THE EFFECTIVENESS OF ELECTRONIC MULTISENSORY DEVICES VS. CLASSIC VISION THERAPY PROCEDURES

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Has been approved

May, 2011

ACCEPTED:

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Doctor of Optometry Senior Paper
Library Approval and Release

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ABSTRACT

Background: The purpose of this study was to determine the effectiveness of utilizing multisensory gaming devices such as the Nintendo Wii™ for therapy of oculomotor dysfunctions, in comparison to the effectiveness of traditional Wayne Saccadic Fixator (WSF) and rotator vision therapy procedures.

Methods: Oculomotor skills of participating Ferris State University Honors students were assessed via a screening process involving the Developmental Eye Movement (DEM) test and the Visagraph Readalyzer. Thirty-eight subjects met the requirements for normal oculomotor skills and were randomly divided into two equal groups: control and experimental. The control group underwent four weeks of vision therapy using traditional WSF and rotator procedures, while the experimental group conducted four weeks of vision therapy using Nintendo Wii Sports™ and Guitar Hero™ procedures. At the conclusion of vision therapy, the oculomotor skills of each subject were reassessed with the DEM and Visagraph tests.

Results: Statistical analysis of participants' oculomotor skills following vision therapy with Nintendo Wii™ revealed results no different than that of traditional methods. Additionally, both groups showed statistically significant improvements in these skills.

Conclusions: Multisensory gaming devices such as the Nintendo Wii™ are viable options for vision therapy of oculomotor skills in place of or in conjunction with traditional oculomotor vision therapy devices.

ACKNOWLEDGEMENTS

We would like to express our sincere gratitude to all those that have helped make this project a reality. To our families, thank you for the patience to see us through the long hours and endless nights preparing, completing, and finishing our project. To our advisor, professor, friend, and colleague, Dr. Daniel Wrubel, thank you for your insight, enthusiasm, and assistance in developing and seeing this study through. To Dr. Robert Buckingham, we thank you for your assistance in analyzing and understanding our data. To the staff at the Michigan College of Optometry, thank you for your numerous kind acts that have helped make this study a success. To the Ferris State University Honors program staff, thank you for your help in recruiting students to participate in this study. To the Honors students, thank you for your time and dedication. Without you, this project would not have happened. To Mike Bulof at Pioneer International, a sincere thanks to you and your company for loaning us patches and anaglyphic glasses necessary to complete this study. Without the help of so many people this project would never have been seen through to completion. Thank you to all!

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INTRODUCTION

Society places a high value on the role of our visual system in learning. The American Optometric Association (AOA) reports that 80% of all learning is visual.[1] In order for learning to be efficient, many components of the visual system need to work in unison. When they do, the system is capable of decoding images from visual space for the interpretation of that information. When the system is dysfunctional, an individual may struggle even through the simplest of tasks.

Small, but important parts of the visual system include the basic skills of saccades, pursuits, and fixations which function for tracking and scanning. Combined, these skills are better known as oculomotor skills. Saccades are fast eye movements that are used to quickly change fixation from one object to another. Pursuits allow us to follow an object moving at a steady velocity. Fixations involve maintaining one's gaze on a target. Oculomotor dysfunctions can lead to inefficiency of the visual system whereby individuals may experience a decrease in speed, efficiency, attention, and/or comprehension, as well as an increase in errors during visual tasks.[2]

Vision therapy, also known as vision training or orthoptics, is aimed at the management and enhancement of the visual system to function with its fullest potential. Treatment methods for vision therapy are highly individualized and variable based both on practitioner and patient goals. Whatever the treatment plan, vision therapy typically involves multiple visits to the optometric physician's office. Therapy involves repetition and training tasks, by means of any number of devices, in addition to at-home procedures to supplement the in-office activities. Prisms, loose lenses, anaglyphic

glasses, occluders, filters, and computer programs are just a few of the tools utilized by eye care providers for vision therapy.[3,4]

More specifically, the use of the Wayne Saccadic Fixator (WSF) and rotators has long been part of standard treatment for oculomotor vision therapy.[2,3] Both devices integrate visual, auditory, and motor components that aid in developing fixation, saccadic, and pursuit skills. Electronic multi-sensory gaming devices such as the Nintendo Wii™ also integrate these very same skills. The Nintendo Wii™ has already found a niche with numerous physical therapy and rehabilitation programs worldwide. The Wii™ system has reportedly been used for physical fitness and balance training in nursing homes, as well as rehabilitation for stroke and cerebral palsy patients.[5,6,7]

Researchers have begun to analyze the effects of gaming systems on the visual system. One study found a positive impact on contrast sensitivity with gaming.[8] Another correlated visual attention and processing skills to use of the video games.[9] The purpose of this study was to determine whether Nintendo's Wii™ gaming system would be useful in vision therapy programs, specifically to help treat oculomotor dysfunction involving pursuit, saccade and fixation deficits.

METHODS

PATIENT SELECTION

After seeking approval by the Human Subjects Research Committee, Ferris State University Honors students were recruited for participation in the study. Students were invited to a pre-study session where each participant was given a packet which contained an Information Sheet, Consent Form, and Contact Information Form including medical and ocular history (Appendixes A-C). Subjects were encouraged to participate on a volunteer basis, with an incentive to receive community service hours.

A vision screening was later conducted to assess visual skills for participation in the study. Screening included Snellen distance and near monocular acuities, distance and near cover testing for binocular posture, and Wirt ring stereopsis. The Developmental Eye Movements (DEM) test and the Visagraph Readalyzer were also administered to establish baseline data and for final analysis at the conclusion of the study.

Inclusion criteria required a minimum age of 18 years, best corrected monocular acuities of 20/30 or better, and binocular stereopsis of at least 40 arc seconds (Table 1). Participants with history of strabismus, brain injury, seizure, major surgery and/or debilitating symptoms were excluded from the study. Thirty-eight subjects met the inclusion criteria. Each subject was assigned a subject number at random for identification purposes throughout the vision therapy sessions. Participant's identifying information was never revealed to examiners involved in data collection or interpretation.

Table 1: Inclusion Criteria for Vision
▪ Monocular VA ≤ 20/30
▪ Local stereopsis ≤ 40 seconds of arc
▪ Negative history of strabismus

PROCEDURE

Subjects were divided equally and at random into two groups: control and experimental. The control group (Group 1) was assigned vision therapy using traditional WSF and rotator procedures. The experimental group (Group 2) underwent vision therapy using Nintendo Wii Sports™ and Guitar Hero™ procedures. Subjects from both groups attended eight sessions of therapy lasting twenty minutes in duration, over the course of four weeks. Supervision responsibilities were rotated between the two groups throughout the duration of the study.

During week one, subjects were acquainted with either the Nintendo Wii™ games or the WSF and rotators. Examiners instructed the subjects how to use each instrument. Group 1 therapy consisted of five minutes of exercises per eye using the WSF, and five minutes of exercises per eye using the rotator. Group 2 completed five minutes of exercises per eye using Wii Sports™ baseball and tennis, and five minutes of exercises per eye using Guitar Hero™. At the second session, subjects continued monocular exercises at higher difficulty levels.

During week two, biocular training was introduced with anaglyphic red/green glasses while maintaining the same activities as in week one. Exercise difficulty was increased gradually at each session, in accordance with the subject's progress. Gross motor and cognitive distracters were added at the second session. Distracters included saying "hit" while hitting the ball for Wii Sports™ activities, reciting the alphabet from A-Z then Z-A, and counting aloud from 1-100 then 100-1.

Week three introduced binocular therapy activities, with the difficulty levels increasing

into week four. Additional distracters were added as needed; including muting the gaming system or WSF, stabilizing on a teeter board, or saying the color of key being played for Guitar Hero™. In addition, speed and difficulty levels were increased. Therapy plans were adjusted on an individual basis during the study, in accordance with subjects' difficulty levels (vision therapy plans are further detailed in Appendix D and E). At the conclusion of the four weeks of vision therapy, each participant was reevaluated with DEM and Visagraph testing.

RESULTS

Participating in the study were 16 males and 22 females, ranging in age from 18 to 21 years (mean age of 18.74 ± 1.04 years) and meeting the requirements for normal ocular health and function. All 38 subjects completed the study in its entirety. The data from one control group outlier was withheld from statistical analysis.

The markers by which the study weighed its effectiveness were the DEM and Visagraph tests. The DEM measures the saccadic movements of the eyes by having patients read through a series of numbers as quickly as possible. Vertical and horizontal speeds are documented and adjusted for errors and then calculated into a ratio.[10]

Statistically significant improvements were noted for the both group's adjusted horizontal time results. Mean adjusted horizontal times for Group 1 decreased from 28.20 to 25.43 seconds (s=0.002). Group 2 reduced the average adjusted horizontal time from 28.53 to 24.89 seconds (s=0.000).

Table 2: DEM Results

	Mean Adjusted Horizontal Time		Mean Calculated Ratio	
	Before	After	Before	After
Group 1: Traditional VT	28.20	25.43	1.02	1.05
Group 2: Wii VT	28.53	24.89	1.15	1.05

Another analysis of the data was done comparing the differences in calculated DEM ratios. The ratio is calculated by dividing the adjusted horizontal time by the total vertical time. The mean DEM ratios before the study were 1.06 ± 0.11 for Group 1 and 1.15 ± 0.14 for Group 2. After the four weeks of respective therapy programs, DEM ratios for both groups showed overall reductions; however only the experimental group showed statistically significant improvement. The ratios were as follows: 1.05 ± 0.08 (s=0.663) for Group 1 and 1.05 ±0.10 (s=0.003) for Group 2. Although the data suggests improvement in saccadic skills for both groups, researchers have indicated that the DEM ratio may be a less reliable indicator of oculomotor dysfunction than the horizontal score, especially in higher grade levels.[10,11]

The Visagraph monitors eye movements while a subject reads a paragraph. The computer-based system tracks fixations, average duration of fixations, regressions, and number of saccades per return sweep. Words per minute reading speeds, estimated grade level efficiencies, and overall comprehensions are also calculated.[10] For comparison between the experiment and control groups, reading rate and mean grade level efficiency were analyzed.

Visagraph analysis of both the control and experimental groups did not produce statistically significant results for average reading speed or grade level. The preliminary screening showed subjects in Group 1 held an average reading speed of 277.61 ± 124.01 words per minute (WPM) and grade level efficiency of 11.36 ± 3.41. Group 2 had an average reading speed of 284.95 ± 83.30 WPM and grade level efficiency of 11.83 ± 3.12.

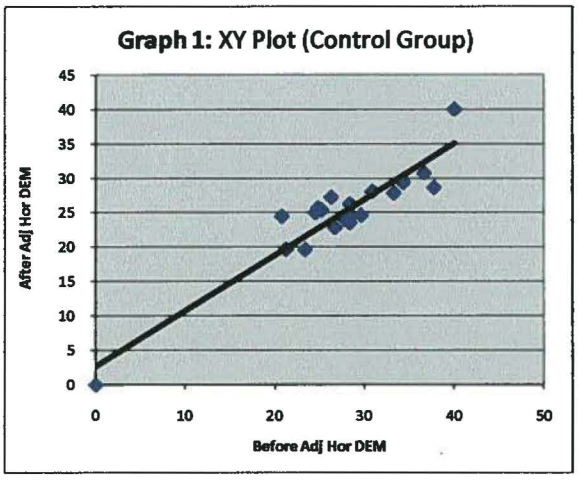
Following the vision therapy sessions, Group 1 reading speed decreased to 270.39 ± 663.14 WPM (s=0.683), but reading level increased to 11.88 ± 2.39 (s=0.489). Group 2 data increased to speeds averaging 304.11 ± 100.99 WPM (s=0.452) with a mean 12.10 ± 2.97 grade level (s=0.772).

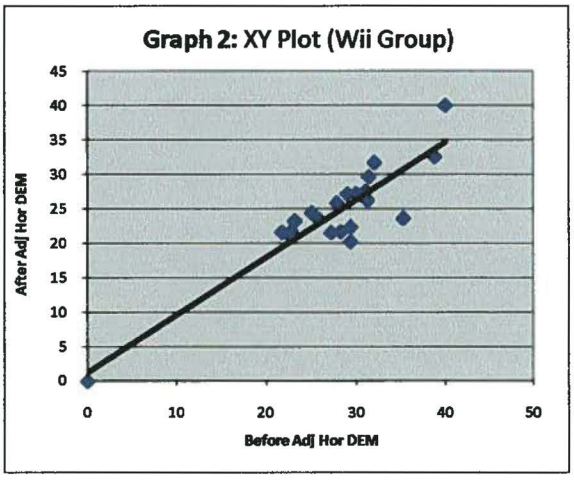
Table 3: Visagraph Results

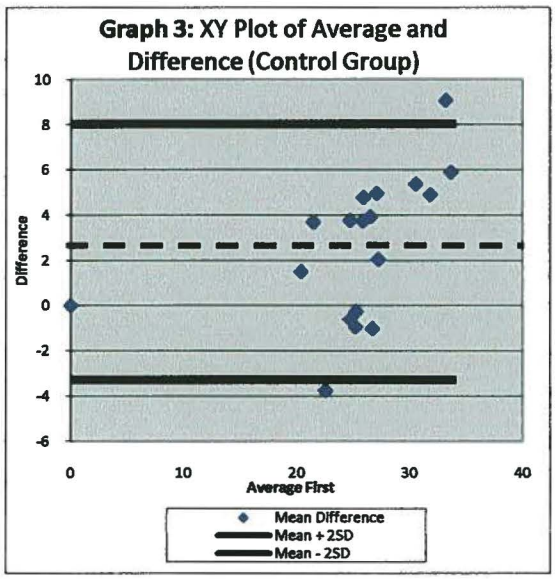
	Reading Rate: words per minute		Mean Grade Level Efficiency	
	Before	After	Before	After
Group 1: Traditional VT	277.61	270.39	11.36	11.88
Group 2: Wii™ VT	284.95	304.11	11.83	12.10

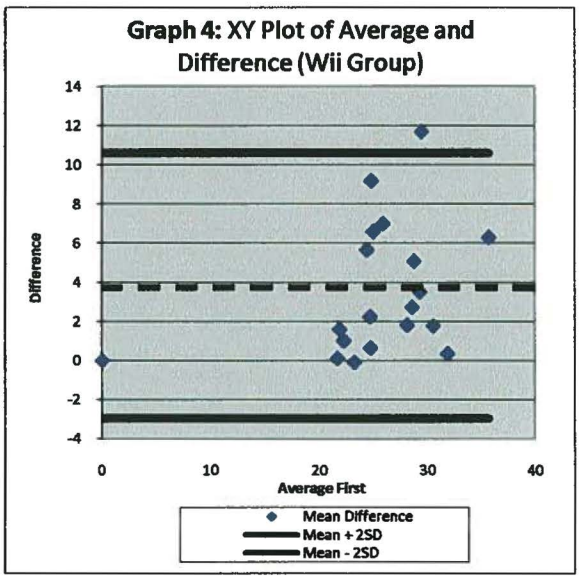
Bland-Altman analysis was further conducted to equivocate the effectiveness between the control and experimental groups. Paired t-test results only indicate statistically significant improvements for DEM adjusted horizontal scores. The t-test does not allow for comparison of equivalence between the two groups. The Bland-Altman method allows these statements to be made.[12]

The XY plots of the before and after data for both the control (Graph 1) and experimental (Graph 2) groups had similar slopes to the trend line and showed comparable clustering of data points. However, the XY plots of average and differences for the two groups showed slightly different results. The plot for Group 2 revealed a mean difference of 3.8 (Graph 4). Group 1, also showed an increased average difference in the adjusted horizontal DEM score, but less substantial at a measure of only 2.4 (Graph 3).


Graph 1: XY Plot (Control Group)
After Adj Hor DEM
Before Adj Hor DEM
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50


Graph 2: XY Plot (Wii Group)
After Adj Hor DEM
Before Adj Hor DEM
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50


Graph 3: XY Plot of Average and Difference (Control Group)
Difference
Average First
10
8
6
4
2
0
-2
-4
-6
0
10
20
30
40
Mean Difference
Mean + 2SD
Mean - 2SD


Graph 4: XY Plot of Average and Difference (Wii Group)
Difference
Average First
14
12
10
8
6
4
2
0
-2
-4
0
10
20
30
40
Mean Difference
Mean + 2SD
Mean - 2SD

DISCUSION

Results from the study indicate that using multisensory devices for vision therapy can work to improve oculomotor skills, similar to or better than more traditional procedures. Following either four weeks of Wii Sports™ and Guitar Hero™ or traditional therapy plans, both groups showed noteworthy improvements in oculomotor skills. Visagraph results were not found to be statistically significant, even though differences in means indicated minor improvements for both groups, except for the reading comprehension rates of Group 1. Results from the Visagraph may have been confounded by patient effort, repeatability of the test, or any slight variations in instructor directions. However, of significance were DEM findings. Only the experimental group showed statistical improvement in DEM ratio scores. Independent t-test analysis of the DEM adjusted horizontal time indicated improvement for both the control and experimental groups, demonstrating there is no statistical difference between the more traditional vision therapy approach and the Wii Sports™ and Guitar Hero™ training. Analysis by the Bland-Altman method suggested findings that the Wii™ training may actually produce better results than traditional vision therapy practices, thus providing further evidence that these types of devices can be incorporated into traditional oculomotor therapy programs to offer a variety of options for practitioners and patients.

Gaming systems such as the Wii™ have many advantages over other traditional means of vision therapy. The Wii™ system, in addition to other multisensory gaming devices, captivates interest among children, adolescents, and adults.

The entertainment and variety of exercises makes vision therapy engaging and enjoyable. Gaming systems are also relatively low in cost and are easily accessible. Other medical specialists have already benefitted from incorporating these systems into their rehabilitation plans. This study provides evidence to support the use of multisensory devices within vision therapy programs.

Future studies may uncover even greater potential for gaming systems in optometry. This study had a few limitations, which could be adapted in future research. The subject pool for this project consisted of healthy college students with normal binocular systems. Subjects with true oculomotor dysfunctions would better test the effectiveness of the Nintendo Wii™ system for vision therapy. Using better indicators for improvement with more reliable results for evaluation would also be desirable. Although DEM and Visagraph are often used for this purpose, both can produce learning curves that impact variability.[10] Patients' self-motivation throughout the study may fluctuate and also influence results. One final shortfall of this research project was the small population size. Studies incorporating more participants will show more definitive significance.

Electronic multisensory devices are not only useful for entertainment, but also provide many benefits for oculomotor therapy including user-friendly interfaces, low costs, and in-home availability. Incorporation into current vision therapy programs offers fresh perspective and welcomed variety to patients and practitioners. While further research should be conducted to support the efficacy of utilizing gaming devices, they show grand potential for use in vision therapy programs.

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APPENDIX A

INFORMATION SHEET

INFORMATION SHEET

INTRODUCTION

You are being asked to participate in a research study. In order to decide whether or not you want to be a part of this study, you should understand fully the demands and benefits to make an informed decision. Upon reading this consent form, you will be asked to sign the form indicating your desire to participate.

DESCRIPTION

Students at the Michigan College of Optometry are studying the effects of vision therapy on the oculomotor system. This research is being conducted as a senior project for the students' requirements for graduation.

As a Ferris State University Honors student, you are being asked to volunteer time for the research project. During an initial screening, visual acuity (VA), Developmental Eye Movement (DEM), and Visagraph will be tested. Upon meeting the study criteria, you will randomly be assigned a research identification number and contacted to set up therapy dates and times.

Vision therapy will consist of a total of eight sessions, two each week for four weeks. Each session will take no more than one hour time and will require no preparation on your behalf. At the conclusion of the eight sessions, a short reevaluation of your oculomotor system will be assessed using the same tests as the initial screening. In return for volunteer hours of service, subjects will be awarded community service hours.

ELIGIBILITY & COMMITMENT

In order to participate, you must currently be a FSU Honors student. Signs of amblyopia, strabismus, uncorrected vision, or other ocular conditions may exclude you from the study. Students with medical conditions will be assessed on an individual basis for inclusion in the study, based on severity, debilitation, and relevance of the condition.

You must be able to attend all eight sessions to be included in the study, in addition attend the initial screening and reevaluation. There are no fees associated with the study, nor monetary compensation. You must also refrain from playing Wii Sports™ and/or Guitar Hero® outside of the study during your six weeks of vision therapy.

BENEFITS

You will be awarded volunteer hours for participation, at minimum ten hours of service. A certificate will be provided verifying your participation. Furthermore, this is a great opportunity to experience firsthand the binocular vision aspect of optometry!

CONFIDENTIALITY

A third party Michigan College of Optometry student will be responsible for processing identifying and contact information, along with awarding service hours. Each participant will be randomly assigned a subject number (SN) during the initial screening and only your number will be used for identification purposes throughout the study.

Participation will in no way have any effect on class grades, acceptance into graduate school programs, or any other academic achievement. All identifying information will be kept completely anonymous, with exception of your subject number.

APPENDIX B

CONSENT FORM

CONSENT FORM

I have been satisfactorily informed of the aforementioned details of this research study. I have read and understand all the requirements and agree to the terms of study. I give permission for my participation in this study and for the use of the associated findings of the study.

I understand that if I have any questions at any time before, during, or after the study, Dr. Dan Wrubel, study advisor, can be contacted by email or phone (wrubeld@ferris.edu or (231) 591-2193) for any concerns that I may have. I am signing this consent form before participation in the study. I know that I am free to withdraw from the study at any time, but will not receive volunteer hours for my service, even after signing this form. I have been offered a copy of the research consent form information.

By signing this consent form that all identifying information provided is correct to the best of my knowledge. All information provided will be held in strict confidence, used only for the purpose of this research project.

_____ _____

Signature of Participant Date

Thank you for considering your participation in our study. Your volunteer time is greatly appreciated by all those involved in and benefiting from this research project.

As a subject in this study, your randomly assigned subject number will be the only identifying information used. It is imperative to remember this number when arriving for research sessions!

Subject Number (SN): _____

APPENDIX C

CONTACT INFORMATION FORM

CONTACT INFORMATION

Last Name	First Name	MI	Hall Name	Room #
Local Address		City	State	Zip Code
E-mail*		Room phone*	Cell phone*	

*Please provide a phone number and/or email address that is easiest to contact you at. Primary correspondence for the study will be by e-mail.

PERSONAL MEDICAL HISTORY- Do you have any of the following health problems?

	Y	N	If yes, please explain.
Cardiovascular (high blood pressure, vascular disease, etc)			
Respiratory (asthma, emphysema, etc)			
Muscles/Bones/Joints (arthritis, etc)			
Endocrine (diabetes, thyroid, etc)			
Psychiatric (anxiety, depression, etc)			
Blood/Lymph (anemia, high cholesterol, etc)			
Allergic/Immunologic (hay fever, lupus, etc)			
Neurological (headaches, MS, etc)			

- List medications you are currently taking (prescription & over-the-counter)? _____
- Do you have any allergies to medications? Y N If yes, please explain. _____
- List major illnesses, injuries, and surgeries you have had. _____
- Date/Place of last physical exam _____ Are you pregnant/nursing? Y N

PERSONAL EYE HISTORY- Do you have any of the following ocular conditions?

	Y	N	If yes, please explain.
Reading/learning disability			
Color vision deficiency			
Amblyopia/lazy eye			
Eye turn/strabismus			
Glaucoma			
Cataract			
Macular Degeneration			

As a subject in this study, my randomly assigned subject number will be the only identifying information I use throughout the six weeks of research. It is imperative that I remember this number when arriving for research sessions!

Subject Number (SN): _____

APPENDIX D

VISION THERAPY PLAN- GROUP A

S	Wayne Saccadic Fixator (10 min)	Rotators (10 min)
1 Monocular	OD, OS • Subj. sitting down • 20 attempts OD, OS • Record Times OD, OS	OD, OS • Subj. standing 1 ft from rotator • Baseline speed setting at medium • Pegboard – Subj. creates a designated design w/ pegs (square, triangle, star) using only one hand (switch hands on second attempt) • Sound Rotation – Subj. hits Buzzer when a designated target reaches 3, 6, 9, and 12 o'clock positions • Record type of attempt OD, OS, and speed setting
2 Monocular	OD, OS • Subj. standing up • 20 attempts OD, OS • Record Times OD, OS	OD, OS • Subj. standing 1 ft from rotator • Increase speed setting to make challenging • Pegboard – Subj. creates a designated design w/ pegs (square, triangle, star) using only one hand (switch hands on second attempt.) • Sound Rotation – Subj. hits Buzzer when a designated target reaches 3, 6, 9, and 12 o'clock positions • Record type and attempts OD, OS, speed setting,
3 Bi-Ocular	R/G glasses OU (Red lens over OD) • Subj. standing up • Subj. must say the letter of the button as he/she hits the button • Record number of attempts OU • 20 games/session	Vertical Prism (6-8^ BU) OU • Subj. Standing 2 ft from rotator • Subj. follows designated target on upper image through one complete rotation, then follows same target on lower image through one complete rotation R/G glasses OU (Red lens over OD) • Flashlight rotation - Subj. follows designated green target with red flashlight as rotator moves. • Record type and attempts OU, and speed setting
4 Bi-Ocular	R/G glasses OU (Red lens over OD) • Subj. standing up • Subj. must say the letter of the button as he/she hits the button • Record number of attempts OU • Record Times OU	Vertical Prism (6-8^ BU) OU • Subj. Standing 3-4 ft from rotator • Increase speed setting R/G glasses OU (Red lens over OD) • Subj. follows designated green target with red flashlight • Record type of attempts OU, speed setting, & time per attempt.

S	Wayne Saccadic Fixator (10 min)	Rotators (10 min)
5 Binocular	OU • Subj. Sitting down • Record # of attempts OU • Record Times OU	OU • Pegboard designs (square, triangle, star) *see week 1 directions • Light rotation – Subj. follows designated target w/ red flashlight • Record type of attempts OU, speed setting, & time per attempt.
6 Binocular	OU • Subj. standing up • Record # of attempts OU • Record Times OU	OU • Pegboard designs (square, triangle, star) *see week 1 directions • Light rotation – Subj. follows designated target w/ red laser pointer • Record type of attempts OD, OS, speed setting, & time per attempt.
7 Binocular	OU • Subj. standing in front of WSF → Add teeter board on 2nd attempt. • Distractions (add on later attempts if time warrants): Subj. says letter of button as button is his, Subj. counts up to 100, Subj. says alphabet • Record # of attempts & times OU • Record distractions used	OU • Subj. standing 3-4 ft from rotator • Baseline speed • Subj. follows designated target with little-to-no head/body movement • Distractions: Subj. counts up to 100, Subj. says alphabet, Subj. on teeter board • Record type of attempts OU, speed setting, & time per attempt.
8 Binocular	OU • Subj. standing on teeter board in front of WSF • Distractions (add on later attempts if time warrants): Subj. says letter of button as button is his, Subj. counts up to 100, Subj. says alphabet • Record # of attempts & times OU • Record distractions used	OU • Subj. standing 3-4 ft from rotator • Increased speed • Subj. follows designated target with little-to-no head/body mvmt • Distractions: Subj. counts up to 100, Subj. says alphabet, Subj. on teeter board • Record type of attempts OU, speed setting, & time per attempt.

At each session, record the following:

- Subj. difficulty with the procedure/task
- Subj. comments/attitude toward the procedures
- PreceSubj.ors overall comments/observations

*For each procedure, subject's head should remain as still as possible, centered on the middle of the task.

Distractions Short-Hand Notations:

A. Subj. says letter of button as button is hit
B. Subj. counts up to 100
C. Subj. says alphabet
D. Subj. on teeter board
E. Subj. says color of the button as he/she hits the button
F. Subj. says "Hit" as ball is hit
G. Volume Off

APPENDIX E

VISION THERAPY PLAN – GROUP B

S	Guitar Hero (10 min)	Wii Sports Tennis (10 min)
1 Monocular	OD, OS • Subj. standing 36 inches from TV's 1 & 2 • Begin on Easy • Record Level, Score, & Notes Hit OD, OS	OD, OS • Subj. standing 43.6 inches from TV 3, 51.6 inches from TV 4 • Begin with Tennis Training (all three) (5 min) and record results • At 5 min, switch to playing Tennis Matches (Single Matches) o Subj.'s play the system o Record games, scores, winners/losers
2 Monocular	OD, OS • Subj. standing 12 inches from TV's 1 & 2 • Begin on Easy, move up if Subj. is has >95% accuracy • Record Level, Score, & Notes Hit OD, OS	OD, OS • Subj. standing 12.6 inches from TV 3, 15.36 inches from TV 4 • Begin with Tennis Training (all three) (5 min) and record results • At 5 min, switch to playing Tennis Matches (Single Matches) o Subj.'s play the system • Record games, scores, winners/losers
3 Bi-Ocular	R/G glasses OU (Red lens over OD) • Subj. standing 36 inches from TV's 1 & 2 • Begin on Easy, move up if Subj. is has >95% accuracy • Record Level, Score, & Notes Hit OD, OS	R/G glasses OU (Red lens over OD) (R/G Acetate sheets over TV) • Subj. standing 43.6 inches from TV 3, 51.6 inches from TV 4 • Begin with Tennis Training (all three) (5 min) and record results • At 5 min, switch to playing Tennis Matches (Single Matches) o Subj.'s play the system • Record games, scores, winners/losers
4 Bi-Ocular	R/G glasses OU (Red lens over OD) • Subj. standing 12 inches from TV's 1 & 2 • Begin on Easy, move up if Subj. is has >95% accuracy • Distractions as needed to keep challenging for subject • Record Level, Score, Notes Hit and Distractions OU	R/G glasses OU (Red lens over OD) (R/G Acetate sheets over TV) • Subj. standing 12.6 inches from TV 3, 15.36 inches from TV 4 • Distractions as needed to keep challenging for subject • At 5 min, switch to playing Tennis Matches (Single Matches) o Subj.'s play the system • Record games, scores, winners/losers, and distractions
5 Binocular	OU • Subj. standing 36 inches from TV's 1 & 2 • Begin on Easy, move up if Subj. is has >95% accuracy • Distractions as needed to keep challenging for subject • Record Level, Score, Notes Hit and Distractions OU	OU • Subj. standing 43.6 inches from TV 3, 51.6 inches from TV 4 • Begin with Tennis Training (all three) (5 min) and record results • At 5 min, switch to playing Tennis Matches (Single Matches) o Subj.'s play the system • Distractions as needed to keep challenging for subject • Record games, scores, winners/losers, and distractions

S	Guitar Hero (10 min)	Wii Sports Tennis (10 min)
6 Binocular	OU • Subj. standing 36 inches from TV's 1 & 2 • Begin on Easy, move up if Subj. is has >95% accuracy • Distractions as needed to keep challenging for subject • Record Level, Score, Notes Hit and Distractions OU	OU • Subj. standing 43.6 inches from TV 3, 51.6 inches from TV 4 • Begin with Tennis Training (all three) (5 min) and record results • At 5 min, switch to playing Tennis Matches (Single Matches) o Subj.'s play the system • Distractions as needed to keep challenging for subject • Record games, scores, winners/losers, and distractions
7 Binocular	OU • Subj. standing 12 inches from TV's 1 & 2 • Begin on Easy, move up if Subj. is has >95% accuracy • Distractions as needed to keep challenging for subject • Record Level, Score, Notes Hit and Distractions OU	OU • Subj. standing 12.6 inches from TV 3, 15.36 inches from TV 4 • Begin with Tennis Training (all three) (5 min) and record results • At 5 min, switch to playing Tennis Matches (Single Matches) o Subj.'s play the system • Distractions as needed to keep challenging for subject • Record games, scores, winners/losers, and distractions
8 Binocular	OU • Subj. standing 12 inches from TV's 1 & 2 • Begin on Easy, move up if Subj. is has >95% accuracy • Volume off • Distractions as needed to keep challenging for subject • Record Level, Score, Notes Hit and Distractions OU	OU • Subj. standing 12.6 inches from TV 3, 15.36 inches from TV 4 • Begin with Tennis Training (all three) (5 min) and record results • At 5 min, switch to playing Tennis Matches (Single Matches) o Subj.'s play the system • Volume off • Distractions as needed to keep challenging for subject • Record games, scores, winners/losers, and distraction

At each session, record the following:

- Subj. difficulty with the procedure/task
- Subj. comments/attitude toward the procedures
- Preceptors & Subject's overall comments/observations

Distractions Short-Hand Notations:

H. Subj. says letter of button as button is hit
I. Subj. counts to and from 100
J. Subj. says alphabet (A-Z, Z-A)
K. Subj. on teeter board
L. Subj. says color of the button as he/she hits the button
M. Subj. says "Hit" as ball is hit
N. Subject marches in place
O. Subject stands on one leg
P. Volume Off