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Validity and Test-Retest Reliability of a Digital Dynamic Visual Acuity Test of Vestibular Function

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Abstract

The vestibular system senses head motion and facilitates gaze stabilization, allowing for clear vision during movement. The vestibulo-ocular reflex (VOR) causes the eyes to move opposite head motion, thus maintaining focus on a target. Consequently, uncompensated loss of vestibular function leads to reduced VOR function resulting in dizziness, nausea, and visual disturbance. Different testing methods have been developed to measure VOR loss. These tests generally require bulky, expensive equipment, and must be performed by a trained examiner. A newly developed digital form of the dynamic visual acuity (DVA) test requires less equipment, is cost-effective, and may be performed at home making it more accessible. The purpose of this study was to determine the validity and test-retest reliability of the digital DVA test and provide normative data for healthy adults. Fifteen adults – 10 female and 5 male (mean age = 22.0 ± 3.1, range: 19-31 years) – completed the study. Exclusion criteria included age older than 49 years, history of vestibular or neurological disorders, and history of significant head injury. Subjects were screened for normal vestibular function using video head impulse testing. The study consisted of two visits, 3-15 days apart. Participants underwent DVA testing with both the validated NeuroCom (InVision software) system and newly developed digital DVA during the initial visit and the digital DVA during the second visit. The digital DVA system consists of a laptop computer paired with a head/eye tracker (Tobii Eye Tracker 5) and Health in Motion software (Blue Marble Health Company). Outcome measures of interest were the difference between static and dynamic visual acuity measured in LogMAR (DVA loss) for rightward and leftward head movement. Pearson Product-Moment bivariate correlations were used to determine validity of the digital DVA outcomes compared to NeuroCom outcomes. Intraclass correlation coefficients (ICCs) were calculated to determine test-retest reliability of the digital DVA. Pearson correlation coefficients for validity were r = 0.025 and r = -0.015 for left and right DVA loss, respectively. ICCs for test-retest reliability were r = 0.366 and r = 0.313 for left and right DVA loss, respectively. Mean values across both sessions for left and right DVA loss measured by digital DVA were 0.26 ± 0.13 and 0.26 ± 0.11, respectively. Correlations between the digital DVA and standard computerized DVA were poor indicating the need for further development of the current digital system/software. Test-retest reliability for the digital DVA system in its current state was also poor. Tobii sensor used in the software is limited by a 200 ms delay in reporting head motion to the software. Future development of a digital DVA may need to consider other sensors. The current digital DVA will not replace the computerized system; however, it may provide important information for clinicians who do not have access to computerized DVA.

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Introduction

Peripheral vestibular hypofunction (PVH) is estimated to affect between 53 and 95 million adults in Europe and the United States alone. [1] Consequences of uncompensated vestibular hypofunction can include, but are not limited to, feelings of dizziness, nausea, and vertigo.[1-2] People with PVH also experience more gait/postural instability, hearing impairment, visual disturbances, and tend to be much older as compared to those with healthy vestibular function.[1-3] With the current rise in the aging population worldwide, there will be an increased need for interventions that target vestibular issues to help mitigate the increased risk of falls and trouble with tasks of daily living that can result from PVH.[4-5]

The ability to maintain visual acuity during rapid head movement or dynamic visual acuity (DVA) is a principal function of the vestibular system.[2] The vestibulo-ocular reflex (VOR) is what allows for gaze stabilization while the head is moving by causing the eyes to move equally and opposite to the direction of the head motion[6-9]. When a person's VOR is deficient, the target does not stay precisely on the fovea, which is the central part of the retina responsible for sharp and clear vision. This misalignment results in a phenomenon known as 'retinal slip,' where the image on the retina becomes unstable and moves away from the fovea. In response to retinal slip, the brain initiates compensatory saccades – rapid, involuntary eye movements – to reposition the image back onto the fovea for clear vision. These compensatory saccades are an adaptive mechanism in attempt to overcome the VOR deficiency and maintain visual stability. An impacted VOR leads to a decline in Dynamic Visual Acuity (DVA), which is the ability to see clearly while in motion. Since the eyes are unable to maintain a stable fixation on a target during head movements, individuals with VOR deficits experience a drop in DVA. [7-8, 10-11] Therefore, addressing VOR deficits is crucial in the context of maintaining clear and stable vision during motion.

Angular VOR (aVOR), the component of VOR that compensates for angular rotation of the head, is mediated by the semicircular canal (SCC) which results in opposing eye movement to the direction of head motion.[7-9, 12] Many different methods exist for testing aVOR. One of these methods is video head impulse testing (vHIT) which involves high acceleration, low amplitude head rotation in the plane of the semicircular canal being tested.[11-12] vHIT measures head and eye velocity and identifies VOR hypofunction through calculation of VOR gain (low

gain indicates hypofunction) and the presence of overt and/or covert saccades. Normal gain measurements are close to 1.0 and VOR gain is considered abnormal <0.8.[12]

Current intervention programs for rehabilitation of a deficient DVA include exercises developed to improve gaze stability.[12] These exercises involve rotating the head while fixing the eyes on a target that is either stationary or moving.[12] Identification of an impaired DVA provides clinicians with valuable insight for assessing the functional impact of PVH as well as the effectiveness of vestibular rehabilitation programs aimed at improving VOR compensation.[11-17] Currently, the standard tool for measurement of functional VOR is the computerized NeuroCom DVA (Figure 1) test which uses a convergence algorithm to identify visual acuity during head movement.[11, 14-16] However, this method for testing functional VOR is very expensive and bulky which creates problems in the test's accessibility. To address these issues, a new form of digital DVA (dDVA) testing has been developed with the goal of increasing accessibility to vestibular patients and clinicians (Figure 2). The purpose of this study is to determine validity, in comparison to the gold standard NeuroCom DVA system, and test-retest reliability for the newly developed digital DVA system.

Methods

Participants

Sixteen healthy adults (5 male and 11 female) between the ages of 19 and 31 (mean age= 22.3 ± 3.2 years) were recruited via word of mouth from East Tennessee State University and Washington County VA/TN. Each participant signed a written consent form approved by the East Tennessee State University/Veterans Affairs IRB. Inclusion criteria consisted of age from 18 to 49 years and normal horizontal VOR gain (≥ 0.8[13]). Exclusion criteria included history of vestibular conditions (e.g., vertigo, severe motion sickness, migraines), presence of compensatory saccades with vHIT testing, history of neurological disorders, more than one previous concussion, and any previous concussion with symptoms lasting longer than 7 days. Each subject filled out a brief demographic questionnaire including education, ethnicity/race, health conditions, use of visual correction, and current level of physical activity.

Upon completion of initial screening, each participant underwent vHIT (MicroMedical, Chatham, IL) performed by a single examiner to confirm normal vestibular functioning of the

horizontal SSC. Normal function was defined as the absence of compensatory saccades and normal gain (≥ 0.80) for both leftward and rightward head movements. All 16 participants exhibited normal horizontal SSC function and were cleared for study participation; however, one subject was disqualified due to significant static visual acuity (SVA) impairment which made her unable to complete DVA testing (described in protocol).

Equipment

The Neurocom SMART EquiTest (version 9.2.0) InVision^{TM} software (NeuroCom®, a division of Natus ®, Clackamas, OR, USA) was used to test DVA (Figure 1). The NeuroCom InVision^{TM} system is composed of a computer monitor attached to a movable arm which can be adjusted for height and angle, an adjustable headpiece which holds the IMU for sensing head speed and motion, and a remote control. Participants were seated on a stable chair and asked to wear a hairnet for all testing with the NeuroCom system (Figure1).

The dDVA test (Health in Motion, Blue Marble Health Co. Pasadena, CA) consisted of a portable laptop computer paired with a Tobii eye tracker 5 (Tobii, Danderyd Sweden) and Health in Motion software. The Tobii is an eye and head-tracking device connected via USB at the bottom of the monitor (Figure 2). Head speed and motion were detected using the eye tracker. Participants were seated in a non-adjustable, stationary chair during assessment.

Protocol

Testing for this study occurred on two separate occasions (between 3 and 15 days apart) by the same examiner to maintain consistency. On the initial day of testing, both NeuroCom and dDVA assessments were performed to evaluate validity of the dDVA system. Order of administration for the two DVA tests (digital versus computerized) was counterbalanced for each subsequent participant. On the second day of testing, only dDVA testing was conducted to evaluate test-retest reliability of the dDVA system. Due to issues with the eye tracker detecting the subjects' eyes, testing was conducted with the subject's personal lens correction if wearing contacts, but without their glasses. To maintain consistency, glasses were also removed prior to the NeuroCom DVA test and participants were asked to bring the same form of visual correction (e.g., contacts or glasses) for both days of testing. All assessments were carried out in a well-lit, quiet room.

NeuroCom Protocol. Protocol for the NeuroCom DVA followed a standard script of verbal instructions for how to properly complete the testing. Participants were seated 1.5 meters from the monitor that was positioned at eye level. NeuroCom testing began with the Static Visual Acuity (SVA) test, followed by the Minimum Perception Time (MPT) test, and finished with DVA testing. Each of the InVision^{TM} systems' assessments repeatedly displayed the optotype "E" in random order of orientation (up, down, left, or right) on the computer monitor. Participants were asked to verbally indicate the direction of the optotype and then the examiner manually input their response. Progression of the assessments followed the manufacturers convergence algorithm which started with an easier target and adjusted based on the participant's responses. Answers were recorded as correct when participants indicated the orientation that accurately corresponded to the orientation of the optotype being displayed. The difficulty level increased (i.e., optotype size decreased) with correct responses and decreased (i.e., optotype size increased) with incorrect ones, continuing until three out of five correct answers at the same difficulty level were achieved. Optotype size was reported in units of logarithm of the minimum angle of resolution (logMAR).

Prior to testing, participants were provided with practice and guidance on proper speed and range of head motion. Participants were instructed not to guess regarding the orientation of the "E" and when they were unsure of the orientation, they should say "pass" or "I don't know". A "pass" registered in the software as an incorrect answer. Each participant went through a round of practice prior to actual testing to ensure their understanding of the procedure.

Static Visual Acuity (SVA) was defined as the smallest optotype in which the orientation could be determined in three out of five trials, at the same size, while the head remained still.[14] During SVA testing, optotype size was determined according to the manufacturer's convergence algorithm while display duration remained consistent. Static visual acuity SVA testing results for this study were recorded in units of logMAR.

Minimum Perception Time (MPT) assessed the minimum time it took for participants to perceive and correctly identify the orientation of the optotype while the head remained still. During MPT testing, the optotype was displayed for differing durations and with a consistent optotype size (set to 0.2 logMAR above the participants SVA outcome). MPT testing results were recorded in milliseconds (ms) with the briefest possible display time being 20 ms.

Following the manufacturer's guidance, MPTs of 70 ms or more were categorized as extended and could lead to inaccurate DVA scores. For individuals with MPTs of 70 ms or longer, the test was repeated.[14] Those who could not achieve MPT results under 70 ms were not excluded from the study.

Dynamic Visual Acuity (DVA) for this study assessed the participants' ability to see clearly during horizontal head movement. For DVA testing, subjects were instructed to horizontally rotate their heads in a smooth, sinusoidal motion while keeping their eyes fixed on the center of the screen to identify the orientation of the optotype. The range and velocity of head rotations were directed by a feedback bar on the screen that provided visual feedback to the participant. Measurements for leftward and rightward head movements were based on the smallest optotype which received at least 3 of 5 correct responses and were recorded in units of logMAR. DVA loss scores were determined by the difference between dynamic and static scores and reported for both directions.

Digital DVA Protocol. Protocol for the digital DVA began with calibration of the Tobii eye tracker. Once the assessment was initiated, participants were prompted to position themselves 30 cm from the laptop screen, with the distance being monitored by the eye tracker. Integrated instructions and animations were provided before each test to model appropriate behavior. Subjects were asked to sit through instruction during their first visit but were allowed to skip this step during retesting. The digital DVA testing software included both static and dynamic visual acuity testing. SVA testing occurred prior to DVA testing for all subjects. During both SVA and DVA testing, an "E" optotype was flashed on the screen in different randomized orientations (up, down, left, or right). Optotype size progression remained consistent across all trials, regardless of the subject's responses. It initiated with the largest display of the optotype and gradually decreased in size by 0.1 LogMAR after the subject correctly identified 3 optotypes at a particular size. The process repeated, with the subject having to identify 5 optotypes at each size, until they made more than 2 consecutive incorrect responses at a specific size. Subjects input their answers manually using the laptop's arrow keys.

For DVA testing, subjects were instructed to horizontally rotate their heads in time with an integrated metronome while keeping their eyes fixed on the center of the screen to identify the orientation of the optotype. During DVA testing, subjects were instructed to take breaks if they

began to feel dizzy or nauseous and were given tips to make rapid, impulse head movements (versus continuous sinusoidal rotations) if the system did not register their head movements. Dizziness ratings, based on a 10-point scale, were recorded for each participant before and after testing. SVA and DVA scores were based on the smallest optotype which received at least 3 of 5 correct responses (measured in logMAR). Testing outcomes for dDVA were the difference between static and dynamic scores.

Data Analysis

The outcome measure for analyses was DVA loss (i.e., the difference between static and dynamic visual acuity) measured in units of logMAR for rightward and leftward horizontal head movement. To determine validity of the digital DVA compared to NeuroCom, bivariate correlations (Pearson Product-Moment correlations) were calculated. To determine test-retest reliability of the digital DVA, intraclass correlation coefficients (ICCs) were calculated. Pearson and ICC values were interpreted as follows: excellent (0.75–1.0), fair to good (0.40–0.74), and poor (<0.39). Correlations were considered significant if values were $p < 0.05$.[14] Descriptive statistics (mean, SD, and range measure in logMAR) were calculated for each assessment performed for both rightward and leftward head movement. All statistical analyses were computed using IBN SPSS Version 29.0.

Results

Among the 16 participants enrolled in the study, complete data for both sessions from 15 participants (5 male and 10 female) were included in statistical analysis (data from one subject was removed due to poor static visual acuity). Pearson correlation coefficients between dDVA and NeuroCom DVA were $r = 0.025$ ($p = 0.928$) and $r = -0.015$ ($p = 0.957$) for left and right DVA loss, respectively, suggesting poor correlation (Table; Figure 3). ICCs for dDVA test-retest reliability were $r = 0.366$ and $r = 0.313$ ($p = 0.256$) for left and right DVA loss, respectively, suggesting poor correlation (Table; Figure 4). All correlations fell short of statistical significance ($p < 0.05$). The mean, standard deviation, and range for DVA loss outcomes of all measures were calculated and presented in Table.

Discussion

According to the data collected in this study, the dDVA test is not yet validated against the established NeuroCom standard for DVA. The poor correlation observed between dDVA and NeuroCom DVA outcomes for both left and right DVA loss raises doubts about the dDVA test's accuracy in detecting PVH. Moreover, the modest ICCs for left and right DVA loss during test-retest assessments indicates a need for improved consistency within the InVisionTM software, which houses the dDVA test.

Previous research on the NeuroCom system reported fair-to-excellent reliability for raw DVA scores but considerably worse reliability (poor-to-fair) for DVA loss scores, particularly in younger adults. This may, in part, explain the exceptionally low correlation between the two tests considering the population for this study consisted solely of that demographic. Similar to this study, statistical significance was not achieved, indicating a lack of validation for both the NeuroCom and dDVA systems against established standards. Improved consistency was also a concern in previous research on the NeuroCom system, suggesting common challenges in achieving reliable DVA measurements between it and the dDVA system.[14]

Due to the low validity and reliability, further development of the dDVA is necessary before it can be used commercially. A possible reason for the poor outcomes may be due to the 200-millisecond delay between when the Tobii sensor records data and when it is sent back to the software. This discrepancy leaves large time gaps in the reporting of head position. Therefore, a different sensor may need to be utilized in future studies to improve outcomes.

Although the digital DVA does not replace the NeuroCom DVA in its current state, it may still be a viable option for clinicians that cannot afford the high cost of the NeuroCom system. Practitioners without access to advanced equipment, like the NeuroCom system, typically rely on clinical or bedside versions of vHIT and DVA testing to assess PVH. However, despite their cost-effectiveness, these methods have limitations in their ability to provide clear, objective outcomes[18-19]. For example, in clinical DVA testing, an examiner moves the subject's head while they attempt to verbally report what they read on a Snellen chart placed 10 feet in front of them. Due to the nature of its protocol, this testing method struggles to discriminate between left vs right vestibular impairment and is instead relegated to assessing the presence of significant and general PVH.[20] Because the dDVA is intended to pick up on and provide

quantitative outcomes for more subtle loses in VOR function, such as the presence of unilateral PVH, it may provide useful information to clinicians who do not have access to a NeuroCom system but still desire a more defined diagnosis.

The dDVA test used in this study is part of a software program (Health in Motion) that aims to incorporate both the assessment and therapeutic exercise components of a vestibular rehabilitation program into a single, portable unit that patients can operate within the comfort of their own home. This possibility for increased accessibility makes the dDVA setup an ideal one, provided it can deliver accurate assessments. Without accurate DVA testing, vestibular rehabilitation clinicians may find it difficult to evaluate the usefulness of the digital exercise programming that is tied to the Health in Motion program. While the dDVA test holds promise as a novel tool for assessing vestibular function, our findings highlight its current limitations in terms of validity and reliability compared to the established NeuroCom measures. Further refinement and validation efforts will be necessary to improve the accuracy and consistency of the dDVA system.

References

1. Grill E, Heuberger M, Strobl R, et al. Prevalence, Determinants, and Consequences of Vestibular Hypofunction. Results From the KORA-FF4 Survey. *Front Neurol*. 2018;9:1076. doi:10.3389/fneur.2018.01076
2. Dougherty JM, Carney M, Hohman MH, et al. Vestibular Dysfunction. [Updated 2022 Aug 29]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan. Available from: https://www.ncbi.nlm.nih.gov/books/NBK558926/
3. Erdinest N, London N, Lavy I, Morad Y, Levinger N. Vision through Healthy Aging Eyes. *Vision (Basel)*. 2021;5(4):46. doi:10.3390/vision5040046
4. World Health Organization. (2022, October 1). Ageing and Health. World Health Organization. Retrieved March 3, 2023, from https://www.who.int/news-room/fact-sheets/detail/ageing-and-health#:~:text=Every%20country%20in%20the%20world,aged%2060%20years%20or%20over.
5. McGarvie LA, MacDougall HG, Halmagyi GM, Burgess AM, Weber KP, Curthoys IS. The Video Head Impulse Test (vHIT) of Semicircular Canal Function - Age-Dependent Normative Values of VOR Gain in Healthy Subjects. *Front Neurol*. 2015;6:154. doi:10.3389/fneur.2015.00154
6. Pritcher MR, Whitney SL, Marchetti GF, Furman JM. The influence of age and vestibular disorders on gaze stabilization: a pilot study. *Otol Neurotol*. 2008;29(7):982-988. doi:10.1097/MAO.0b013e31818457fb
7. Bronstein AM, Patel M, Arshad Q. A brief review of the clinical anatomy of the vestibular-ocular connections-how much do we know?. *Eye (Lond)*. 2015;29(2):163-170. doi:10.1038/eye.2014.262
8. Fetter M. Vestibulo-ocular reflex. *Dev Ophthalmol*. 2007;40:35-51. doi:10.1159/000100348
9. Somisetty S, Das M. Neuroanatomy, Vestibulo-ocular Reflex. [Updated 2023 Jul 25]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK545297/
10. Robinson DA. Basic framework of the vestibulo-ocular reflex. *Prog Brain Res*. 2022;267(1):131-153. doi:10.1016/bs.pbr.2021.10.006
11. Starkov D, Strupp M, Pleshkov M, Kingma H, van de Berg R. Diagnosing vestibular hypofunction: an update. *J Neurol*. 2021;268(1):377-385. doi:10.1007/s00415-020-10139-4
12. Hall CD, Herdman SJ, Whitney SL, et al. Vestibular Rehabilitation for Peripheral Vestibular Hypofunction: An Updated Clinical Practice Guideline From the Academy of Neurologic Physical Therapy of the American Physical Therapy Association. *J Neurol Phys Ther*. 2022;46(2):118-177. doi:10.1097/NPT.0000000000000382
13. Zamaro E, Saber Tehrani AS, Kattah JC, et al. VOR Gain Calculation Methods in Video Head Impulse Recordings. *J Vestib Res*. 2020;30(4):225-234. doi:10.3233/ves-200708
14. Riska KM, Hall CD. Reliability and Normative Data for the Dynamic Visual Acuity Test for Vestibular Screening. *Otol Neurotol*. 2016;37(5):545-552. doi:10.1097/mao.0000000000001014

15. Herdman SJ, Tusa RJ, Blatt P, Suzuki A, Venuto PJ, Roberts D. Computerized dynamic visual acuity test in the assessment of vestibular deficits. Am J Otol. 1998;19(6):790-796.
16. Murray N, Hunfalvay M, Roberts C, Lange B. Reliability and Normative Data of Computerized Dynamic Visual Acuity Tests. *Vision Dev Rehabil*. 2017;3(1):24-33. doi:10.31707/vdr2017.3.1.p24
17. Janky KL, Patterson JN, Shepard NT, Thomas MLA, Honaker JA. Effects of Device on Video Head Impulse Test (vHIT) Gain. *J Am Acad Audiol*. 2017;28(9):778-785. doi:10.3766/jaaa.16138
18. Jorns-Häderli M, Straumann D, Palla A. Accuracy of the bedside head impulse test in detecting vestibular hypofunction [published correction appears in J Neurol Neurosurg Psychiatry. 2008 Aug;79(8):967]. *J Neurol Neurosurg Psychiatry*. 2007;78(10):1113-1118. doi:10.1136/jnnp.2006.109512
19. Dannenbaum E, Paquet N, Chilingaryan G, Fung J. Clinical evaluation of dynamic visual acuity in subjects with unilateral vestibular hypofunction. *Otol Neurotol*. 2009;30(3):368-372. doi:10.1097/MAO.0b013e31819bda35

Figure Legends

Figure 1. DVA testing using the NeuroCom SMART EquiTest (version 9.2.0) with InVision™ software.

Figure 2. A person undergoing DVA testing via the new digital DVA testing system.

Figure 3. Validity of dDVA (y-axis) compared to the gold standard NeuroCom DVA (x-axis) for right and left DVA loss.

Figure 4. Reliability of the dDVA test determined through comparison of results for first (x-axis) and second (y-axis) sessions for right and left DVA loss.

Table. Descriptive outcomes (mean, SD, range) of NeuroCom and Digital DVA testing for all subjects (n = 15)

		Pearson Correlations (r)*
	Initial Visit	
NeuroCom Right DVA Loss (logMAR)	0.22 ± 0.17 (-0.12–0.40)	-0.015
Digital Right DVA Loss (logMAR)	0.25 ± 0.11 (0.07–0.44)	
NeuroCom Left DVA Loss (logMAR)	0.22 ± 0.14 (-0.08–0.40)	0.025
Digital Left DVA Loss (logMAR)	0.28 ± 0.15 (0.10–0.63)	
		ICCs (r) †
	Second Visit	
Digital Right DVA Loss	0.27 ± 0.11 (0.10–0.47)	0.313
Digital Left DVA Loss	0.24 ± 0.11 (0.10–0.54)	0.366

*Pearson Correlations between NeuroCom and Digital DVA testing

† Intraclass Correlation Coefficients between initial and second Digital DVA testing

Figure 1. DVA testing using the NeuroCom SMART EquiTest (version 9.2.0) with InVision™ software.

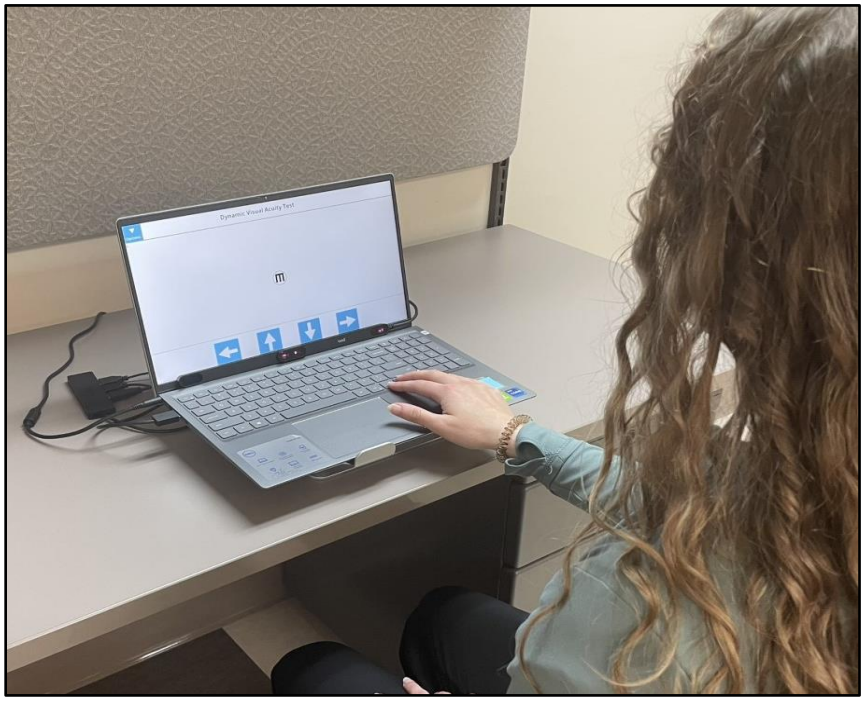
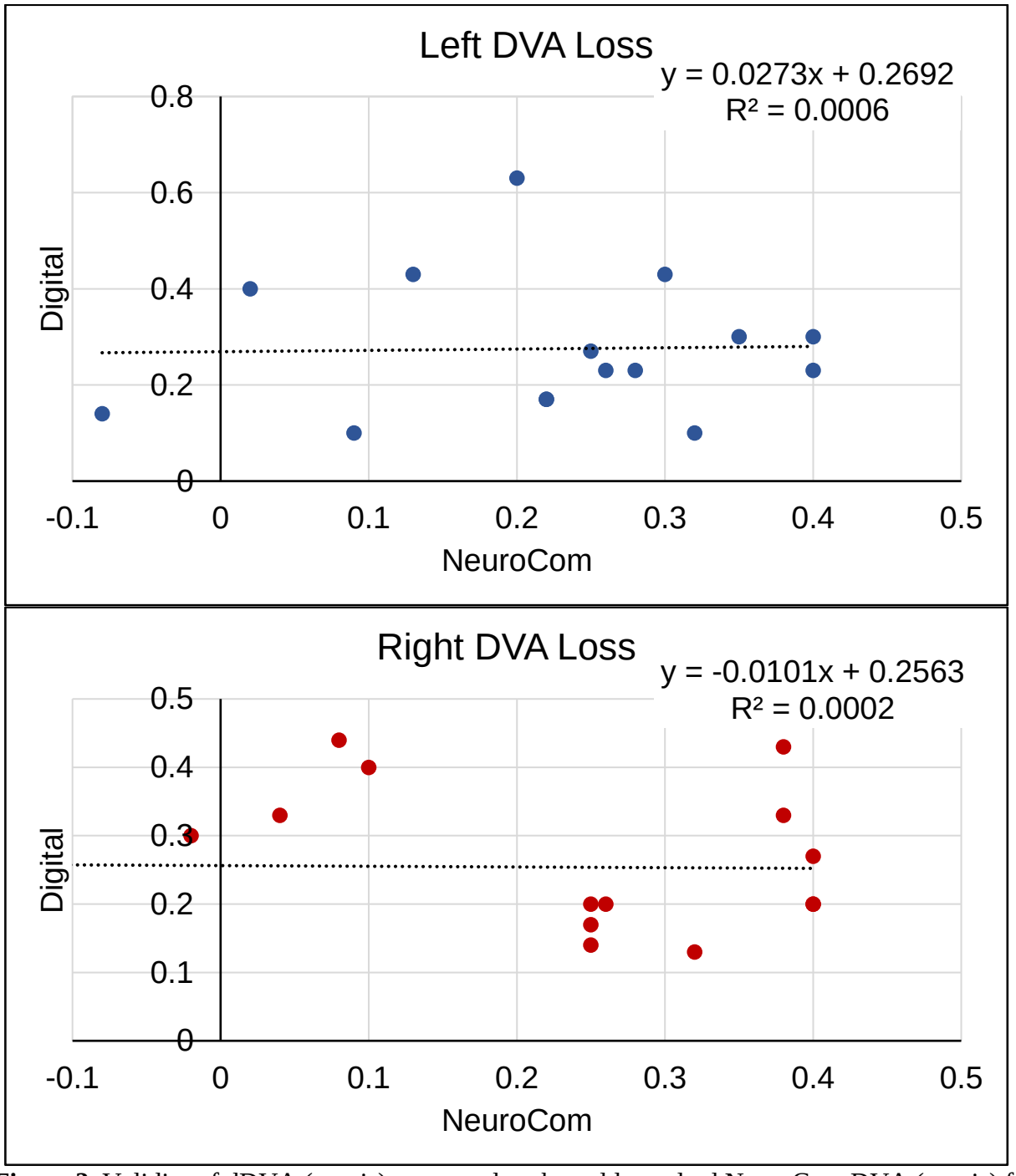


Figure 2. A person undergoing DVA testing via the new digital DVA testing system.



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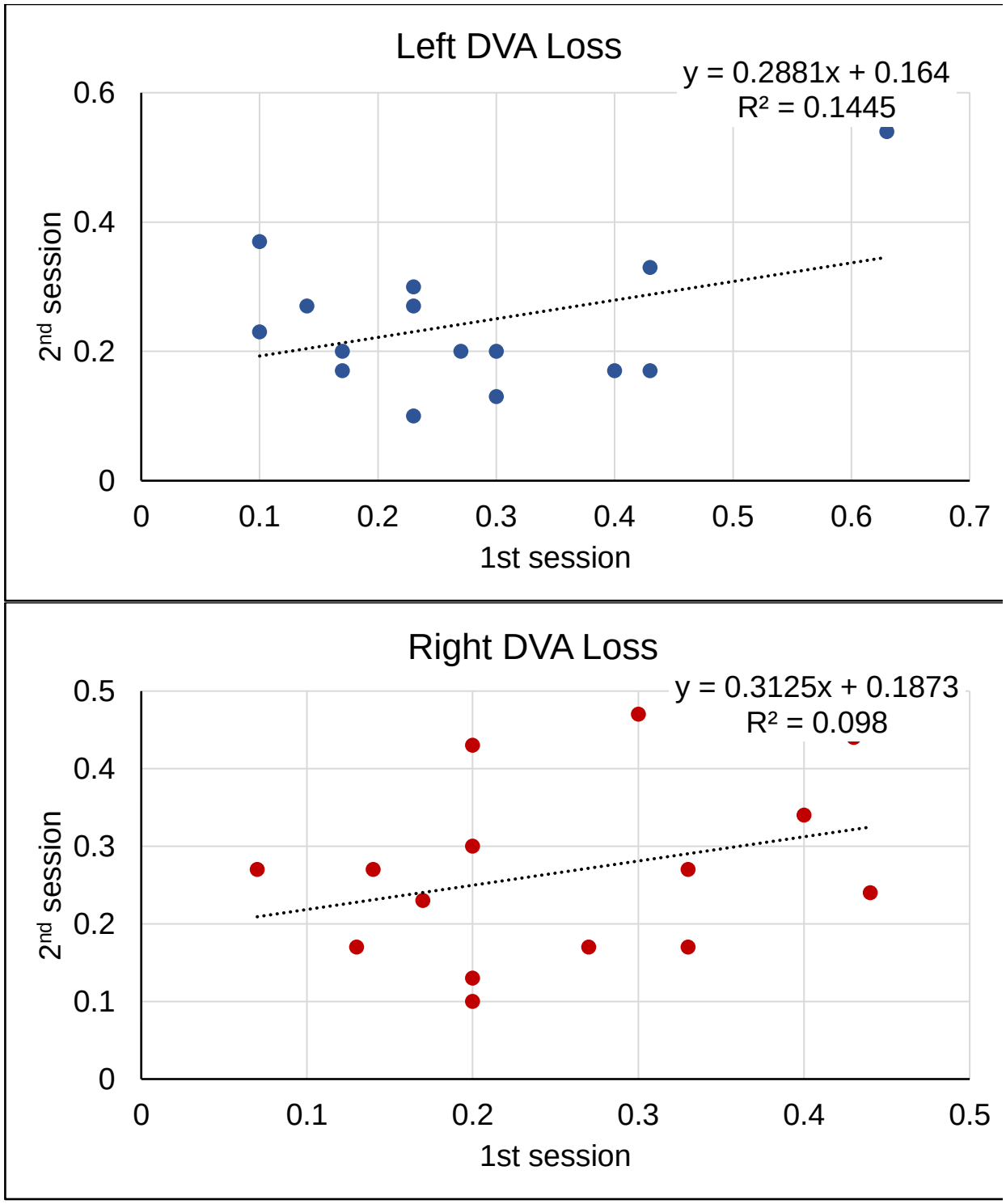

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