary to fill in all fields. The birth date information must be in the form MM/DD/YYYY. Once the relevant information has been entered, click the Save button. Once this process has been completed, the software returns to the home screen.

The two most common uses for the UFOV® software are for assessment of attentional loss (i.e., screening) and the improvement of the participant's attentional skills (i.e., training).

Screening: In order to access the screening software, select the Screening option from the Tool Bar. The Screening menu has four options. As described earlier, the UFOV® measure consists of three sub-tests of increasing difficulty and the software permits the user to select any of the sub-tests singly or the combination of all three sub-tests. **Selecting the 1-3 option (first choice on the menu list) leads to the standard screening software and should be the most frequently used option**. The option to test each sub test separately is provided in the event that a screening is interrupted. It is possible to complete the screening at a later date without necessarily administering all previous subtests. Such a situation should be avoided if possible. For detailed instructions for administering the screening protocol see the test Administration section below.

Training: Select the Training option from the Main Menu. See the training manual for information about training options and techniques. If you have purchased only the Screening software this menu will not be available.

IV. Administering UFOV®

Prior to seating the examinee, the examiner should enter the examinee's name, date of birth, and ID number.

To begin, the examiner should say: "There will be three parts to this evaluation. Each part will be a few minutes long. For each part of the test, I will show you what you will need to watch for, and how to respond. Then I will let you practice a few times to familiarize yourself with what you need to do. In each of the three parts of the test, you will be shown some things on the screen. The length of time in which they are shown on the screen will get shorter and shorter. The computer will measure the point at which you are unable to see accurately the information presented on the screen. Everyone has a point where the test becomes impossible. Therefore, do not become alarmed if you cannot see or recognize everything that is presented on the screen."

Subtest 1: Processing Speed

To begin, a stationary display, with a white box containing an icon of a car, is presented on the screen. This is the foveal or central vision target, and is presented with the instructions "This is an example of our car. Look carefully at this object." After the examinee has examined the target and read the instructions, touch the 'Continue' button. A tone indicates that the computer registered the touch.

A second screen appears and asks the examinee to select the central target (in this case the car) presented in the previous screen. "After each presentation you will be asked the following question, 'Which object was inside the white box?'" Touch the button showing the icon of the car.

A third screen introduces the truck icon. As with the car, it is presented as the central vision target along with the instructions, “This is an example of our truck. Look carefully at this object.” After the examinee has examined the target and read the instructions, touch the ‘Continue’ button.

As before, a fourth screen asks the examinee to select the central target (in this case the truck) presented in the previous screen. “After each presentation you will be asked the following question, ‘Which object was inside the white box?’” Touch the button showing the icon of the truck.

Throughout UFOV®, allow the examinee to take his or her time in responding. UFOV® is not a reaction time test; in other words, it does not matter how quickly the examinee answers the questions, and reaction time (the speed with which the examinee responds to a question or selects an answer) is not measured. Rather, it is the accuracy of his or her responses that counts. At the same time, however, extensive delays in responding may lead to forgetting of the target or nature of the task.

Following these four stationary introductory screens, a series of four practice trials are presented. It may be necessary to assist or prompt some examinees during the practice trials. Although the practice trials are presented at a relatively slow presentation speed (i.e., the car or truck remains on the screen for a relatively long period of time), some examinees may experience difficulty. Guessing is permitted without penalty. Throughout UFOV®, the software provides no feedback about the correctness of a response. Prior research (Ball et al., 1993) has shown that feedback during testing is counterproductive for most examinees. The examiner may provide feedback about whether a response was correct or incorrect during practice trials, but never during scored testing. However, the examiner should provide encouragement as necessary at any time.

After the four practice trials, UFOV® prompts the Client to begin the test. In prior versions of the software an option was provided at this point to allow clients more practice before beginning the actual test. Since this option was rarely used, it was dropped from the current software. In the event that the client does not understand the task after the four practice trials, continue with the screening anyway since the client may grasp the task during the actually assessment. The software self adjusts to find the correct threshold for the individual. If the client “figures out” the task during the assessment phase, this will merely add a few moments to the test duration. If after completing task 1 it is clear that the client does not understand the task, exit the software by pressing the “esc” key. From the main menu screen select Screening. Select task 1. This will permit you to select either the two demonstration trials, four additional practice trials, or the test. In order to run a client under this protocol, the three steps (demonstration, practice, and test) of the protocol for each task must be selected individually. The normally screening protocol takes care of these chores automatically and does not require selection of each of the three steps for each of the tasks.

Practice should continue until the examinee scores 3 out of 4 correct on a single set of practice trials, or the amount of available practice (16 trials) is exhausted. If the examinee completes all 16 practice trials, but still feels unready to continue or has not reached 3 out of 4 correct, Subtest 1 should begin anyway. Failure to adequately perform the Subtest after 16 practice trials indicates that the examinee's threshold is above the practice level and will be measured by UFOV®.

For each of the three subtests, UFOV® will automatically adjust the length of stimulus presentation in milliseconds as needed. After two correct responses, stimulus presentation time for the next item will be shortened, whereas stimulus presentation time for the next item will be lengthened if the a response was is incorrect. This process of tracking the perceptual threshold is continued until a stable estimate of 75% correct is calculated. This period may be as short as 14 presentations or much longer. The length of time necessary to obtain the stable measure will depend upon the consistency of the examinee's responses.

Subtest 2: Divided Attention
In Subtest 2, the examinee is asked to identify the centrally presented object and locate a simultaneously presented car displayed in the periphery. Note that unlike the object target presented in the center of the screen, which may be either a car or truck, the target presented on the periphery is always a car, never a truck. The examinee should be so informed, and reminded if necessary. It should also be emphasized, however, that the examinee will not be likely to be able to identify the peripheral target, but need only remember where it was located.

Similar to Subtest 1, a series of introductory screens are presented. The central target (car or truck) is shown within a white box, and the car is shown by itself in the periphery. "This is an example of our car. Look carefully at this object. Notice the object outside the box." After clicking the 'Continue' button, the next screen questions the examinee about which object appeared in the white box. After clicking a response, the following screen asks the examinee about the location of the peripheral car. "On which spoke was the outside object located?" A central box, along with a series of 8 boxes attached with radial spokes and numbered 1-8 in a clockwise direction, is shown. "Indicate your answer by pressing the button that corresponds to the direction of the target." A similar series is presented with the truck icon appearing in the center box. A tone indicates that the computer registered the examinee's touch.

For most examinees, once Subtest 2 begins, the presentation time for the items becomes so brief that they cannot identify the target presented on in the periphery. The examiner should emphasize, as necessary, that the icon presented on in the periphery is always a car, and that he or she need only identify its location.

Some examinees may be reluctant to guess when unsure of the correct answer. This may be especially true for determining the location of the car presented in the periphery. Examinees should be encouraged to guess, as the test will not move forward until a response is made. Examinees are frequently correct even though they are unsure of the correct response and argue that they did not see the target.

Once the scored items begin, presentation time varies depending on the accuracy of the examinee’s responses, and the subtest will continue until a stable measure of the threshold is determined. As before, the 75% correct threshold for correct performance (for both tasks) is calculated. The administration time necessary to reach this threshold will depend upon the consistency of the examinee's performance.

Subtest 3: Selective Attention

The third part of UFOV® is identical to Subtest 2, except that the car displayed in the periphery is embedded in a field of 47 triangles or distractors. All other procedures and conditions remain the same.

Results and Reports

After the third task, or if the test is aborted by the examiner, or if UFOV® automatically concludes the test because the examinee displayed extreme difficulty performing Subtests 1 or 2, a results screen containing demographic information and test results will appear. Next, a screen thanking the participant appears. Four reports are generated at the end of testing with each report appearing as a minimized option on the lower tool bar. For each of the three subtests that comprise the UFOV® measure a separate report containing information about the client’s performance is generated. A table of “reversal values” is generated and is provided for individuals who use the UFOV® measure for research purposes. This table indicates the method of determining the threshold for that individual. These reports also list the overall threshold value for that subtest of the UFOV® measure. The fourth report that is generated is a risk report. Based upon the performance of the participant on all three subtests a crash risk is determined and provide in this summary report. Individuals who use the UFOV® measure in a clinical setting will find this fourth report most useful.

At the end of each screening the software returns to the Main Menu screen. Caution: If a second screening is administered, it is necessary to select a new Client from the Client Info Menu. If a new Client is not selected, subsequent screening data will be stored under the current client’s name.

Aborting UFOV®

The examiner may choose to abort or end the test at any point during administration. To do so, press the ‘esc’ key on the keyboard. Note that the “esc” key may have to be pressed multiple times, if the software is in the middle of one of the subtests. Records are saved to the data file, and may be printed.

Optimal Testing Conditions

The examinee will be viewing displays that are presented very rapidly. It is crucial that the viewing conditions be as ideal as possible. The recommended viewing distance is 18-24 inches.

Experience has shown that some examinees are reluctant to sit close to the monitor and tend to back away from the screen. Monitor the examinee′s viewing distance during testing and correct at each stopping point, if necessary.

The testing room should be dark. If lighting is necessary, ensure that glare on the screen is minimized. Test results may be skewed if glare interferes with the screen.

The room should be as quiet as possible. Ensure that any extraneous and/or background noise is minimized. The examiner should avoid speaking to the examinee during the test, as this will distract many examinees. Remember that although background noise will not affect the test results of all individuals, it will have the most negative effect on those individuals already having difficulty with the test.

Test Examiner Demeanor

To make testing as pleasant as possible for both examiner and examinee, follow these simple guidelines:

First, make sure the examinee is seated comfortably.

Second, the examinee must be informed of the purpose of the test; this is often termed “informed consent.” It is not fair or ethical to test an examinee without informing him or her of the purpose of the exam. For example, if the test is used as part of a determination of driving risk or ability to drive, the examinee should be so informed. Any refusal to begin or finish UFOV® must be honored, and the examinee should never feel coerced. The examinee should be encouraged to complete UFOV® in its entirety, but should be informed prior to starting the test that he or has the right to choose to discontinue participation at any point during testing. Professionals, such as health care professionals, must follow codes of ethical conduct mandated by the professional organizations to which they belong. However, all examiners are strongly recommended to provide thorough informed consent to all examinees.

Third, inform the examinee that the test will take about 15 minutes to complete.

Fourth, make sure that the examinee understands all instructions. Instructions may be repeated during testing, as necessary. Use of the “Commonly Asked Questions” card may be of help.

If the Examinee Asks about Wearing Glasses

Suggest glasses be worn if the examinee typically wears glasses for viewing information at similar distances. If the glasses are very dirty or smudged, suggest they be cleaned before starting the test. Fortunately, UFOV® results are not seriously affected by even a substantial degree of blurred vision. If the examinee chooses not to wear glasses or expresses concern about the degree to which test results might be impacted by blurring, inform him or her that the computer will first determine whether he or she can see well enough to take all portions of the test and, if not, will automatically conclude the test after the first part is finished. In such a case, an eye exam will be recommended.

If the Examinee becomes Frustrated

UFOV® is challenging and some examinees may become frustrated with their performances and wish to discontinue the test. Reassure the examinee as needed and praise effort made thus far.

You may remind him or her of the opening instructions (e.g., sometimes the information presented on the screen is shown for very short periods of time, and most people reach a point where they cannot identify it). Also, you may tell the examinee that one can make errors and yet do well on the test, and that it is difficult for examinees to estimate how well they're doing during the test. He or she may be doing better than presently believed.

If the Examinee is Reluctant to Guess
Many examinees may be reluctant to respond when not absolutely sure of a correct answer. Encourage a best guess.

If the Examinee wants to "Back Away" from the screen
Many older adults may wish to consciously or unconsciously increase the viewing distance, or move away from the screen, in an attempt to make the targets presented on in the periphery appear within their field of central vision. This defeats the purpose of Subtests 2 and 3. Try to discourage backing away, and many examiners find saying something like the following to be of help: "The rules of the test require that you sit close to the screen, like this." Demonstrate or ask the examinee to move or lean forward to reach the correct distance (e.g., 24 inches).

V. The Concept of Useful Field of View

There is consensus among scientists and clinicians from diverse disciplines that the speed with which we process information slows with age. For example, older adults have been found to require longer delays between two visual events in order to discriminate that two events, as opposed to one, occurred. This type of processing speed loss has been demonstrated in many studies using different types of stimuli and different experimental designs (Botwinick, 1984; Salthouse, 1985; Welford, 1977). Similarly, many cognitive tests are normed by age to adjust for differences in speed of processing.

Slowing may result because nervous systems in older people recover more slowly from the effects of stimulation, and because neural transmission speeds decline. Slowing is believed to be one of the primary reasons cognitive functioning may worsen with advancing age, and why age-related declines tend to be more prominent in complex activities. When compared to younger people, older individuals tend also to be more disadvantaged by multiple perceptual demands or distractions. The speed with which we perform everyday activities may vary depending on the number of things or people competing for one's attention, as well as the amount of distraction that is present. These well-documented age-related changes in cognitive function are evaluated by UFOV®.

Survey results from several studies (Kosnik, Winslow, Kline, Rasinski & Sekuler, 1988) suggest that the difficulty reported by older adults with everyday tasks associated with visual search, peripheral vision, and cluttered visual scenes, is about five times greater than that reported by younger adults. This difficulty has been described as a reduction in the size of the perceptual "window", causing some older adults, as well as some cognitively impaired adults regardless of age, to take smaller samples of a visual scene and to scan each sample more slowly (Cerella, 1985; Scialfa, Kline & Lyman, 1987; Ball et al., 1988; Ball, Roenker & Bruni, 1990). Further, age-related increases in latency of ocular movements are common (Carter, Obler, Woodward & Albert, 1983).

As a result, the portion of the field of view that is available (i.e., of use) to an individual is constricted. Even with unlimited viewing time, people with a reduced field of view may be forced to perform more eye fixations in order to scan the same visual area. The net effect, even when eye and head movements are not precluded, is poorer performance on visual search tasks and other visually oriented behaviors for those individuals, young and old, with a reduced useful field of view. For these people, visual information must be more salient or conspicuous, presented for a longer period of time, or presented in isolation for it to trigger an orientation to that particular location in space. They are at a disadvantage in everyday situations involving visual search, especially where quick reactions are important for safety, as in driving.

Early work on UFOV® indicated that, in general, the size of the useful field of view appears to shrink with age (Sekuler & Ball, 1986; Ball et al., 1988; Ball, Roenker & Bruni, 1990). Nonetheless, there is tremendous variability between people, and many older adults function at a level equivalent to that of college students. Therefore, although the prevalence of individuals with significant impairment increases with age, not all older individuals are affected. A number of studies were conducted to better understand the basis for reductions in useful field of view. Multiple factors were discovered and are reviewed briefly below.

It is important to recognize that UFOV® does not measure visual field sensitivity. Results should not be interpreted in terms of percentage of visual field loss as is traditionally evaluated by automated perimeters. Although an individual may suffer visual field loss, and this loss may impact test results, a reduction in the useful field of view can also be due to impairments in attention without the presence of visual field pathology.

VI. Studies Linking Useful Field of View to Everyday Competence

An analysis by the Transportation Research Board (1988) of skills necessary for driving a motor vehicle has produced four components. First, visual stimuli must be sampled and registered at the sensory level. For a given driver, if available stimuli are not salient enough to be visible or more samples are required to process the same scene, that driver would be at a perceptual disadvantage. Second, once registered, stimuli must be recognized or identified and localized. Difficulties at this stage will delay the driver’s reaction to any potential hazards. Third, once recognized and localized, the driver must decide what action to take. Fourth, the driver must execute a motor response to carry out the decision.

Recent work with the concept of useful field of view has indicated a conceptual link between UFOV® and some of the components of the driving task. For example, for some people, a reduction in the size of the useful field of view appears due to a slower sampling rate and/or shrinkage in the amount of information sampled from a visual scene. Thus, some older adults require more time to “see” information, as well as take smaller samples (i.e., visual information toward the periphery is less often or less fully seen) of the information available for them to see, than do younger adults (Ball, Roenker & Bruni, 1990; Scialfa, Kline & Lyman, 1987). UFOV® assesses sampling rate and shrinkage in amount of information sampled by varying stimulus duration depending on accuracy of responses, and determining a threshold duration whereby responses are correct 75% of the time.

Drivers must also identify or recognize, as well as localize, visual information. They must identify what is there and locate the positions of obstacles while concurrently monitoring other visual events in the scene. Many older adults can localize peripheral targets as well as young adults when no distracters are present and there are no central task demands [Ball, Owsley & Beard, 1990; Owsley, Ball, & Keeton, 1995]. In complex displays with divided attention requirements, however, a large proportion of older adults display a reduction in their useful field of view, in that they experience difficulty identifying and localizing information [Ball et al., 1993]. UFOV® taps this ability by requiring observers to localize a peripheral target embedded in a complex display while concurrently attending to and identifying a central target.

Thus, at a conceptual level, an analysis of UFOV® performance appears relevant for an understanding of the age-related difficulties underlying driving performance. The following preliminary studies represent an empirical investigation of this logical connection.

Despite having good visual field sensitivity, many older adults have serious difficulty locating objects of interest in the environment.
Older adults commonly report problems with visual search tasks and experience a higher incidence of mobility problems (e.g., falls and vehicle crashes) involving visual skills [Kosnik, Winslow, Kline, Rasinski & Sekuler, 1988; Ball et al., 1988; Sims, Owsley, Allman, Ball & Smoot, in press]. To evaluate whether target localization problems in older adults can be adequately explained by impairments in peripheral visual sensitivity, or whether deficits in higher order visual processing also contribute, 59 adults (ages 59-88) who exhibited varying degrees of visual field loss (none to severe) were tested with UFOV®. Participants were asked to localize briefly-presented, high contrast targets in the center 60 degrees (diameter) of the visual field, while simultaneously performing a visual discrimination task at fixation. Visual sensitivity accounted for only 36% of the variance in localization performance across subjects, and this relationship grew weaker (13%) when the target was embedded in distracting stimuli, suggesting that impaired attentional skills also underlie older adults' localization problems. Not surprisingly, older adults with severe visual field loss were also poor at localizing targets. However, about half of those older people with normal or near-normal visual fields also had severe useful field of view reductions. This study illustrates that clinical tests for identifying visual performance problems in the elderly should embody stimulus and task features that better reflect the visual demands of everyday life. (Owsley, Ball, & Keeton, 1995)

Policies that restrict driving privileges, based solely on age or on common stereotypes of age-related declines in vision and cognition, are scientifically unfounded.
With development of a visual attention measure highly predictive of crash problems in the

elderly, there may be a way in which suitability of licensure in older adult populations could be based on objective, performance-based criteria. Several aspects of vision and visual information processing were assessed in 294 drivers aged 55 to 90 years. The sample was stratified with respect to age and crash frequency during the 5-year period before the test date. Variables assessed included eye health status, visual sensory function, UFOV® outcome, and cognitive status. Crash data were obtained from state records. UFOV® displayed high sensitivity (89%) and specificity (81%) for predicting which older drivers had a history of crash problems. This level of predictability is unprecedented in research on crash risk in older drivers (Ball, Owsley, Sloane, Roenker, & Bruni, 1993; Ball & Owsley, 1993; Owsley & Ball, 1993; Ball & Rebok, 1994). Older adults with substantial shrinkage in the useful field of view were six times more likely to have incurred one or more crashes in the previous 5-year period. Eye health status, visual sensory function, cognitive status, and chronological age were significantly correlated with crashes, but were relatively poor at discriminating between crash-involved versus crash-free drivers (Ball, Owsley, Sloane, Roenker, & Bruni, 1993; Ball & Owsley, 1993; Owsley & Ball, 1993; Ball & Rebok, 1994).

Functional measures, such as a comprehensive test of visual processing, a falls history, and a review of current medications, are of greater relevance than specific medical conditions in the identification of older at-risk drivers.
A case-control study was conducted to examine associations between medical and functional variables and at-fault car crashes in a cohort of older drivers. Participants consisted of older drivers (ages 55-90 years) from a randomly selected age and crash-stratified cohort who resided in Jefferson County, Alabama. Cases were drivers who had at least one at-fault crash in the prior six years, whereas controls were drivers who had no such crashes during the same time period. Variables included self-reported medical conditions, reported and observed functional measures, and urinary drug screens. The occurrence of one or more at-fault car crashes in the six years prior to the 1991 assessment date represented the outcome measure. Ninety-eight older drivers experienced between one and seven at-fault vehicle crashes during the period 1985 through 1991, and 76 drivers did not. Logistic regression models indicated that the following variables were independently associated with crash involvement: A 40% or more reduction in the useful field of view (Odds Ration (OR) =6.1; 95% CI, 2.9 to 12.7: $p<0.001$); African-American ethnicity (OR=6.6; 95% CI, 1.7 to 26.2; $p=0.0007$); a history of falling in the prior 2 years (OR=2.6; CI, 1.1 to 6.1; $p=0.025$) and not taking a beta-blocking drug (OR=4.3; CI, 1.2 to 15.0; $p=0.023$). A dose-response relationship was evident between the number of falls and the number of at-fault crashes (Sims, Owsley, Allman, Ball, & Smoot, in press).

Impaired visual processing and glaucoma may have a role in the etiology of older driver crashes that result in injury.
The objective of this case-control study was to identify visual risk factors for vehicle crashes by elderly drivers that result in injury. Cases (N=78) were defined as those drivers between the ages of 55 and 87 years who had incurred at least one vehicle crash between 1985 and 1990 resulting in an injury to anyone in the involved vehicles, according to the accident reports. Controls (N=115), also selected from ADPS public safety files, were older drivers not involved in crashes during the same five year period. Participants underwent a battery of visual processing tests and a

comprehensive eye examination. Results suggested that UFOV and glaucoma were the only significant independent predictors of injurious crash involvement. Odds ratios (ORs) for reductions in the useful field of view of 23-40%, 41-60% and >60% were 4.2 (95% confidence interval [CI], 1.5-11.8), 13.6 (95% CI, 5.8-39.7), and 17.2 (95% CI, 5.3-55.6), respectively, compared to baseline reductions of less than 23% (p for trend <.001.) The OR for glaucoma was 3.6 (95% CI, 1.0-12.6) (Owsley, McGwin, & Ball, in press).

High fidelity driving simulation provides a unique new source of performance parameters to standardize assessment of driver fitness.
Detailed observations of crashes and other safety errors provide unbiased evidence to aid in the difficult clinical decision of whether older or medically impaired people should continue to drive. The effect of Alzheimer's Disease (AD) on driver collision avoidance was examined using the Iowa Driving Simulator, which provided a high fidelity, closely controlled environment in which to observe serious errors by at risk drivers. Visual and cognitive variables known to be negatively impacted by aging and AD served as predictors of unsafe events. Thirty-nine licensed drivers were evaluated: 21 with AD and 18 controls without dementia. Number of crashes and related performance errors were assessed. During simulations, 6 participants (29%) with AD experienced crashes vs. none of the 18 controls (p=.022). Drivers with AD were also more than twice as likely to experience close calls (p=.042). Plots of critical control factors in the moments preceding a crash revealed patterns of driver inattention and error. Strong predictors of crashes included visuospatial impairment, reduction in UFOV, and reduced perception of 3 dimensional structure from motion (Rizzo, McGehee, Petersen, & Dingus, in press; Rizzo, Reinach, & McGehee, 1997; Rizzo, Reinach, McGehee, & Dawson, 1997).

Many stroke survivors may be making decisions about their driving capabilities in the absence of professional advice and evaluation.
Little is known about the extent to which stroke survivors return to driving and the advice and/or evaluations they receive about driving. The aim of this study was to estimate the prevalence of driving after stroke, as well as the advice and evaluations that survivors receive about driving. A convenience sample of 290 stroke survivors was surveyed regarding driving status following stroke, driving exposure, advice received about driving, and evaluation of driving performance. Thirty percent of stroke survivors who actively drove before stroke resumed driving following stroke. Forty-eight percent reported that they did not receive advice about driving and 87% reported that they did not receive any type of driving evaluation. Almost one-third of post-stroke drivers had high exposure, driving 6-7 days per week and/or 100-200 miles per week. (Fisk, Owsley, & Pulley, in press)

Limiting driving exposure may not be enough.
A cohort of 257 older drivers participated in assessments of visual sensory function, eye health, and cognitive function; completed a structured questionnaire on driving exposure and how frequently they avoided challenging driving situations; and took UFOV®. Older drivers with objectively determined visual and/or cognitive impairments reported more avoidance than drivers free of impairments. Drivers with the most impairment reported avoiding more types of situations than less impaired or non-impaired drivers. However, this avoidance behavior is not

fully adequate for prevention of accidents, as drivers with a history of at-fault crashes in the prior five years reported more avoidance than drivers who had crash-free records (Ball, Owsley, Stalvey, et al., in press).

A structured behavioral intervention was effective in reducing hazardous driving maneuvers on the road, as well as reducing stopping time in a driving simulator.
Participants included 456 older adults (ages 48 to 94) who were grouped as either "high risk" (UFOV® > 30) or "low risk" (UFOV® < 30) for crash involvement. From the initial sample, 27 "low risk" participants were randomly selected for a control group, 26 "high risk" individuals were assigned to driving simulator training, and 51 "high risk" individuals were assigned to visual attention training with UFOV®. Simple and choice reaction times, as well as on-road driving evaluation, served as outcome measures. Results to date suggest that UFOV® training translates into significant improvement in at least one area of driving performance (i.e., hazardous maneuvers in which the driving evaluator had to take control of the vehicle were reduced by half). Training also resulted in a reduction in stopping distance to hazardous stimuli by 22 ft in a driving simulator. Data have subsequently been collected and analyzed to identify the long-term effects of training. The training results observed immediately following training persisted after 18 months, although in somewhat weakened form, for both the reduction in hazardous driving maneuvers, as well as reduction in stopping distance. In addition, although the amount of driving of the control groups significantly decreased over the subsequent 18 months following the post-training evaluation, the amount of driving of the trained group increased. Since reduced mobility is a potent predictor of loss of independence, these results indicate that the benefits of a behavioral intervention can be multi-faceted (Ball, 1997; Roenker, Cissell, & Ball, 2003).

VII. Technical Properties

Comparability Between Hardware Formats
UFOV® was first developed for a touch screen format, and was later converted to a PC mouse-based format. A study was conducted to assess the comparability of the two versions, and the appropriate scale for the PC versions so that scaling would be equivalent to the original version.

Three versions of the test were counterbalanced in order of administration: A 20 inch touch screen monitor, a smaller touch screen monitor, and a smaller screen with mouse. The two smaller screen versions, each PC based, also followed a brief screening protocol. In the large monitor version, Subtests 2 and 3 held stimulus duration constant throughout a block of trials, and stimulus eccentricity was varied 10, 20 or 30 degrees in order to calculate the useful field of view (degrees of visual angle) at a particular speed of presentation. In the PC versions the eccentricity of the stimuli was held constant and a threshold stimulus duration, or the point at which the examinee was correct at localizing the target presented on the periphery 75% of the time, was calculated.

Participants were aged 65 years or older, with no prior experience with UFOV®. All three versions were administered during a single visit.

Previous studies [Ball et al., 1993] had identified several cutpoints for maximizing sensitivity and specificity of UFOV® for crash risk. A 40% or greater reduction in size of the useful field of view (relative to a 30 degree radius) yielded the best single cutpoint for separating high risk from low risk drivers. In the PC versions, using stimulus duration as the outcome, threshold durations greater than 100 msec. on Subtest 2 and greater than 350 msec. on Subtest 3 resulted in sensitivity of .91 and specificity of .91. Thus, of the people who passed the original version, 91% passed the PC versions using either a touch screen or mouse. Of the people who failed the original version, 91% also failed the PC versions.

The following table illustrates a comparison of the three versions of UFOV□.

Original UFOV® (% Reduction)	New PC UFOV® (Speed in msec)	Injurious Crashes Odds Ratio (95% CI)	Non-Injurious crashes Odds Ratio (95% CI)
< 22.5	< 100 Task 2 and < 350 Task 3	1.0 (Referent)	1.0 (Referent)
23.0 - 39.5	Task 2 >= 100 or, Task 3 >= 350	5.3 (1.9-14)	2.3 (1.1-4.5)
40 - 60	>= 100 Task 2 and >= 350 Task 3	16.3 (5.8 - 46)	4.6 (2.1-10.1)
> 60	>500 Task 2 and >500 Task 3	22.0 (7.0-69)	7.1 (2.9-17.5)

RELIABILITY

Reliability is a measure of test outcome consistency. For example, if UFOV® were given twice to the same person, would the scores for the second administration be similar to those from the first? Test-retest reliability was assessed with a sample of 70 participants aged 65 years and older. The delay between administrations ranged from two weeks to 18 days, with the average being two weeks. Correlation coefficients are presented below.

	Part 1, Time 1	Part 2, Time 1	Part 3, Time 1	Composite
Part 1, Time 2	.72			

Part 2, Time 2	.81		
Part 3, Time 2		.80	
Composite			.88

Relatively good reliability coefficients were obtained for each of the three UFOV® subtests. In addition, all participants who scored as low risk at time 1 (Subtest 1 < 100 msec.) also scored as low risk (Subtest 1 < 100 msec.) at time 2. For those who scored at high risk at time 1 (Subtest 1 >= 350 msec.) 60% scored at high risk at time 2, and 40% moved to the moderate risk (Subtest 1 > 60 but < 350 msec.) category. Most of those participants who shifted to moderate risk were close to the cutpoint score on the first testing.

Validity

Validity refers to the issue of whether UFOV® actually measures driving risk. Several studies were conducted to investigate the degree to which UFOV® is a valid measure of risk.

One way to assess validity is to examine UFOV® ‘s ability to predict which drivers are at risk for crashing, and whether UFOV® improves upon other methods of assessing risk. A prospective follow-up [Owsley et al., 1998 see below] was performed to identify measures of visual processing associated with involvement in motor vehicle crashes in older drivers. Participants were 294 drivers aged 56-90 years being seen at an ophthalmology clinic. The main outcome measure was crash occurrence. Multivariate Cox proportional hazards models with adjustments for person-miles traveled were used to identify visual variables independently associated with crash occurrence. Older drivers with a 40% or greater impairment in the Useful Field of View were 2.2 times (95% CI 1.2-4.1) more likely to crash during the 3-year follow-up period. Driving fewer than 7-days per week was associated with a 50% (95% CI 0.27-1.01) reduction in crash risk. UFOV® showed better sensitivity and specificity than visual sensory or mental status tests in identifying those older drivers who subsequently crashed. UFOV ® ‘s superior predictability to visual sensory or mental status tests which were also evaluated is most likely due to its reliance on both visual sensory abilities and higher order attentional skills. This study suggests that interventions which reduce either visual sensory or attentional impairment may also reduce accident risk in older drivers, an issue which is currently being investigated. (Owsley, 1994; Owsley, 1996; Owsley et al., , Ball, McGwin, Sloane, Roenker, White, & Overley, submitted1998).

Another way to assess validity is to examine UFOV® ‘s ability to predict drivers□ performance during on-road driving tests. Study participants were 66 people who had been referred to the Bryn Mawr Driving Assessment Center for evaluation of driving ability. A study was conducted to examine the value of a clinical driving assessment battery in predicting performance on an on-road driving test. Participants were administered a visual screening measure, a reaction time task, a split attention task, the Motor Free Visual Perception Test, the Hooper Visual Orientation Test, tasks involving verbal and symbolic sign recognition, and UFOV®. Following completion of the battery, participants underwent an in-lot and on-road driving assessment. Logistic regressions were conducted to determine which pre-driver screening variables could be used to predict (pass/fail) outcomes for the on-road test. This analysis showed that the UFOV® was significantly related to whether or not an older individual passed the driving evaluation (odds ratio = 22.9; 95% CI 4.8 □ 253,7).. The probability of failing the on-road test was less than .10 for those individuals scoring at 30% reduction or less, but jumped to .73 for 50% reduction or greater, and .94 for those with a 60% reduction or more**.** Results indicated that the addition of tests other than UFOV did not increase or add to the usefulness of UFOV® for predicting performance on-road test. These findings suggest that extensive pre-driver screenings with multiple screening tests may not provide enough information to justify the time and cost required for administration. Similar results were obtained in studies conducted at Washington University and by Visual Awareness, Inc. (Duchek, Hunt, Ball, Buckles, & Morris, submitted; Myers, Ball, Kalina, Roth, & Goode, submitted; Roenker, Cissell, & Ball, submitted).

Several of the previously mentioned studies were conducted using populations with neurological deficits. Duchek, Hunt, Ball, Buckles, & Morris (In Press1998) used three groups of examinees: healthy controls, individuals with very mild dementia of the Alzheimer type (DAT), and individuals with mild DAT. Findings revealed that UFOV scores increased (i.e., became worse) with dementia severity. Specifically, examinees with mild DAT demonstrated a 75% reduction in their useful field of view (UFOV®) on the average, examinees with very mild DAT demonstrated a 34% reduction on the average, and healthy controls demonstrated a 29% reduction on the average. Greater UFOV® reduction was found to be significantly related to poorer on-road driving performance r=-.56, p<.01).

Similarly, Rizzo and colleagues evaluated driving performance in a high fidelity driving simulator for normal older individuals as well as those diagnosed with mild to moderate DAT. UFOV® was a sensitive indicator of the presence of DAT, as well as an excellent predictor of driving performance.

Myers, Ball, Kalina, Roth, & Goode (2000) examined the relationship between UFOV® and driving performance in patients who were referred for evaluation to the Bryn Mawr Rehab Adapted Driving Program. Each patient had at least one medical diagnosis, the most common being cerebrovascular accident (57%). Other diagnoses included Parkinson's disease, hypertension, traumatic brain injury, subarachnoid hemorrhage, and transient ischemic attacks. UFOV® was found to be a significant independent predictor of on-road driving performance as described above. X^2 =10.95, p<.0001, OR=1.07.

Finally, a meta analysis of the existing literature by Clay et al. (2007) found that the UFOV® measure was a reliable predictor of crash risk over a wide variety of measures of crash risk. In fact the UFOV® measure was so robust that Clay et al reported that an additional 513 studies would have to be performed **AND** result in no effect in order to remove the predictive value of the UFOV® measure. Thus, the predictive value of the UFOV® measure is unparalleled in the driving safety literature.

X. Interpreting Results

Scores

UFOV® provides one score, reported in milliseconds (msec.) for each of the three subtests. The Tables below display the various cutpoints for each of the three subtests. Cutpoints were selected to optimize sensitivity and specificity.

Subtest 1

Score	Finding
0	The subtest was voluntarily aborted (and therefore incomplete) by the examiner. Subtests 2 and 3 are not administered, and no scores are reported.
> 0 but <= 30	Normal central vision and processing speed.
> 30 but <= 60	Normal central vision but somewhat slowed processing speed.
> 60 but < 350	Central vision loss and/or slowed processing speed.
>= 350 but <= 500	Severe Central vision loss and/or very slowed processing speed.
> 500	Severe Central vision loss and/or very slowed processing speed. Subtests 2 and 3 are not administered because the examinee displayed severe difficulty completing Subtest 1.

Note: It is not possible to tell whether poor results in subtest 1 are due to vision loss or speed of processing loss without evaluating visual function independently. It could be due to either one or the other or both.

Subtest 2

Score	Finding
0	The subtest was voluntarily aborted (and therefore incomplete) by the examiner. Subtest 3 was not administered, and no scores for Subtests 2 or 3 are reported.
> 0 but < 100	Normal divided attention ability.
>= 100 but < 350	Some difficulty with divided attention.
>= 350 but <= 500	Severe difficulty with divided attention.
> 500	Severe difficulty with divided attention. Subtest 3 was not administered because the examinee displayed severe difficulty completing Subtest 2.

Subtest 3

Score	Finding
0	The subtest was voluntarily aborted (and therefore incomplete) by the examiner. No score is reported for Subtest 3.
> 0 but < 350	Normal selective attention ability.
>= 350 but <= 500	Difficulty with selective attention.
> 500	Severe difficulty with selective attention.

Category Levels and Risk Statements

Combinations of various scores are automatically calculated and result in one of five categories of risk, with Category Level 1 being the lowest risk. Risk statements accompany the category levels. If no subtest is voluntarily aborted and scores for each Subtest are <= 500 msec., 14 outcomes or combinations of scores are possible.

The Table below presents the 14 possible outcomes. All scores are reported in msec.

Scores for Subtests 1-3	Category Level	Risk Statement
Subtest 1 > 0 but <= 30, and Subtest 2 > 0 but < 100, and Subtest 3 > 0 but < 350	1	Very Low
Subtest 1 > 0 but <= 30, and Subtest 2 > 0 but < 100, and Subtest 3 >= 350 but <= 500	2	Low
Subtest 1 > 0 but <= 30, and Subtest 2 >= 100 but < 350, and Subtest 3 > 0 but < 350	2	Low
Subtest 1 > 0 but <= 30, and Subtest 2 >= 100 but < 350, and Subtest 3 >= 350 but <= 500	3	Low to Moderate
Subtest 1 > 0 but <= 30, and Subtest 2 >= 350 but <= 500, and Subtest 3 >= 350 but <= 500	4	Moderate to High
Subtest 1 > 30 but <= 60, and		

Subtest 2 > 0 but < 100, and Subtest 3 > 0 but < 350	2	Low
Subtest 1 > 30 but <= 60, and Subtest 2 > 0 but < 100, and Subtest 3 >= 350 but <= 500	3	Low to Moderate
Subtest 1 > 30 but <= 60, and Subtest 2 >= 100 but < 350, and Subtest 3 > 0 but < 350	3	Low to Moderate
Subtest 1 > 30 but <= 60, and Subtest 2 >= 100 but < 350, and Subtest 3 >= 350 but <= 500	4	Moderate to High
Subtest 1 > 30 but <= 60, and Subtest 2 >= 350 but <= 500, and Subtest 3 >= 350 but <= 500	5	High
Subtest 1 > 60 but < 350, and Subtest 2 >= 100 but < 350, and Subtest 3 > 0 but < 350	3	Low to Moderate
Subtest 1 > 60 but < 350, and Subtest 2 >= 100 but < 350, and Subtest 3 >= 350 but <= 500	4	Moderate to High
Subtest 1 > 60 but < 350, and Subtest 2 >= 350 but <= 500, and Subtest 3 >= 350 but <= 500	5	High
Subtest 1 >= 350 but <= 500, and Subtest 2 >= 350 but <= 500, and Subtest 3 >= 350 but <= 500	5	Very High

If the score for Subtest 1 or 2 is > 500 msec., two additional outcomes are possible. If Subtest 1 > 500, Category Level 5 is assigned and the examinee is classified as "Very High" risk. Subtests 2 and 3 are not administered to avoid undue frustration of the examinee, and are automatically assigned scores of 500. If the score for Subtest 1 > 0 but <= 500, and Subtest 2 > 500, Category Level 5 is assigned and the examinee is classified as "High Risk." Subtest 3 is not administered to avoid undue frustration of the examinee, and is automatically assigned a score of 500.

If the test is voluntarily aborted at any point, scores for any previously completed subtests are reported, but no category level or risk statement is calculated. A score of zero is assigned for the aborted subtest and any subsequent subtest.

As can be seen by reviewing the Tables above, stimulus durations required to achieve 75% correct performance tend to be higher for Subtest 2 than Subtest 1, and highest for Subtest 3, reflecting the increasing difficulty of the Subtests. Poor scores for Subtest 1 may reflect poor central vision, processing speed, attention, working memory, or a combination of these factors. In most cases, poor performance on Subtest 1 is followed by poor performance on Subtest 2, since Subtest 2 incorporates the features of Subtest 1 but adds an additional target in the periphery.

On occasion, examinees have performed poorly on Subtest 1 and well on Subtest 2. This is an unusual event, and may indicate poor understanding by the examinee of what he or she was to do. Should this event occur, UFOV® automatically adjusts the score for Subtest 1 to reflect the level of performance on Subtest 2. Unusual events for Subtest 2 are defined as scores that fall between >= 350 on Subtest 1 and < 350 on Subtest 2. In such cases, the adjusted score for Subtest 2 will be used to calculate Category Levels and Risk Statements.

Similarly, poor performance on Subtest 2, followed by good performance on Subtest 3 is an unusual event, and automatically adjusts the examinee's score for Subtest 2 to reflect the level of performance on Subtest 3. Unusual events for Subtest 3 are defined as scores that fall between >= 350 on Subtest 2 and < 350 on Subtest 3. In such cases, the adjusted score for Subtest 3 will be used to calculate Category Levels and Risk UFOV®Statements.

IX. Utilities

There are a number of utility functions built into the UFOV® software. The purpose of each of these utilities and the method for access is described below.

Screen Size. The UFOV® software is designed for use on a 17 inch monitor. In the event that a larger monitor is used it is possible to use the software to adjust the projection area of the displays to the same size as a 17 inch monitor. This option may be accessed by selecting "Screen settings" from the Options Menu. Follow the directions on the screen for setting the proper display area.

Screen Refresh. Different computer monitors are capable of different rates of refreshing the screen. All timing in the UFOV® software is measured in refresh cycles of the monitor. Therefore it is critical that the refresh rate of the monitor is known. The software determines the refresh rate of the monitor when the software is started and displays this information.

Calibrating Touch. Follow the directions for installing the touch software that accompanies the touch monitor. The screen **must** be calibrated in mode 1024x768.
If you have an EloTouch monitor then the procedure for calibrating the screen through windows is as follows: From the Start menu select "Control Panel". Then select the ELO Touchscreen icon. Next choose the "Align" button and follow any further directions on the screen.

Mouse Practice. In the event that the mouse is used as the method of data entry instead of the touch screen, it may be advisable to allow the participant to practice using the mouse. This is particularly useful for participants who are not used to using computers.

Reviewing Client Files. It is possible to review a client's screening or training history. First select Client Info from the Main Menu. From the Client Info Menu select the Browse Client option, highlight the participant whose records you wish to review and double click with the left mouse button. You may now review this participant's records by pulling down the Report Menu and selecting the appropriate option. If you select the option "Screening History of Current Client" a separate window will open with all of the results of all screenings of that client. If you select the second option "Screening Results of Current Client" a window will appear containing the dates of all past screenings for that client. Double click the appropriate date and a report will be generated based upon the results of that screening. A summary of the individual's training history may be obtained by selecting the "Training History of Current Client". To obtain a copy of any of the reports, click the print button at the top of the window.

Timing Errors. As noted earlier, the UFOV® software operates by carefully controlling the length of time that an image is available on the screen. The presence of other applications may cause timing errors. Although trials involving timing errors are not stored and are repeated, the software only permits a limited number of timing error trials before the screening is aborted. The default number of timing trials and the default error tolerance are 5 trials and 4 milliseconds (0.004 seconds). The User may change these default values by selecting Settings from the Option Menu. Once the new values have been selected, click the save button. It is recommended that the number of trials should not be higher than 10 and the timing tolerance no greater than 12 msec.

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