Article ▸ Establishment of Standard Methods for the Measurement of Eye-Hand Visual-Motor Reaction Time

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ABSTRACT

Background: Eye-hand visual-motor reaction time (EH-VMRT) is critical for sports performance. However, there are no validated standardized methods available for determining baseline EH-VMRTs or for training EH-VMRT. This study validated methods for assessing baseline EH-VMRT and implementing training programs using the Sports Vision Trainer (SVT, Australia).

Methods: Proactive, Go/NoGo, and Reactive protocols were evaluated. Each protocol was examined using central and peripheral EH-VMRT tasks. Participants completed 10 trials of each task. The Proactive protocol was used to determine the number of trials needed to measure a baseline EH-VMRT. The relationship between stimulus duration (relative to baseline EH-VMRT) and response accuracy were examined for Go/NoGo and Reactive training protocols.

Results: Significant overall concordance was found for EH-VMRT across trials for central (ρ^c_o = 0.694) and peripheral (ρ^c_o = 0.858) tests. Session mean EH-VMRT was strongly concordant with the mean of the first three trials of the central (ρ_c = 0.908) task and the mean of the first 2 trials of the peripheral (ρ_c = 0.937) task. Moderate accuracy (75%) was achieved on Go/NoGo protocols when the stimulus duration was increased by 45 ms (central) and 94 ms (peripheral) relative to the baseline EH-VMRTs. Moderate accuracy was attained on Reactive protocols by adding 40 ms (central) and 59 ms (peripheral) to the baseline EH-VMRTs.

Conclusion: Representative baseline EH-VMRTs can be obtained within two to three trial runs for central and peripheral tasks. Implementation of Go/NoGo training programs require longer stimulus durations relative to baseline (70 ms) than Reactive training programs (50 ms) to achieve moderate accuracy, which suggests that Go/NoGo protocols may be more difficult than Reactive protocols. These methods should be used in the development of future sports vision training programs.

Keywords: eye-hand coordination, Sports Vision Trainer, visual-motor reaction time

Introduction

Vision and eye-hand visual-motor coordination play a critical role in sports performance. For example, many ball sports have very complex visual-motor integration demands because athletes must be aware of the location of the ball and other players in their visual field in order to be ready to react quickly and accurately to, and make decisions about, the dynamic visual environment of the game.[1] Eye-hand coordination is a specific type of visual-motor coordination. It is a complex function and involves using vision to guide hand movements while simultaneously using eye movements to optimize vision.[2] Eye-hand visual-motor reaction time (EH-VMRT) provides a measure of eye-hand coordination and is defined as the time between the presentation of a visual signal and the completion of a motor response with the hand.[3] At higher levels of sports, where it is imperative to maintain the maximum possible level of performance, faster EH-VMRTs may provide the edge necessary for success.[4] One question that has been of much interest in sports vision is whether or not EH-VMRT and eye-hand coordination can be improved with training. Previous studies have shown that training can decrease EH-VMRT in both the central and peripheral visual fields.[1,4] Moreover, this training appears to be transferrable to other tasks and areas of the visual field of view.[4] The effects of training also appear to be retainable for several weeks after completion.[5,6] Finally, research suggests that improvements in EH-VMRT and eye-hand coordination through training translate into improvements in performance during sports.[7,8]

In general, sports may be categorized into open-skill and closed-skill sports. Open-skill sports are those in which players are required to react in a dynamically changing, unpredictable environment and include many ball sports (e.g., basketball, tennis, soccer), whereas closed-skill sports are those in which the environment is relatively consistent and self-paced (e.g., running, swimming, gymnastics).[8] Previous studies have suggested that eye-hand coordination training may be especially beneficial in open-skill sports, particularly when the task is externally paced and involves dynamic choice responses.[8,9]

Many types of eye-hand coordination training tools have been designed that improve visual-motor reaction time in athletes.[10] There are currently no recognized standard

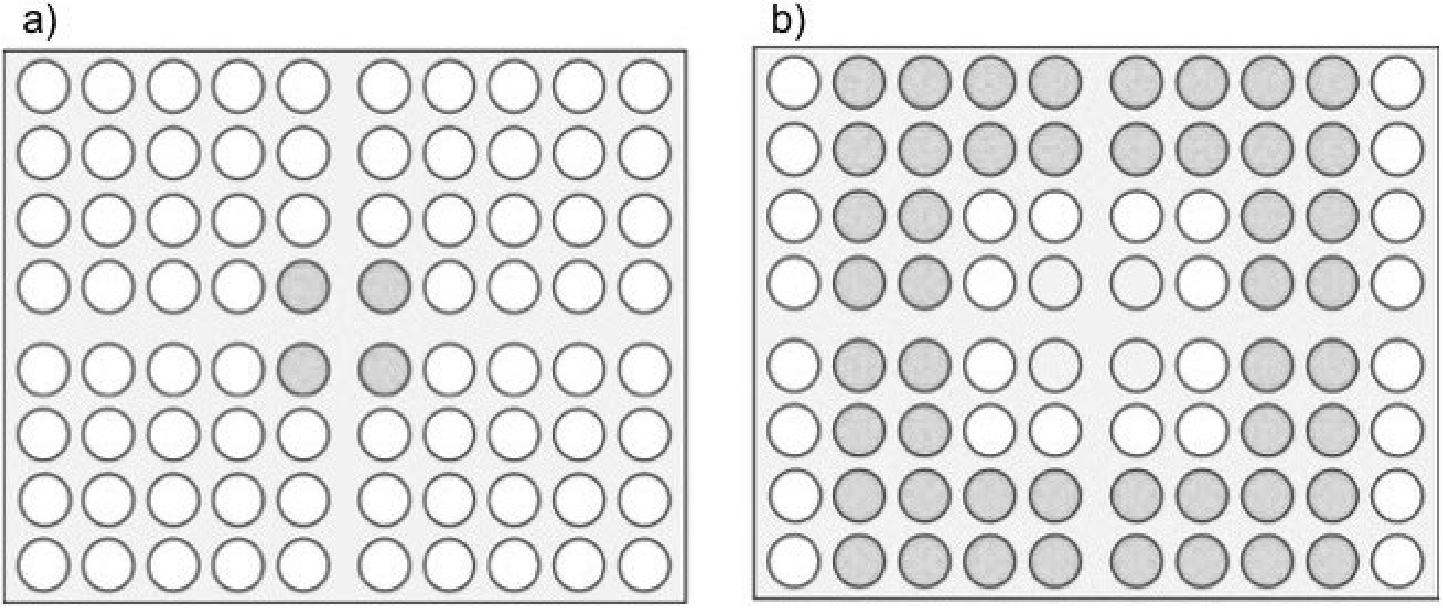

Figure 1. *Schematic diagram of SVT board with (a) central and (b) peripheral light configurations.*

methods for assessing and training eye-hand coordination, and researchers have traditionally used tools that either have not been validated or tools with little established accuracy.[11] The establishment of valid, reliable testing methods is important for researchers, clinicians, and coaches alike in order to ensure consistency between measures and methods used to improve eye-hand coordination in athletes. The establishment of valid, reliable testing methods would also permit easier comparison between devices that measure EH-VMRT.

The Sports Vision Trainer (SVT, Australia) is one device designed to measure EH-VMRT. The SVT board[12] is an advantageous tool for use with sports vision due to its versatility. It can be used to test simple EH-VMRT, where there is only one type of stimulus and one type of response, as well as complex Go/NoGo reaction times, which require participants to make quick and accurate decisions before reacting. During Go/NoGo tasks, participants are required to make a response when one type of stimulus (the Go stimulus) appears but to withhold the response when a second type of stimulus (the NoGo stimulus) appears. The aim of this type of training is to maximize the number of valid responses and to minimize the time it takes to respond to the Go stimuli while minimizing the number of invalid responses to NoGo stimuli. This ability to make quick online decisions is a skill that is very relevant to many sports. In baseball, for example, hitters must quickly decide whether or not to swing. They must be able accurately to determine the type of pitch and whether or not the ball will be inside or outside of the strike zone in a fraction of a second.[13] As with simple EH-VMRT, Go/NoGo reactions have been shown to improve with training.[13]

To date, there is limited data available on the use of the SVT and other eye-hand coordination training tools for the assessment and training of EH-VMRT. There has been only one study that has examined the reliability of the SVT as a measure of eye-hand coordination. This study found that acceptable reliability could be achieved after the completion of four sets of trials on the SVT. The four sets of trials were reliable when they were completed one week apart over the course of four weeks and also when they were completed all at once in a more practical 20-minute session.[11] However, even a 20-minute session is too long to be a practical method for collecting baseline EH-VMRTs. Therefore, the purpose of this study was to find the shortest protocol that yielded acceptable reliability in order to employ efficient and effective methods for measuring EH-VMRT using the SVT in both central and peripheral visual fields.

In the present study, we examined participants' performance on both simple EH-VMRT tasks and Go/NoGo reaction tasks using the SVT. We examined the consistency of participants' scores across consecutive trials in order to estimate the number of practice trials and test trials necessary to gain a representative baseline EH-VMRT score for both central and peripheral tests. We also explored the relation between participants' EH-VMRT scores and their accuracy on corresponding Reactive and Go/NoGo tasks when the presentation duration of the stimuli was varied. This allowed us to examine common patterns of performance on these tasks and to determine how best to use participants' baseline EH-VMRTs to estimate a stimulus presentation duration that is optimal for training on Reactive and Go/NoGo tasks.

Methods

Participants

Participants were undergraduate and graduate students at the University of Waterloo. Seventeen participants (13 males, 4 females) completed the first part of this study. Thirteen participants (8 males, 5 females) completed the second part of this study. One participant completed both parts of the study.

This study followed the tenets of the Declaration of Helsinki. All experimental procedures were reviewed by and received ethics clearance through the Office of Research Ethics at the University of Waterloo prior to testing. All participants signed an informed consent form before taking part in the study.

Apparatus

This study used the Sports Vision Trainer (SVT, Australia, http://bit.ly/2ocLMx8) to measure EH-VMRTs. The SVT board consists of a grid of 80 touch-sensitive light emitting diodes (LEDs) arranged in 8 rows and 10 columns. The target lights are 2cm in diameter, spaced 12.15cm apart. The lights illuminate one at a time, and participants must respond to the lights as they appear by hitting them with their hands. The SVT can be run in different modes to assess EH-VMRT: 1) Proactive mode (standard), where the stimulus is present until the participant makes a response, 2) Reactive mode, where the stimulus is present for a fixed amount of time, and 3) Go/NoGo mode, where 1 of 2 stimuli is present for a fixed amount of time, and a decision must be made about whether or not to respond. Reaction time is recorded by SVT software as the time it takes for the participant to make a response once the light is presented. During this study, the SVT board was mounted on an adjustable table stand. The height of the board was adjusted for each participant so that the board was centred roughly at the participant's eye level.

The SVT was programmed using the computer software provided by the manufacturer. For this study, two configurations of lights were programmed to test central and peripheral EH-VMRT. The central tests used a square of four lights in the centre of the SVT board (Figure 1a),[14] and the peripheral tests used a box of 48 lights around the edges of the board (Figure 1b). All tests presented a total of 48 lights in randomized order each time they were run. The central and peripheral configurations were both programmed in 3 different test modes: Proactive, Reactive, and Go/NoGo. In the Proactive and Reactive test modes, participants were instructed to hit every light they saw, while in the Go/NoGo mode, participants were instructed to respond to one colour of light (Go lights), but not to the other colour of light (NoGo lights). In this study, red-coloured lights were used for Proactive and Reactive tests and for Go lights in the Go/NoGo test, and green-coloured lights were used for NoGo lights. One participant was red-green colour blind, so blue NoGo lights were used instead of green for this participant. Two-thirds of the lights presented were Go lights, and one-third were NoGo lights (Figure 1).

Design

This study was divided into two parts. Each part of this study used a repeated measures design, where all participants completed all experimental blocks for that part. The first part of the study tested participants on Proactive reaction time tasks and reactive Go/NoGo tasks. The second part of the study tested participants on Reactive tasks.

Part 1

The first part of the study was divided into two separate visits, each with two blocks: one central and one peripheral. Each block consisted of 10 experimental trials plus one or two practice trials. The first visit used the Proactive mode. Participants were randomly assigned to complete either the central or the peripheral block first and to complete either one or two practice trials. The practice trials were identical to the test trials and were completed for each block prior to the test trials. A reaction time was recorded for each light in each test trial, as well as an average reaction time score across all 48 lights in each trial.

The second visit used the reactive Go/NoGo mode. Participants completed the central and peripheral blocks in the same order as they did for the first visit. The predetermined light illumination duration decreased after each trial and was calculated relative to the participant's average reaction time score across the 10 Proactive trials from the central and peripheral blocks in the first visit. To determine the light duration for each trial, the participant's average reaction time score was multiplied by a percentage, starting at 200% for trial 1 and continuing in decreasing intervals of 20% for each subsequent trial, down to 20% of their baseline average reaction time in trial 10. All participants were given one practice in Proactive mode at the beginning of each Go/NoGo block. At the end of each trial, accuracy was recorded as the percentage of Go lights that were correctly hit. All incorrectly hit NoGo lights were also recorded as a percentage of the total number of NoGo lights.

Part 2

The second part of the study was completed in a single visit and consisted of a central and a peripheral block in Reactive mode. Participants were randomly assigned to complete either the central or peripheral block first. For each block, we first measured a baseline EH-VMRT score by giving participants one practice and then three test trials in Proactive mode. The mean of the three tests represented the participant's baseline EH-VMRT for that light configuration. Light illumination durations were calculated for the 10 Reactive mode trials using the baseline EH-VMRT by the same method described above for the Go/NoGo test. An accuracy score was recorded at the end of each trial representing the percentage of lights the participant was able to hit.

Data Analysis

To analyze the consistency of reaction time scores across the ten Proactive trials in the central and peripheral blocks from the first part of the study, we first tested for statistically significant differences between trials. Since we were also interested in whether the number of practice trials a participant completed or the order in which participants completed the two blocks had any effect, we conducted analyses using three-way mixed factorial ANOVAs, with trial number as a within-subject factor

Table 1. Concordance Correlation Coefficients for RT Scores between Each Pair of Central Trials (strong (ρ_c = 0.7 to 0.9) and very strong (ρ_c > 0.9) correlations are highlighted in bold)

Trial	1	2	3	4	5	6	7	8	9	10
1	—									
2	**0.919**	—								
3	**0.819**	**0.817**	—							
4	**0.860**	**0.822**	**0.744**	—						
5	**0.808**	**0.793**	**0.734**	**0.949**	—					
6	**0.792**	**0.778**	**0.715**	**0.868**	**0.924**	—				
7	0.568	0.599	0.424	0.576	0.657	0.644	—			
8	**0.722**	0.653	0.681	**0.779**	**0.822**	**0.845**	0.534	—		
9	0.628	**0.711**	0.683	0.698	**0.714**	**0.844**	0.417	0.685	—	
10	0.523	0.522	0.617	0.597	0.623	**0.737**	0.326	0.680	**0.758**	—

Table 2. Concordance Correlation Coefficients for RT Scores between Each Pair of Peripheral Trials (strong (ρ_c = 0.7 to 0.9) and very strong (ρ_c > 0.9) correlations are highlighted in bold)

Trial	1	2	3	4	5	6	7	8	9	10
1	---									
2	**0.888**	---								
3	**0.797**	**0.905**	---							
4	**0.871**	**0.85**	**0.891**	---						
5	**0.787**	**0.83**	**0.903**	**0.855**	---					
6	**0.821**	**0.845**	**0.906**	**0.865**	**0.938**	---				
7	**0.787**	**0.845**	**0.865**	**0.819**	**0.892**	**0.921**	---			
8	**0.839**	**0.863**	**0.848**	**0.831**	**0.849**	**0.895**	**0.873**	---		
9	**0.761**	**0.768**	**0.773**	**0.835**	**0.896**	**0.889**	**0.858**	**0.85**	---	
10	**0.827**	**0.876**	**0.87**	**0.893**	**0.892**	**0.909**	**0.879**	**0.916**	**0.914**	---

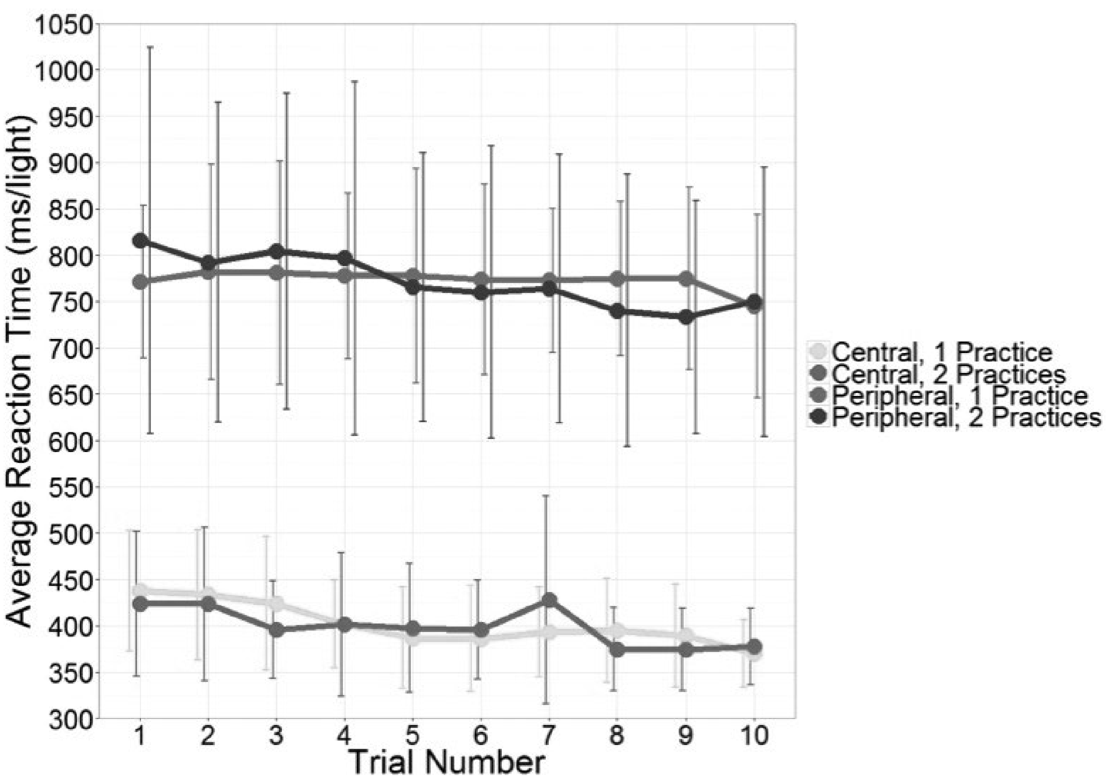

Figure 2. *Average participant reaction times with standard error bars for central and peripheral blocks across the 10 test trials.*

Table 3. Concordance Correlation Coefficients for RT Averages across Trials (strong (ρ_c = 0.7 to 0.9) and very strong (ρ_c > 0.9) correlations are highlighted in bold)

	Trial 1	Trials 1- 2	Trials 1-3	Trials 1-4	Trials 1-5
Central (Trials 1-10)	**0.866**	**0.884**	**0.908**	**0.939**	**0.961**
Peripheral (Trials 1-10)	**0.890**	**0.937**	**0.966**	**0.9744**	**0.987**

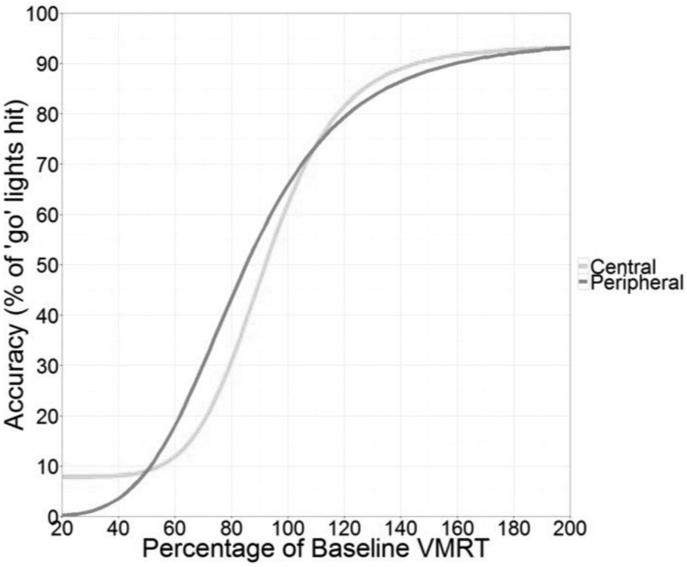

Figure 3. *Dose-response curve models for central and peripheral Go/NoGo tests, with the percentage by which participants' baseline reaction times were multiplied (to calculate light presentation duration) representing the 'dose' and 'Go' light accuracy representing the 'response.' Sample means and standard error bars for each trial condition are shown.*

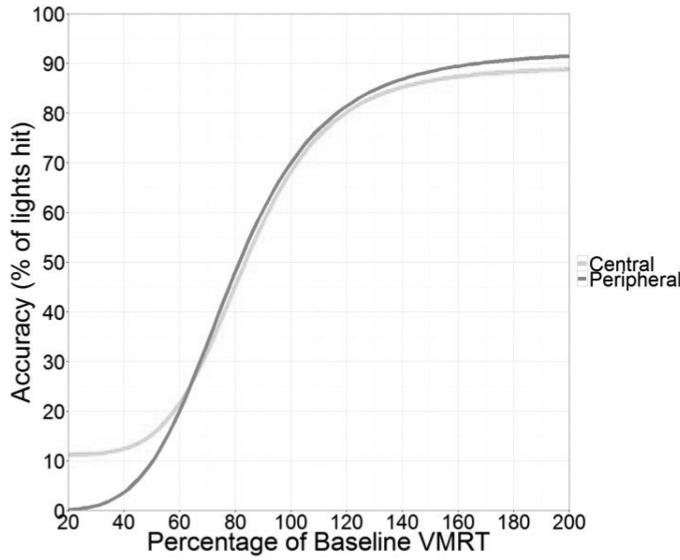

Figure 4. *Dose-response curve models for central and peripheral Reactive tests, with the percentage by which participants' baseline reaction times were multiplied (to calculate light presentation duration) representing the 'dose' and light accuracy representing the 'response.' Sample means and standard error bars for each trial condition are shown.*

and number of practice trials and block order as between-subject factors. For central block analyses, Mauchly's test indicated that the assumption of sphericity had been violated for the trial number factor, so a Greenhouse-Geisser correction was used. Finally, the agreement between trials within each block was assessed by calculating Lin's concordance correlation coefficient for trials within the central and peripheral blocks. Coefficients were considered to be strong if $\rho_c > 0.7$.

To analyze the relationship between accuracy and stimulus duration, Reactive and Go/NoGo data were fitted with 4 parameter log-logistic dose-response curves using the R Statistics package 'drc'[15] and R Statistics 3.0.2. Each trial within the block represented a 'dose' and was reported as a number between 20 and 200 corresponding to the percentage by which participant baseline EH-VMRTs were multiplied to calculate the light presentation duration for that trial, and participants' accuracy for each trial represented a 'response.' The curves were defined by Equation 1.

$$A(x) = c + \frac{d - c}{1 + e^{-b(\log(a) - \log(x))}}$$

Equation 1. *Dose-response equation used to define EH-VMRT curves. x is the stimulus duration; A(x) is the Accuracy at stimulus duration x; c represents the minimum accuracy (the accuracy as the stimulus duration approaches zero); d is an estimate of the maximum accuracy (the accuracy as the stimulus duration becomes arbitrarily large); b is a determining factor of the steepness of the curve, such that a larger value of b indicates a steeper slope; and a represents the stimulus duration at which the curve reaches the midpoint between minimum and maximum accuracy.*

Results

Proactive EH-VMRT

Reaction time data were first analysed for statistically significant differences between trials as well as the effect of having one or two practice trials. A significant difference in reaction time was found across trial number [$F(9, 117) = 3.919$, $p = 0.008$, $\varepsilon = 0.429$, $\eta^2_G = 0.0667$)]. No main effects or interaction effects were found for number of practice trials or block order. Post-hoc analyses on the central block were conducted using Tukey's HSD. The first trial (M = 431.21ms, SD = 86.34ms) and the second trial (M = 428.71ms, SD = 92.05ms) were both shown to have significantly slower reaction times than the eighth trial (M = 385.22ms, SD = 63.43ms; $p = 0.0151$; $p = 0.0287$), ninth trial (M = 382.52ms, SD = 62.37ms; $p < 0.01$; $p = 0.0141$), and tenth trial (M = 373.86ms, SD = 46.91ms; $p < 0.01$; $p < 0.01$). No other differences were significant. For peripheral block analyses, no significant differences in reaction times were found across trial number [$F(9, 117) = 1.315$, $p = 0.237$, $\eta^2_G = 0.0110$], and no main effects or interaction effects were found for number of practice trials or block order (Figure 2).

Reaction time data were next analyzed for agreement between trials for each block. Significant overall correlation coefficients were found both for the central block (ρ^c_o =

Table 4. Estimates for the Stimulus Duration at which Participants will Perform at 50%, 75%, and 85% Accuracy on Central and Peripheral tasks (Given as a percentage by which participants' baselines RT scores should be multiplied. In brackets, the corresponding estimates of the number of milliseconds that must be added to or subtracted from baselines are given, calculated relative to the average RT scores across all participants)

		Accuracy Level		
Test Type	Block	50%	75%	85%
Go/ NoGo	Central	92.0% (-32 ms)	111.3% (+45 ms)	127.0% (+108 ms)
	Peripheral	85.2% (-114 ms)	112.2% (+94 ms)	134.8% (+269 ms)
Reactive	Central	83.6% (-70 ms)	109.3% (+40 ms)	138.7% (+166 ms)
	Peripheral	81.5% (-153 ms)	107.1% (+59 ms)	131.4% (+259 ms)

0.694) and for the peripheral block (ρ^c_o = 0.858). Individual correlation coefficients for each pair of trials can be seen in Tables 1 and 2. Strong concordance ($\rho_c > 0.7$) was found between all pairings within the first 6 trials of the central block and between all pairings within all 10 trials of the peripheral block.

To estimate the number of trials required to get an accurate average baseline RT, we used Lin's concordance correlation coefficient to analyze the agreement between the average session RTs (across all 10 trials) and averages of RTs calculated across differing numbers of trials (trial 1, trials 1-2, trials 1-3, trials 1-4, and trials 1-5; Table 3). Strong concordance ($\rho_c > 0.7$) was found across all comparisons. Very strong concordance ($\rho_c > 0.9$) was found when the session mean was compared to averages calculated using as few as the first three trials for the central block ($\rho_c = 0.908$) and using as few as the first two trials for the peripheral block ($\rho_c = 0.937$).

Reactive and Go/NoGo EH-VMRT

Accuracy data from the Go/NoGo and Reactive parts of the study were analyzed by fitting participant data with four-parameter log-logistic dose-response curves. One of these curves was generated for each of the four blocks of trials using all participant data. The curves for the Reactive central and peripheral blocks are displayed in Figure 3, and the curves for the Go/NoGo central and peripheral blocks are displayed in Figure 4. These dose-response curves were used to make estimations of the light presentation durations at which participants were able to achieve a specified amount of accuracy for each test type. Estimations of appropriate stimulus durations were given as the percentage by which a participant's baseline EH-VMRT score should be multiplied in order to get the millisecond stimulus duration at which participants would achieve the specified accuracy. We represented these estimations both as a percentage and as the corresponding number of milliseconds on average (calculated relative to mean EH-VMRT scores across all participants) that would be added to or subtracted from the participant baselines to get the appropriate stimulus duration. We made these estimations for low accuracy: 50% of lights correctly hit; medium accuracy: 75% of lights correctly hit; and high accuracy: 85% of lights correctly hit. These values were selected based on qualitative judgments to estimate the optimal challenge point, which is the point where the available potential information from which to learn is maximized.[16] The results of these estimations for Go/NoGo and Reactive tasks can be seen in Table 4.

Individual participant data were also fit with log-logistic dose-response curves to get an estimate of the four curve parameters for each participant on each block of trials. Each of the four curve parameters—minimum accuracy, maximum accuracy, curve steepness, and midpoint location—were then compared in a factorial ANOVA, with light configuration (central or peripheral) as a within-subject factor and test type (Reactive or Go/NoGo) as between-subject factors. Central tests were found to have a higher minimum value (M = 9.0084, SD = 4.8578) compared with Peripheral tests (M = 0.4120, SD = 1.1248; $F(1,28) = 99.2307$, $p < 0.001$, $\eta^2_G = 0.6496$). Central tests were also found to have a steeper curve (M = 9.3988, SD = 4.4014) than peripheral tests (M = 5.1753, SD = 1.2779; $F(1,28) = 20.9115$, $p < 0.001$, $\eta^2_G = 0.2984$). Finally, central tests were found to have a midpoint located at a higher stimulus duration (M = 88.1052, SD = 13.3312) than peripheral tests (M = 81.7888, SD = 81.7888, SD = 8.6221; $F(1,28) = 6.5123$, $p = 0.0165$, $\eta^2_G = 0.0775$). Go/NoGo tests were also found to have a midpoint located at a higher stimulus duration (M = 87.9648, SD = 11.3145) than Reactive tests (M = 81.0006, SD = 10.8978; $F(1,28) = 4.7719$, $p = 0.03746$, $\eta^2_G = 0.0982$). No other results were significant.

Discussion

Both the central and peripheral Proactive protocols tested on the SVT demonstrated good consistency across trials. While reaction time scores for both the central and the peripheral blocks had significant concordance, the peripheral block had stronger overall concordance, as well as consistently strong concordance between all individual pairs of trials. Additionally, the peripheral test did not demonstrate any differences between trials that reached the level of significance. Together, this suggests that participants' scores on the peripheral test remain highly consistent between all 10 consecutive trials. For the central test, however, although the first 6 trials demonstrated consistently strong concordance between all pairs of trials, reaction time scores were shown to decrease significantly between the first trials (1 & 2) and the last trials (8, 9, & 10). This may be interpreted as indicative of a training effect that occurs even within the first 10 trials of the task. Ideally, a baseline reaction time score should provide a consistent measure of hand-eye coordination while minimizing any effects the measurement procedure has on the participant. It is possible that 10 trials is too many to get an accurate baseline reaction time score for the central task, as a significant amount of EH-VRMT training already begins to occur in this time, beyond the learning involved with gaining a basic familiarity with the equipment. Thus, it would appear that training occurs faster on the central task than on the peripheral task.

Results from the Proactive tasks allow us to establish valid protocols for collecting a baseline reaction time score. Since there was no significant effect of the number of practice trials (one or two) on reaction time performance on subsequent test trials for either the central or peripheral Proactive tests, and since even the first few test trials showed strong concordance with the session mean, it is presumed that one practice trial is sufficient to familiarize the participant with the task for both central and peripheral tasks. For the peripheral task, correlation results indicated very high concordance between session means and the average of trials 1 and 2. Hence, we conclude that recording 2 peripheral trials is sufficient to get an accurate baseline reaction time score. Similarly, the central task showed high concordance between session means and the average of trials 1 to 3, so we conclude that recording 3 central trials is sufficient to get an accurate baseline reaction time score.

Results from the Go/NoGo and Reactive parts of the study estimated the light presentation durations at which participants were able to achieve low (50%), medium (75%), and high (85%) response accuracy. Again, these values were selected based on qualitative judgments to estimate the optimal challenge point, which is the point where the available potential information from which to learn is maximized.[16] If the task is too difficult for participants, they will not have enough time to make responses to enough stimuli and so will not have the benefit of visual and motor feedback from Go and NoGo reactions and inhibitions. Similarly, if the task is too easy for participants, they will have too much time to react and will not learn to make judgments and reactions faster. We estimated that if participants were only hitting 50% of the lights or less, the task was too difficult, and participants were not getting enough feedback information from which to learn; if participants were scoring 85% or above, they weren't being challenged enough to make fast reactions. We deemed that 75% represented a good balance between completing enough reactions to learn from reaction feedback information and being challenged to complete those reactions faster. This allowed us to establish protocol guidelines for this type of test that will enable us optimally to challenge participants during testing and training.

Participants should start off with a light presentation duration at which they will be moderately successful (i.e., 75% accuracy). If participants struggle with the task and fall below a 50% accuracy rate, the light presentation duration should be adjusted to bring the participant back up to around 75% accuracy. If participants improve to an accuracy level of 85% or higher, the light presentation duration should be adjusted to bring the participant back down to a more optimal challenge point of about 75% accuracy. While these values provide a good starting place for employing the Go/NoGo tests, the accuracy values selected are based on a qualitative judgment, and further research is needed to determine the actual accuracy rates that provide the optimal challenge levels for training improvements. The dose-response curves that were used to model the data provide us with estimates of the appropriate number of milliseconds, on average, that should be used to adjust the light presentation duration to achieve the desired effects.

Comparisons of curve fits between the different protocols found that central tests had significantly higher minimum accuracy values than peripheral tests. This is likely due to the fact that only four lights were used in the central protocols, so participants had a higher probability of hitting a light by chance alone, even if they hit the lights randomly without taking the time required to process the stimuli. We also found that central tests tended to have steeper curves than peripheral tests, indicating that a comparatively smaller increase in stimulus duration was generally required to increase participant accuracy on central tests compared with peripheral tests. Although central tests had a midpoint accuracy value that was located at a higher stimulus duration than peripheral tests, this could be accounted for by the fact that the midpoint itself would have been at a higher accuracy value on average for the central tests due to the higher minimum accuracy. Thus, it makes sense that a higher stimulus duration would be required. We also found that the Go/NoGo tests had a midpoint located at a significantly higher stimulus duration than the Reactive tests. No other differences were found between Go/NoGo and Reactive tests. Together, this indicated that the Go/NoGo and Reactive curves were similarly shaped, but the Go/NoGo curves tended to be shifted toward higher stimulus durations. Thus, it would seem that the Go/NoGo tests require longer response times on average to achieve the same accuracy as the Reactive tests. This result is consistent with the common finding that Go/NoGo tasks require more time to respond than simple reactions, since Go/NoGo reactions require the added perceptual and cognitive processes of stimulus discrimination and response inhibition.[17]

Conclusions

Representative baseline EH-VMRTs can be obtained within two to three trials for central and peripheral tasks. Go/NoGo training programs require longer stimulus durations relative to baseline (about 70 ms longer than baseline) than Reactive training programs (about 50 ms longer than baseline) to achieve moderate accuracy, which suggests that Go/NoGo protocols may be more difficult than Reactive protocols. These methods are recommended for use in all future sports vision assessments and training programs.

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