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Validation of a 5-minute VPC Test to Assess and Compare Cognitively Intact Individuals and Individuals with Cognitive Impairments

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Validation of a 5-minute VPC Test to Assess and Compare Cognitively Intact Individuals and
Individuals with Cognitive Impairments

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science in Kinesiology

by

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Auburn University
Bachelor of Science in Kinesiology, 2016

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Abstract

The prevalence of cognitive impairments in the older adult population is growing. Finding treatment solutions to impede a cognitive decline can possibly lead to fewer cases of mild cognitive impairment, dementia, and Alzheimer's disease. A Visual Paired Comparison (VPC) could serve as a tool to predict, monitor, and regulate people who are susceptible to a cognitive decline. The purpose of this study was to 1) to determine the validity of the Neurotrack 5-minute VPC test with the Neurotrack 30-minute VPC test, 2) to determine the test-retest reliability of the Neurotrack 5-minute VPC test, 3) to compare Neurotrack 5-minute VPC scores between individuals with cognitive impairment (Mild Cognitive Impairment and/or Alzheimer's Disease) to cognitively intact adults, 4) lastly to compare Neurotrack VPC results with other cognitive tasks (MoCA, NIH toolbox, Dual task) performed within the study. This study included older adults age 60+ split into cognitively intact individuals and cognitively impaired individuals based from the MoCA. Analysis was ran on 28 subject in which 11 were cognitively impaired ($mean=.687$; $Std=.137$) and 17 were cognitively intact ($mean=.851$; $Std=.044$). The relationship between 5-minute VPC and the 30-minute VPC revealed a positive associations for both the first ($r=.504$; $p=.006$) and second ($r=.420$; $p=.019$) time points/trials. No significant differences between the 2 time points/trials ($p=.212$) which indicates a reliable 5-minute VPC test. A significant difference was found between the groups ($p=.000$). Domain-specific cognitive functions were examined through other assessments, in which the 5-minute VPC test was correlated to each of these tests. This study suggests that VPC to be a potentially reliable tool to assess cognitive function.

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Introduction

As of January 2016 there are 46 million Americans ages 65 and older within the United States. This number is expected to grow to over 98 million by 2060. This increase in the total share of the population will be reflected by an increase of 15% to a staggering 24% (Mather, Jacobsen, & Pollard, 2015). This population increase will also be associated with an increase in age related diseases such as Alzheimer's Disease and dementia. Dementia has been defined as a general term for a decline in mental ability severe enough to interfere with daily life such as severe memory loss (Alzheimers Association, 2018). Alzheimer's Disease (AD) is the most common type of dementia that causes problems with memory, thinking, and behavior. It is known that 75% of the cases of dementia are diagnosed as the AD. Dementia is thought to be a progressive disease, which typically starts with mild cognitive impairment (MCI). MCI is a syndrome defined as cognitive decline greater than that expected for an individual's age and education level but that does not interfere notably with activities of daily life (Gauthier et al., 2006). Prevalence of Dementia and MCI is high among older adults. 15-20% of individuals 65 years of age or older have MCI with approximately 32% of these individuals developing AD within the next 5 years. (Jellinger & Attems, 2010; Alzheimers Association, 2018). This makes dementia one of the most common diseases among the elderly. MCI has shown to have a high likelihood of progression toward dementia, and as cognitive abilities worsens with time, the presumed inevitability of institutionalization, disability, and mortality becomes more apparent.

MCI, dementia, and AD impact much more than just the individual suffering with the disease. Families, friends, and caregivers are also affected by the large responsibility that is accompanied with cognitive decline. Physical, emotional, and economic strain brought forth by this disease can cause anxiety to any individual associated with this problem. This problem does

not only strain family, friends, and caregivers but often demands support from health, social, financial, and legal systems (World Health Organization, 2012).

One of the most influential figures that the Alzheimer's Association published states that early and accurate diagnosis could save 7.9 trillion dollars in medical and comprehensive care costs. In the United States alone, every 65 seconds someone develops Alzheimer's/dementia. These sobering statistics indicate a clear and alarming problem. The initial area for researchers to begin to try and solve this world wide problem needs to be establishing a functional measure to assess cognition. Luckily, research has been conducted that exhibits an association between eye movements and cognition levels. Until just recently, eye tracking could only be measured by using specific and expensive equipment. It has been determined that even low resolution web cameras, found on smartphones, tablets and computers/laptops, can track eye gaze accurately (Y. Lin, R. Lin, Y. Lin, & Lee, 2013). This technique affords clinicians the ability to utilize common web cameras as a tool for tracking eye movements for individuals that might be at risk for a cognitive decline.

Changes in cognition can go unnoticed for many years; suggesting that process of a decline of cognition begins years before a clinical diagnostic confirmation (Small, 2000). There is not a practical and reliable approach to accurately detect cognitive changes in the early stages of MCI or dementia. Diagnoses of dementia rely on neurological exams, brain imaging, assessments on mental function, and reports from friends and family. The amount of energy and effort that goes into a diagnosis of MCI or AD is extremely excessive and needs a more practical approach. Visual paired comparison (VPC) is a validated memory recognition test with a potential to be used for detecting memory impairments. VPC compares the amount of time an individual fixates of on a new/novel image compared to a previously seen image when images

are shown side by side. It can be inferred from the eye tracking data that VPC can possibly be used as a screening tool for early dementia (Crutcher et al., 2009). It also can serve as an assessment for detecting MCI in the early stages along with predicting the risks of an individual developing MCI/dementia. When VPC testing is done over time, it gives the ability to monitor changes in cognitive function.

Recently a study was completed that validated a 30-minute VPC eye tracking assessment utilizing a built in web camera (Bott et al., 2017). One of the major drawbacks is the length of the assessment. A shorter edition of VPC could be used as a quick and efficient screening tool for cognitive deficiencies. A concise and accurate assessment could possibly lead to faster cognitive screening, beneficial interventions and eventually a remedy for this plaguing disease.

Threats to Validity

Recruitment for this study primarily involved residents from a retirement home. Many participants have similar social and economic status. This could cause a threat to validity because of the lack of generalization when compared to the 65+ age group population. Another threat to the validity of this study is optical problems within the participants. As age increases so does the chances for developing eye related issues/diseases. Approximately 1 in every 3 people will develop some form of vision reducing eye disease by the age of 65 (Ganley & Roberts 1983). Making it an important factor when examining eye movements. Medical history questionnaires were completed and any participant who was diagnosed with any major optical problems were excluded from the study. Additional screening and research on vision impairments will be critical in preserving valid results for VPC. Results for this study depend on the willingness of participants to complete each battery to the best of their ability. If participants do not complete the assessments to their best ability, internal validity might be threatened. Technology

malfunctions could pose a threat to validity. Manual analysis of the VPC assessment was conducted to establish higher accuracy of results and help negate technological malfunctions.

Limitations

The 30-minute VPC test was only be administered on the first trial, which could possibly allow for mental fatigue to occur. The 30-minute VPC test was not be re-assessed during the follow-up testing session. The participants that were scheduled to complete the Digit Symbol Coding Test and NIH Toolbox test after 30-minute VPC test might have effected scores. The crossover design used should help account for mental fatigue

Delimitations

A total of 33 subjects participated in this study. Participants reported to either the Exercise Science Research Center at the University of Arkansas or Butterfield Trail Village. Participants that reported to the Exercise Science Research Center will be in an isolated room free from distractions with an administrator. Participants that reported to Butterfield Trail Village completed all the assessments in a quiet office free from distractions. There was cognitive assessments completed on paper, IPads, and Laptops. Trials were administered at least 14 days apart.

Review of Literature

Cognitive impairments are not part of normal aging but do impact a substantial population worldwide. In 2017, The World Health Organization stated that there are 50 million people worldwide with dementia with about 10 million new cases formed every year. With the abundance of new cases every year, this growing problem needs a resolution. Currently there is no treatment to cure dementia or change its progressive path. Additional research, treatment, and support could possibly help with finding a solution to this seemingly ubiquitous problem. This

review of literature will highlight some scientific advancements with regard to assessing older adults with unimpaired and impaired cognitive abilities. Research efforts will be the preliminary action to cut down the major problem with screening, diagnosing, and treating cognitive decline.

One of the most widely accepted tools used for estimating the risk of dementia is the CAIDE (cardiovascular risk factors, aging and dementia) model. CAIDE began in 1998 with the purpose of investigating the connection between social, lifestyle, and cardiovascular risk factors together with cognition, dementia, and structural changes in the brain. This model associates risk factors with points. The higher number of points, then the higher the risk for developing dementia within the next 20 years (Kivipelto et al., 2013). An abundance of research has been conducted surrounding the CAIDE model proving it to be a useful prediction tool. A large scale long term study was conducted to assess a diet, exercise, cognitive training, and vascular risk monitoring intervention and its effects in cognitive decline prevention. This multi-domain approach showed promising results that certain risk factors linked to dementia and AD could be modified (Nganda et al., 2015). A similar study set out to determine if the results from the previous study were reliable. Researchers determined that sociodemographic, socioeconomic status, cognition, cardiovascular factors, and cardiovascular comorbidity did not impact the response to the intervention group that was observed (Rosenberg et al., 2018). Thus, indicating that their results were valid and that individuals can exhibit beneficial effects on cognition from multi-domain interventions. This method for enhancing a healthier lifestyle can be applied to nearly all individuals. The beneficial effects of this study were not limited by age, sex, cognitive performance, level of education, household income, cardiovascular risk factors, or presence of cardiovascular comorbidity. Interventions targeting beneficial lifestyle changes prove to be useful with decreasing the potential for a cognitive decline. Suggesting that a valid and reliable

evidence-based assessment to determine and track cognition levels used in accordance with a lifestyle intervention could possibly impede individuals from developing cognitive impairments.

MCI is considered to be the transitional phase between standard cognitive aging and dementia (Morris, 2012). Finding proper assessments to examine and compare cognitively intact to cognitively impaired individuals was the first major step to evaluating these groups. One of the first studies in this field was conducted by Daffner and colleagues (1992) in which they used the notion that dementia patients exhibit diminished curiosity and initiative. The researchers studied curiosity by tracking exploratory eye movements in response to visual stimuli. Individuals with AD distributed their viewing time equally between the two images that were shown to them. Subjects with AD spent the same amount of time on the incongruous stimuli compared to the congruous stimuli (41.5% versus 35.5%). This differed from the cognitively intact control, which spent more time viewing the incongruous stimuli compared to the congruous stimuli (50.7% versus 38.4%). These results led the authors to conclude that AD patients' exhibit diminished curiosity that can be measured by exploratory eye movements. This finding guided the way for more research to be conducted on the significance of eye movement and cognition.

Years later, Visual Paired Comparison (VPC) was studied to test the potential usefulness of predicting the onset of AD. VPC is a behavioral recognition memory task that examines the proportion of time an individual spends viewing a novel picture compared to a previously seen image. It has been exhibited that cognitively intact individuals concentrate their attention to novel features (Loftus & Mackworth, 1978). Normal cognitively intact individuals spend more time inspecting new images while, cognitively impaired individuals spend an equal amount of time viewing a previously seen image compared to a novel image. This was showcased to be true

in a study where eye movements were tracked when presented with novel and previously seen images. Interestingly, with just a 2-second delay results between groups were similar. When the delay was lengthened to 2 minutes, MCI patients spent 53% of their time viewing the new image compared to the control subjects who spent more than 70% of their time viewing the new image (Crutcher et al., 2009). This finding contributed to the theory that VPC tasks can be used as a tool to diagnose MCIs and possibly predict dementia onset. A similar study demonstrated this to be true as well as finding that researchers could distinguish between aged matched normal cognitive individuals and MCI subjects with 87% accuracy, 97% sensitivity, and 77% specificity (Lagun et al., 2011). This study validated Support Vector Machines (SVM), which use an automatic classification algorithm to determine eye gaze. This novel application detects eye movement patterns, specific fixations, saccades, and re-fixation. In a previous study, it was determined that cognitively intact individuals spent 10.8% of time looking at neither stimulus while, AD patients spent 23% (Daffner et al., 1992). The time spent viewing neither stimulus was later termed as the “grey area”. The “grey area” also incorporates the time that is spent fixated between images, in which the SVM can also measure. This was a drastic improvement from the best available classification system that was used at the time, which could only distinguish individuals with a 67% accurate, 60% sensitive, and 73% specificity. Thus, reassuring a hopeful approach for detecting cognitive impairments.

The next problem to arise was the ability to reliably differentiate individuals who are not at risk of cognitive decline to those that are at risk. Since MCI individuals are not assured to develop AD or dementia it is difficult to accurately assess these individuals that are at higher risk for progressing. It has been concluded that MCI has a 6% to 25% chance of converting to AD per year (Peterson et al., 1999). With such a high variability for cognitive decline, it is

immensely important to determine individuals who are at risk and those who are not. Zola and colleagues (2013), tracked elderly subjects with MCI and with unimpaired cognition for three years. This gave the researchers the ability to monitor and test elderly individuals with VPC over a lengthy span of time. In this study, Eight out of nine participants who exhibited a VPC score of 50 or less converted to MCI or AD but no individuals with scores of 67 or higher on VPC converted to MCI or AD. A ROC curve was generated based on VPC scores and whether the individual's diagnosis worsened over three years. The ROC curve displayed area under the curve of .903 indicating a powerful ability to discriminate between individuals who will and will not evolve to MCI or AD. Consequently, suggesting that VPC can serve as a formidable measure for an impending cognitive decline.

Many studies assessing the significance of VPC are using eye tracking systems that are set up within a lab and not easily accessible to many individuals. Without eye tracking instruments and trained technicians to properly administer VPC test, these measures would not be possible. Finding a practical, reliable, and valid method to combat this problem was the next step for VPC testing. A standard asset for most technological devices are built in web cameras. Web cameras are now commonly used on desktop/laptop computers, tablets, and smartphones. Practical alternatives to using expensive infrared eye tracking systems are warranted. It is important to be certain that eye tracking through cameras built into smart devices can yield correct and reliable results. A recent study assessed whether a commercially high frame rate eye tracking camera system can be equivocally accurate to a built in web camera. The high frame rate eye tracker showed strong associations with the web camera in regards to VPC preference score. Along with a strong relationship on VPC preference score between the 3, 5, and 10 frames per second that was that were assessed on the web camera. The conclusion was that the human

scoring of the VPC strongly correlated with the automated scoring of the high frame rate eye tracker camera during the same task (Bott et al., 2017). Interestingly throughout this study, researchers, had significantly less data quality issues using the built in web camera. Built in web cameras on smart devices can be highly accurate and less troublesome.

The purpose of this study was to 1) to determine the validity of the Neurotrack 5-minute VPC test with the Neurotrack 30-minute VPC test, 2) to determine the test-retest reliability of the Neurotrack 5-minute VPC test, 3) to compare Neurotrack 5-minute VPC scores between individuals with cognitive impairment (Mild Cognitive Impairment and/or Alzheimer's Disease) to cognitively intact adults, 4) lastly to compare Neurotrack VPC results with other cognitive tasks (MoCA, NIH toolbox, Dual task) performed within the study.

Methodology

Research Design

In this study, a non-experimental, comparative research design was used. This design was appropriate for the comparison of scores within the adult group (60+ years of age). Cognitive assessments are compared between cognitively impaired adults and cognitively intact adults. The independent variable for this study are the groups in which the individuals are placed (cognitively intact group or cognitively impaired group). The dependent variables will be scores to Neurotrack VPC assessments and other cognitive tests: Montreal Cognitive Assessment (MoCA), Digit Symbol coding Test, NIH toolbox assessments, and Dual Task results.

Participants

All participants in this study are older adults' age of 60+ years of age. Participants were then divided into two subgroups which will make up the independent variables. The subgroups

will be individuals with intact cognition and cognitively impaired individuals as determined by the MoCA.

Measures

MoCA. MoCA is a rapid screening instrument used for mild cognitive dysfunction, which served as an indicator for individuals for either intact or impaired cognitive abilities. This pencil and paper assessment challenges a variance of cognitive domains: attention and concentrations, executive functions, memory, language, visuoconstructional skills, conceptual thinking, calculations, and orientation. The test takes approximately 10 minutes. A score of 30 possible points was obtained and if participants score ≤ 26 a guardian's signature will be needed before their data can be used. Scores ≤ 26 and diagnoses of AD will place participants in the cognitively impaired group. Participants who score >26 will not need any further action for their data to be used. One study exhibited the MoCA has a sensitivity of 83% in detecting subjects with MCI and a sensitivity of 94% in detecting subjects with dementia (Smith, Gildeh & Holmes, 2007).

Digit Symbol Coding Test. A pencil paper test that will serve as another cognition assessment. This coding task will require participants to use a reference key that has digits 1-9 matched with basic symbols. They will use this reference key to manually fill in the rows of blank spaces that are paired with a number. Participants will not be allowed to know how much time they are allotted, just instructed to fill in the rows in order as quickly as possible. After 90 second the test will be concluded and a score will be given depending on the correct amount of symbols they placed in the boxes. This exam challenges information processing, visual processing and motor abilities and has been shown to be a suitable tool for cognitive impairment

screening. This test has demonstrated acceptable values for both retest reliability and practice effects of individual tests being >0.70 (Gonzalez-Blanch et al., 2011).

NIH toolbox. The NIHTB-CB (cognitive battery) is a comprehensive set of measurements that can assess cognitive function from an iPad. The NIH toolbox tests will include: Flanker Inhibitory Control and Attention test, Dimensional Change Card Sort test, Pattern Comparison Processing Speed Test, Picture Sequence Memory Test. Before each test there will be a trial period in which the tasks will be demonstrated. Participants will then take part in practice sets to prove their understanding for the task. If participants are not able to successfully complete the practice set after three attempts, they will move onto the next test. The NIH toolbox is intended to measure neurological and behavioral function (NIH, 2017). The NIH toolbox convergent validity for all cognitive test ranged from $r = 0.48$ to $r = 0.93$ which means they are measuring their desired constructs (Weintraub et al., 2013).

Flanker Inhibitory Control and Attention Test. This test will display arrows pointing in certain direction on the screen. The participants will be instructed to indicate which direction the middle arrow is pointing. Some of the time the arrows will point the same direction and sometimes the middle arrow will be facing the opposite direction. This will require the participant to focus on a specific stimulus while inhibiting attention to the stimuli flanking it. This test shows a high test-retest reliability of .96 with a convergent validity of .48 (Weintraub et al., 2013).

Dimension Change Card Sort Change Test (DCCS). In his test participants will be presented with two target pictures. A cue word of “shape” or “color” will appear on the screen. This cue word will indicate how the participant is supposed to match the images. If “shape” appears, the participant will match by shape and if “color” appears, the participant will match by

color. This 30-item test will help with assessing cognitive flexibility and attention. The DCCS shows a high test-retest reliability of .94 with a convergent validity of .51 (Weintraub et al., 2013).

Pattern Comparison Processing Speed Test. Participants will be presented with two side by side pictures in which they will have to detect whether or not the pictures are the same or if they differ. This is a relatively short test that takes less than 90 seconds for the participant to finish. The picture items are simple and not too complex with hopes to solely measure processing speed. This test shows a high test-retest reliability of .82 with a convergent validity of .49 (Weintraub et al., 2013).

Picture Sequence Memory Test. Participants will be shown a sequence of pictured objects and images with a particular order. Once the sequence concludes, images will get scrambled around the screen. The goal will be to replicate the sequence of pictured objects and activities. There will be two trial consisting of one trail of 15 pictures followed by one trial of 18 pictures. There will be three novel pictures on the second trial. The intention for this test is to assess episodic memory. This test shows a test-retest reliability of .78 and with a convergent validity of .69 (Weintraub et al., 2013).

Visual Paired Comparison (VPC). There will be two different VPC test administered: Neurotrack's 30-minute VPC test and Neurotrack's 5-minute VPC test. The 30-minute VPC test is a passive test that requires relatively no instruction. Subjects are asked to keep relatively still while images are displayed on a laptop computer. The 5-minute VPC test is a shortened version that is classified as an active test because it will instruct the participants to focus on the new image not previously seen. The web camera that is standard on the laptop computer will record

and store the participants face and eye movements. These recorded videos will then get analyzed by Neurotrack.

Demographics. Height and weight were assessed using a stadiometer and balance beam scale. Height was measured to the closest 0.5 inch and weight was measured to the nearest .5 lbs. Participants had the option of completing a body composition using a dual-energy x-ray absorptiometry (DXA). DXA was only available at the Exercise Science Research center at the University of Arkansas. If Participants did not use DXA, body composition was estimated with height, weight, sex, and age.

Dual Task. This physical and mental assessment will be conducted over a length of 20 meters. It will be measured in a well-lit obstacle free location. For risk minimization participants that would usually use assisted walking devices will asked to complete this assessment with those devices. If participants are immobile, this portion of testing will be omitted. Timing gates will be setup at 5 and 15 meters. Subjects will be instructed to walk a full 20 meters to ensure no acceleration or deceleration occurred through the 5 and 15 meter timing gates. They will complete 4 different walking tests: 20-meter walk at usual speed, 20-meter walk at usual speed while doing a simple math problem, 20-meter walk at a fast pace, 20-meter walk at a fast pace while doing a simple math problem. Each of these trials were completed twice. The simple math problem is subtraction by 3 from a randomized 3-digit number. Times will be recorded to the nearest hundredth of a second. The dual task assessment has demonstrated a reliability of >0.75 (Yang et al., 2017). The aim is to determine how gait time is affected by cognitive abilities. Dual-task test have been proven to be a valid and reliable measure to assess working memory in older adults (Montero-Odasso et al., 2009; McCulloch et al., 2009).

Procedures

Since IRB approval has been acquired, participants reported to either the Exercise Science Research Center at the University of Arkansas or a continued care retirement community in Fayetteville Arkansas. Participants reported for two separate trials at least 14 days apart. On the first visit, participants were asked to read and review an informed consent document. Once signed, research was able to be continued. Participants were then given a medical history questionnaire. This was followed by the Montreal Cognitive Assessment (MoCA), which was only assessed on the first visit. The informed consent, medical history questionnaire and MoCA are considered to be the preliminary requirements. The order of testing was randomly selected for all the participants and a crossover design for the two trials was used for the rest of the dependent variables to account for mental fatigue. This means participants that completed the Neurotrack VPC testing before the other cognitive assessments on the first trial, they then completed the cognitive assessments first on the second trial and vice versa.

The Neurotrack VPC testing was completed on a laptop equipped with a web camera in which individuals first completed a 30-minute test, followed by a 5-minute test. Participants only completed the 30-minute VPC testing on their first visit and not their second. Participant's faces were recorded throughout the test. The video was then analyzed and eye movements were tracked. Participants then started the next set of cognitive assessments with the Digit Symbol Substitution Test. In which, Subjects were required to fill in a series of symbols they need to correctly code within 90 seconds. The more symbols that were correctly coded corresponds to a higher score and better performance.

An Ipad was involved with the NIH toolbox testing. Participants were taken through a quick demographic questionnaire on the Ipad before completing the NIH Toolbox tests. There

were four NIH Toolbox assessments in which they completed in the same order for both trials. The order was Flanker Inhibitory Control and Attention Test, Dimension Change Card Sort Change Test, Pattern Comparison Processing Speed Test and lastly the Picture Sequence Memory Test. Before each of the assessments participants completed a practice trial to ensure they understand their objectives. Once all NIH Toolbox tests were completed trial one was concluded.

The second trial was done at least 14 days after the first and the preliminary requirements were not repeated. Participants either started with the VPC testing or the additional cognitive measures depending on the order they were completed during the first trial. After this testing was done, additional demographic testing was then conducted on the participants. Height and weight were assessed using a stadiometer and balance beam scale. Height was measured to the closest 0.5 inch and weight was measured to the nearest .5 lbs. Participants had the option of completing a body composition using a dual-energy x-ray absorptiometry (DXA). DXA was only available at the Exercise Science Research center at the University of Arkansas. If Participants did not use DXA, body composition was estimated with height, weight, sex and age. The last cognitive measure which was only completed on the second trial was the dual task walking test. Participants normal and fast walking times will be measured with and without the task if simple math problems to determine how an additional task affected gait. This concluded all of the assessments in the study.

Data Analysis

A Pearson correlation was used to determine the validity of the 5-minute Neurotrack VPC test compared to the 30-minute Neurotrack VPC test. The test-retest reliability of the 5-minute Neurotrack VPC test was determined by a Pearson's correlation coefficient using the data

from the first trial compared to the second trial. To compare the 5-minute Neurotrack VPC test scores between individuals with cognitive impairments to cognitively intact adults an Anova repeated measures was conducted. To determine the association between VPC-5 scores with the other cognitive tasks (MoCA, NIH Toolbox, Dual task) a Pearson correlation was used with a statistical significance set at $\alpha = .05$. Information on demographics will be presented as means \pm SD.

Results

Participants Characteristics

(Table 1) There were 33 subjects with an age of 60+ years who completed this study. 20 subjects were classified as cognitively intact ($\text{MoCA} \geq 26$), while 13 subjects were classified as cognitively impaired by either clinically diagnosed memory problems or a $\text{MoCA} < 26$.

Relationship Between 5-minute and 30-minute VPC Tests

The relationship between 5-minute VPC and the 30-minute VPC revealed a positive association. This indicates the 5-minute VPC to also be a valid measure for declarative memory. Both the first (Table 2; $r=.504$; $p=.006$) and second (Table 3; $r=.420$; $p=.019$) time points/trials for the 5-minute VPC revealed a significant correlation to the 30-minute VPC test.

Test Re-test Reliability of 5-minute

A paired samples T-test was used to determine the reliability of the 5-minute VPC test. The T-test revealed no significant differences between the 2 time points/trials ($p=.212$). This indicates a reliable 5-minute VPC test.

Comparing 5-minute VPC Test Between Groups

Analysis was ran on 28 subject in which 11 were cognitively impaired ($\text{mean}=.687$; $\text{Std}=.137$) and 17 were cognitively intact ($\text{mean}=.851$; $\text{Std}=.044$). An Anova repeated measures

analysis was used to determine any differences between the intact group and the impaired group. Our findings indicate a significant difference between the groups ($p=.000$).

Associations Between 5-minute VPC Test and Cognitive Assessments

Another purpose of this study was to compare the 5 minute VPC test to other cognitive assessments that were performed during the study. Domain-specific cognitive functions were examined through other assessments, in which the 5-minute VPC test was correlated to each of these tests.

On the initial day of testing (Table 2) significant relationships were not found between any of the NIHTB-CB. The MoCA, which was only taken on day 1, exhibited a significant relationship ($r = .672$; $p = .000$). A significant relationship was also found between the Digit Symbol test and 5-minute VPC test ($r = .643$; $p = .000$). On the second trial (>14 days; Table 3), significant relationships were found between the Flanker ($r = .383$; $p = .044$), PSPAC ($r = .523$; $p = .004$), PSMT ($r = .586$; $p = .001$), While the DCCS ($r = .222$; $p = .256$) did not. The digit symbol test($r = .750$; $p = .000$) showed a significant relationship

Dual –Task. This assessment was only performed on trial 2, There were no significant relationships with the DT and 5-minute VPC trial 1 testing, but there significant relationships found on trial 2 with the 5-minute VPC testing and DT habitual speed ($r = -.385$; $p = .029$)and DT fast pace ($r = -.387$; $p = .031$) when an simple subtraction task was involved.

Discussion

This study had four main objectives which were 1) to determine the validity of the 5-minute Neurotrack VPC test with the 30-minute Neurotrack VPC test, 2) to determine the test-retest reliability of the 5-minute Neurotrack VPC test, 3) to compare 5-minute Neurotrack VPC scores between individuals with cognitive impairment (Mild Cognitive Impairment and/or

Alzheimer's Disease) to cognitively intact adults, 4) lastly to compare Neurotrack VPC results with other cognitive tasks (MoCA, NIH toolbox, Dual task) performed within the study.

The first purpose of determining the validity of the 5-minute and the 30-minute VPC test revealed a moderate convergent validity between tests. Importantly, results from trial one and trial two revealed similar correlational values. Results from the 5-minute VPC test demonstrates a feasible alternative to the 30-minute VPC test for measuring visual recognition memory. While both test are assessing working memory ability there are some distinguishable differences. The 30-minute VPC test has no instructions other than to look at the images on the screen. This test was also intended to only be taken once to achieve a baseline score. The 5-minute VPC test instructs the participants to focus on the image they have not seen before. This test should be considered more active rather than passive because of the basic qualities of the test. Furthermore, the active nature of this test reveals a significant benefit in which it can be taken repeatedly over time.

The second primary objective was to determine the test re-test reliability of the 5-minute VPC. The results revealed no statistical differences between the two time points. This signifies a strong test-re-test reliability of the 5-minute VPC test. Test re-test reliability ensures that individuals can take this assessment repeatedly over time without significant differences in cognitive scores.

The third purpose of this study was to compare the 5-minute VPC scores with the cognitively intact group and the cognitively impaired group. Statistics revealed a significant difference between the intact and the impaired groups. The 5-minute VPC test was able to determine differences and differentiate individuals who were classified as cognitively intact and cognitively impaired. Additionally, there were no significant differences found within the groups

indicating similar results within the two groups. Thus showing additional reliability for the 5-minute VPC test.

The last purpose of the study was to compare the 5-minute VPC scores to the other cognitive assessments performed. The 5-minute VPC test had more significant correlations with cognitive batteries that were performed on second trial day. Three out of four NIHTB-CB test were significantly correlated (Flanker, PSPAC, and PSMT) on day 14 while none of the NIHTB-CB were correlated with trial 1 testing. This possibly indicates some testing effects which can occur when tasks are repetitively practiced and results are changed or improved. The NIHTB-CB only have one version of each of the test and were repeated on both trial days. This repetitive testing for cognitive batteries has been proven to make assessments vulnerable to learning/testing effects and unlikely that these changes are associated to changes in cognitive abilities (Goldberg et al., 2015). Additional practice trials on the NIHTB-CB could possibly mitigate some of these testing effects for future studies. Advantageously, Testing effects are alleviated in the 5-minute VPC tests because of the substituted forms that were used on trial one and trial two.

A limitation displayed in this study was data quality issues from the VPC testing. The data quality issues included glare from glasses, electronic errors, and low lighting. Results were excluded from one older adult for the 30-minute VPC test, five older adults for the 5-minute VPC testing Trial 1, and one older adult for the 5-minute VPC testing Trial 2. The rest of the batteries that were performed by these participants were still included in the assessments because of the completion of both trials. Ecological validity was also a limitation of this study. Testing was done in a research setting which either included a private office or a secluded room instead of participants natural settings such as their home. Moreover, research needed to be conducted in these setting to ensure quality data collection and compliance from participants. Lastly, a small

amount of cognitively impaired individuals participated in the study. Future studies should include more cognitively impaired individuals to increase the ability assess different levels of impairment.

The 5-minute VPC test from Neurotrack shared many significant associations to other gold standard cognitive assessments. There are also beneficial differences that the 5-minute VPC test has exhibited such as scalability. Other assessments have been proven to be valid and reliable but need to be taken in person and with a trained professional. Instead of having to rely on trained professionals to administer cognitive exams, individuals can administer this assessment solely on their own. The alternate forms that are available in the 5-minute VPC test also allows for individuals to retake the assessment to track any cognitive changes. Yet another upside to the 5-minute VPC test is that individuals can take this examination anywhere that has internet connection and a smart device that has a camera built-in or attached.

In conclusion, this study exhibited moderate convergent validity between the 5-minute VPC and 30-minute VPC assessments. A strong test re-test reliability of the 5-minute VPC test was revealed. Significant differences were found between the cognitively intact and cognitively impaired groups and significant correlations were found between the 5-minute VPC test and other cognitive assessments. Results indicate a hopeful approach to screen and monitor cognitive health over time. The 5-minute VPC test is not intended to be a diagnostic test which would require additional research with larger samples of participants. Future studies should be done to examine effects of testing in common environments instead of isolated and unfamiliar places. Because of the minimal recruitment of cognitively impaired individuals in this study more research still needs to be conducted on cognitively impaired populations.

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Appendices

Tables

Table 1. *Characteristics of the study cohort*

	Older Adults (<i>n</i> = 33)
Average age (SD)	78.2 years (6.9)
Sex	
Female	72.7%
Education	
High School Graduate	6.1%
Some College	15.2%
College graduates or higher	78.7%
Race	
European-American	97%
Other	3%
Biometric	
Height (SD)	164.7 cm (10.3)
Weight (SD)	71.3 kg (13.8)
Cognitively Normal	66.7%
Cognitively Impaired	33.3%