Determining eye-hand co-ordination using the sport vision trainer (SVT™): an evaluation of test-retest reliability

Journal:	*Research in Sports Medicine*
Manuscript ID:	GSPM-2012-0043.R1
Manuscript Type:	Original Research
Keywords:	Psychomotor Performance, Visual Motor Coordination, Reliability of Results, Reaction Time, Test-Retest Reliability

Determining eye-hand co-ordination using the sport vision trainer (SVT™): an evaluation of test-retest reliability

Abstract

Objectives: The purpose of this investigation was to assess the number of test-retest trials required to familiarise participants in order to provide acceptable reliability for the measurement of an eye-hand co-ordination task using the Sport Vision Trainer (SVT™). *Design*: Two schedules were conducted (S1 and S2): *Methods*: (S1): Sixty-four participants (male n=51, age 20.8±4.9 years; female n=13, age 20.1±2.1years) attended four sessions each one week apart, and undertook four trials using the SVT™. (S2): Sixty participants (male n=46, age 20.8±4.9 years; female n=14, age 20.1±2.1 years) attended one 20-minute schedule consisting of four consecutive trials using the SVT™. *Results*: Limits of agreement (LoA) analyses showed that absolute reliability was increased in both studies. The LoA for S2 indicate that error decreased between trial 1-2, 2-3, and 3-4; ±0.95 (CI,-1.16,+2.56sec), ±0.97 (CI,-1.66,+2.14sec), ±0.69 (CI,-1.08,+1.62sec). *Conclusion:* Reliable measurements of eye-hand co-ordination can be obtained using the SVT™ in one session.

Keywords: Psychomotor Performance; Visual Motor Co-ordination; Reliability of Results; Reaction Time; Test-Retest Reliability

Introduction

The visual system plays a critical role in sports performance (Williams, Davids, & Williams, 2005), as it does in the performance of virtually all perceptual-motor skills (Paillard, 1990). To advance sports performance through improving vision an understanding of the visual demands of different sports is required. Evaluation of the degree that varying visual parameters can be adapted through the training of visual abilities also needs to be considered. Eye-hand co-ordination is a crucial aspect of sport performance as decisions frequently need to be made very quickly based on the presentation of a wide range of visual stimuli. Eye-hand co-ordination also plays an integral role in sports vision and has been researched in many sport contexts such as goalkeeping in soccer (Nagano, Kato, & Fukuda, 2004), defence in basketball (Laurent, Ward, Williams, & Ripoll, 2006), and general passing, and throwing and hitting in other sports (Zupan, Arata, Wile, & Parker, 2011). Despite this there are currently no recognised standardised measurements for testing eye-hand co-ordination in sport. Traditionally researchers have used non-validated tools, or ones with little established accuracy (Du Toit et al., 2011). The development of a reliable measurement tool would therefore provide athletes and coaches with an effective evaluation device for improving sport performance. The Sport Vision Trainer (SVT™) has the potential to be such a device. The SVT™ 32 sensor pad is a portable system developed for teams/practitioners who want to use the SVT™ in different locations. It can also be used either in landscape or portrait positions to portray both the proactive and reactive eye-hand co-ordination demands of many sports.

Practically, some amount of biological error is always present with continuous measurements (Hopkins, 2000). Therefore reliability could be considered as the

amount of measurement error that has been deemed satisfactory for the successful practical use of a measurement device. The publication of data for reliability studies has been acknowledged to considerably enhance comparisons of the consistency of testing and equipment (Hopkins, 2000). Consequently practitioners can be assured that any improvement in performance is due to interventions introduced and eliminate potential differences in gender, experience, and any familiarisation effect of the SVT™ as a factor. Currently there are no studies that assess the test-retest reliability of the SVT™. Therefore, the purpose of this investigation was to assess the number of test-retest trials required using the SVT™ to familiarise participants in order to provide acceptable reliability for the measurement of an eye-hand co-ordination task. The second purpose of this investigation was to determine if a shorter schedule of familiarisation could be used to assist the researcher in a more appropriate, timely collection period.

Methods

Research Design

Prior to testing all procedures were described and a full demonstration was given to the participants in order to give them an idea of the testing protocol without them actually using the SVT™ before any familiarisation session taking place. Two schedules were then carried out. The same investigator was responsible for data collection for both schedules. Data were recorded electronically via the SVT™ and automatically saved to an excel file. The first schedule (S1) took place over a four week period based on recommendations to assess reaction times (Ando, Kida, & Oda, 2004). Once this had been completed a second period of data collection was undertaken (S2) with different participants to assess whether the same trials (T), as

endorsed by the manufacturer of the equipment (Sports Vision, 2012), could be conducted in a shorter (approx. 20-minutes), and therefore more practical session.

Participants

Sixty-four sports participants (male n=51, Female n=13) volunteered for S1 and sixty (male n=46, female n=14) for S2. The participants were of mixed abilities ranging from collegiate to national standard in a variety of team and individual sports. Records of the experience (S1, 6.03±4.19yrs; S2, 6.21±3.73yrs) and hours of training per week (S1, 5.34±3.52hrs; S2, 5.88±4.27hrs) in the participants sport was obtained. Vision health questionnaires (Williams et al., 2005) were also completed to assess suitability for the study. Anyone who had suspected visual impairment/difficulties was referred to an optometrist. Participants exhibiting any visual deficiencies were excluded from participating and referred to an optician. Four participants (n=2 from S1, and n=2 from S2) were excluded from the final calculations. Any participant suffering shoulder, wrist or finger injury during the last six months was excluded. All included participants reported normal visual acuity either unaided or while wearing their own corrective lenses. All experimental procedures were approved by the Institutional Ethics committee prior to testing. All participants were informed of the risks and procedures of the investigation prior to giving written informed consent.

Testing Procedures

In S1 participants subsequently completed four sessions of six trials using the SVT™ 32 sensor pad. This test is carried out on a display board (135 cm in length, 18 cm in width, and 60cms in height) with 32 touch-sensitive red light emitting diodes (LED's). All trials took place at the same time of day to avoid any effects of circadian variations (Atkinson & Reilly, 1996; Edwards, Waterhouse, & Reilly, 2008). Each

session was separated by one week as reliability of cognitive variables have been shown to be highly reliably over a 4-week period (Wallman, Morton, Goodman, & Grove, 2005). The ambient light in the room was carefully controlled and set at 420 Lux (Sport Vision, 2012) using a Lux light meter (CEM DT-1300, Shenzhen, China).

The SVT™ was programmed to use a proactive mode (Sport Vision, 2012) which meant that lights stayed illuminated until the participant responds by hitting them. Participants were required to touch each light as quickly as possible. The SVT™ programme waits until it has measured the response before switching on the next light. Participants stood directly in front of a panel of 32 lights which displayed a centrally programmed sequence of 20 lights (the centre 16 lights, 4 by 4 array) which randomly illuminated. The height of the top of the SVT™ from the floor was standardised at 1.77cm for men and 164.4cm for females (NHS, 2012) and was positioned in a landscape format. Time to hit the sequence of 20 lights was recorded in milliseconds. The SVT™ program randomised the target order and location for every trial to ensure fair test comparisons between users. The first two trials of 20 lights were practice runs and means of the last four measurement trials were displayed at the end of the each trial. In S2 the same protocol was adhered to, except the six trials were carried out with 10 second breaks, consecutively in one session lasting approximately 20-minutes.

Statistical Analysis

For both S1 and S2 comparisons were conducted on the dependent variable of mean task completion time over the last four trials, in seconds, for Session 1 versus Session 2, Session 2 versus Session 3, and Session 3 versus Session 4, using the software for the Hopkins reliability spread sheet (Hopkins, 2012). This generated coefficients of variation (CV), intra-class correlation coefficients (ICC), Pearson

correlation coefficients (r), and standard errors of measurements (SEM) for each comparison as recommended for these types of investigations (Atkinson & Nevill, 1998; Hopkins, 2000; Morrow & Jackson, 1993) (Table 2). To derive the within-subject variation expressed as a coefficient of variation (CV) all data was log-transformed in accordance with the methodology identified in Hopkins reliability spreadsheet (Hopkins, 2012), differences between trials were then calculated for each participant. Acceptable reliability was identified as being a CV <5% (Vincent 2005) and ICC's >r=0.80, below which reliability has been suggested to be "questionable" (Atkinson and Nevill 1998). With three comparisons within each schedule, probability values for Pearson coefficients were evaluated against a Bonferroni adjusted alpha level of $P \leq .017$. Bland-Altman plots (Bland & Altman, 1986) were used to describe the Limits of agreement (LoA) for each comparison within each schedule, following the method described by Atkinson and Nevill (1998). This generates 95% confidence intervals for differences in the performance of individuals across sessions in each comparison. Differences falling outside these confidence intervals may be regarded as random. A Kolmogorov-Smirnov test was conducted to test normality of data. Mann-Whitney`s (Nachar, 2008) U test was conducted to evaluate the differences in performance between S1 and S2.

Potential gender differences in performance were tested within each schedule, respectively, using a mixed between-within participants ANOVA, with gender as a between-participants independent variable and mean task completion times for Sessions 1 to 4 as a within-participants independent variable at four levels. Finally, the mean difference in participants' task completion times across all four trials was tested using schedule as a between-participants independent variable in a t-test. The suitability of these means for parametric analysis was established by graphical

examination of their distribution and by statistical analysis of their skewness and kurtosis, as described by Tabachnick and Fidell (2001). There was no evidence to suggest that heteroscedasticity was present. All values presented are displayed as mean±standard deviation (SD), and a level of $p < 0.05$ was used to define statistical significance. All statistical procedures were conducted using SPSS17 statistical software (IBM, Chicago, USA).

Results

Acceptable reliability was observed following the completion of four trials in both schedules. All trials demonstrated a reduction in the CV, SEM and ICC across the trial comparisons from T1-2 to T3-4 (Table 1 and Table 2 for mean performance times and reliability measurements, respectively). Pearson's r revealed no significant relationship between experience and difference in means between T1 and T4 for both studies: S1, r (64) =0.128, P=0.352; S2, r (60) =-0.103, P=0.432. Pearson's correlation revealed no significant relationship between training hours per week and difference in means between T1 and T4 for both studies: S1, r=-.106, P=0.452; S2, r=-0.011, P=0.931. There was no significant differences in participants` task completion times across all four sessions: t (122) =1.906, P= 0.059, two-tailed. There was no significant effect of groups between test schedules (The mean ranks of S1 and S2 were 68.11 and 156.52, respectively; n=64, n= 60, U = 1561, p < 0.072, two tailed). A significant main effect for gender was observed for the mean task completion times between trial 1-4 in S1: $F_{(1,62)}=4.828$, P=0.03, $\eta p^2=0.07$, CI=10.52-11.33, and no significant main effect for gender for the mean task completion times between trial 1-4 in S2: $F_{(1,58)}=2.079$, P=0.16, CI=10.39-11.26. In S1 a significant main effect was observed for trial (Greenhouse-Geisser adjustments utilised): $F_{(2.596,160.958)}=29.574$, P=0.001, $\eta p^2=0.323$ (Table 2). In S2 a significant main effect

was observed for trial (Greenhouse-Geisser adjustments utilised): $F_{(2.52,146.163)}$=21.987, P=0.001 (Table 2).

The LoA analysis (Figure 1) shows that absolute reliability is increased from T1-T2 to T3-T4 in both studies. Improved LoA was observed between the four trials (trial 1-2, trial 2-3, and trial 3-4) for S1: ±1.11 (CI, -1.37, +2.99 sec), ±1.07 (CI, -1.76, +2.44 sec), ±0.74 (CI, -1.04, +1.86 sec), and S2: ±0.97 (CI,-1.16, +2.56 sec), ±0.95 (CI, -1.66, +2.14 sec), ±0.69 (CI,-1.08, +1.62 sec) respectively. Pearson's r value also indicated an increasingly strong relationship from trial 2-1 to trial 4-3 in both schedules (Table 2).

Discussion

The purpose of this investigation was to assess the number of test-retest trials required to familiarise participants in order to provide acceptable reliability for the measurement of an eye-hand co-ordination task using the Sport Vision Trainer (SVT™). Furthermore a second testing protocol was conducted in order to determine if a more logistically practical schedule of familiarisation could be achieved with the same number of test-retest trials. As far as can be ascertained, there is no current research evaluating the SVT™, or using it as a research tool, despite existing evidence of effects of influences of familiarisation (Duncan, Al-Nakeeb & Nevill, 2005). The design and analysis of this study factored in a random participants sample identified using recommended methods for assessing reliability in sports medicine based research (Atkinson & Nevill, 2001). In turn this enabled a precise estimate of measurement error parameters (CV; ICC and SEM) which was used to determine whether the SVT™ was acceptable for use in the simplest experimental setting (i.e. same experimenter and identical equipment). Random error was shown

to reduce in all measurement error parameters as more tests were administered, until acceptable reliability was deemed satisfactory using ICC. These were interpreted as 0.70-0.80 acceptable, 0.80-0.89 strong and 0-90-1.0 high correlation (Vincent, 2005). S1 identified an ICC of 0.87 (T3-4) and S2 0.89 (T3-4) respectively. Although the present study showed a significant difference in results between gender in S1, the effect size was small, and should be viewed with caution. There was no significance displayed for gender in S2 supporting previous research on eye-hand visual reaction times (Akarsu, Çaliskan, & Dane, 2009; Dane & Erzurumluoğlu, 2003) using a software package of random stimulus presentation. Applying the protocol outlined in S1 would take 4 weeks to complete; we therefore shortened the protocol (S2) into one testing session to see if acceptable reliability could be achieved in a more optimally practical testing duration. The results for S2 showed similar values to S1 allowing testing to take place in a shorter timeframe. CV's of 4.94% and 4.76% for trials 3-4 in both S1 and S2 respectively identified (Vincent, 2005) (<5%) findings as an acceptable figure for reliability.

As previous measures of eye-hand co-ordination and reaction in a sporting context have generally used non-validated tools, the development of a reliable training aid is highly relevant. Consequently this may provide athletes and practitioners with an effective tool for improving sports performance through increasing eye-hand co-ordination. The results also showed no significant relationships between experience, training hours and abilities offering the prospect of using the SVT™ for different populations using this familiarisation strategy. For example, although the present study focused on its use from a sporting perspective, these findings may present opportunities to use the SVT™ in improving eye-hand co-ordination in general training and other specialised instances (e.g. rehabilitation of motor dysfunction,

visual deficiencies injury rehabilitation process, alternative to physical activities during recovery). Minimal measurement error during the collection of interval-and-ratio-type data has been identified as critically important for the assessment of performance (Atkinson & Nevill, 1998). Practically, as some amount of biological error is always present with continuous measurements, reliability in this study was considered as the amount of measurement error that has been deemed satisfactory for the successful practical use of the SVT™.

The findings also suggest that using the shorter schedule outlined in S2 may allow future researchers to minimise familiarisation testing time and to condense a potentially time constraining activity to less than 20-minutes. The data is reflective and of the same magnitude as would typically be expected for the current population (Chang, Labban, Gapin, & Etnier, 2012). In order for future research on the validity of the SVT™ to be carried out it is important that the values indicated from repeated measurements are sufficiently meaningful. The 95% confidence intervals indicate that in all instances the change in CV is likely to be real for both schedules tested in the present study. Future research should be conducted to determine whether skills learned on the SVT™ can be transferred into other contexts (e.g., improved sport performance, functional movements, rehabilitation outcomes). The SVT™ lends itself to the investigation of various elements impacting upon eye-hand co-ordination (e.g.: nutritional interventions, fatigue, environmental conditions, stimulus characteristics). Of particular interest is how different training approaches may impact upon the effective development of eye-hand co-ordination as measured using the SVT™ (e.g., instructional approaches, practice schedules, implicit and explicit learning, and performance under pressure). Such studies using the SVT™ may provide athletes and practitioners with an effective tool for improving sports performance. A key

limitation of the present study is the use of a relatively typical sample of healthy young adults, and as such the data presented here may not transfer to other populations (e.g., individuals with cognitive and physical impairments). Therefore, future research using the SVT™ as a measure of eye-hand co-ordination in such populations should consider the assessment of effective familiarisation strategies. When investigating healthy populations, it is recommended that practitioners using the SVT™ should include the protocol (S2) described in the present paper to inform future interventions to eliminate any residual learning effects.

Conclusion

To our knowledge this is the first study to identify and analyse the reliability of test-retest familiarisation trials for the SVT™. In summary the findings of the study indicate that the familiarisation trials were statistically reliable over a four week period, and in a shorter 20-minute consecutive session. The shorter familiarisation protocol ensures that the logistics of testing are simplified for practitioners whilst also providing acceptable test-retest reliability. These results suggest that researchers may use the SVT™ for a range of potential training approaches and intervention studies. In order for future research on the validity of the SVT™ to be carried out it is important that the values indicated from repeated measurements are sufficiently meaningful. It can therefore be concluded that reliable measurements of eye-hand co-ordination can be obtained in one short session using the SVT™, providing four familiarisation sessions of six trials have taken place following description and a full demonstration of the procedure.

References

Akarsu, S., Çaliskan, E., & Dane, Ş. (2009). Athletes have faster eye-hand visual reaction times and higher scores on visuospatial intelligence than nonathletes. *Turkish Journal of Medical Sciences, 39*(6), 871-874. doi: 10.3906/sag-0809-44

Ando, S., Kida, N., & Oda, S. (2004). Retention of practice effects on simple reaction time for peripheral and central visual fields. *Perceptual Motor Skills*, (98),897-900. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=13483504&site=eds-live&scope=site

Atkinson, G., & Nevill, A. M. (1998). Statistical methods for assessing measurement error (reliability) in variables relevant to sports medicine. / methodes statistiques pour evaluer le taux d ' erreur (la fiabilite) des variables ayant rapport a la medecine du sport. *Sports Medicine, 26*(4), 217-238. Retrieved from http://articles.sirc.ca/search.cfm?id=S-18827; http://0-search.ebscohost.com.library.edgehill.ac.uk/login.aspx?direct=true&db=s3h&AN=SPHS-18827&site=ehost-live&scope=site; http://articles.sirc.ca/search.cfm?id=S-18827; http://www.adis.com

Atkinson, G., & Nevill, A. M. (2001). Selected issues in the design and analysis of sport performance research. *Journal of Sports Sciences, 19*(10), 811-827. Retrieved from http://articles.sirc.ca/search.cfm?id=S-804991; http://0-search.ebscohost.com.library.edgehill.ac.uk/login.aspx?direct=true&db=s3h&AN=SPHS-804991&site=ehost-live&scope=site; http://articles.sirc.ca/search.cfm?id=S-804991; http://www.tandf.co.uk/journals

Atkinson, G., & Reilly, T. (1996). Circadian variation in sports performance. *Sports Medicine*, 21(4),292-312. Retrieved from http://articles.sirc.ca/search.cfm?id=397061 http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=SPH397061&site=edslive&scope=sitehttp://articles.sirc.ca/search.cfm?id=397061

Bland, M., & Altman, D.G. (1986). Statistical methods for assessing agreement between two methods of clinical measurement. *The Lancet*, 327(8476),307–10. doi: 10.1016/S0140-6736(86)90837-8

Chang, Y. K., Labban, J. D., Gapin, J. I., & Etnier, J. L. (2012). The effects of acute exercise on cognitive performance: A meta-analysis. *Brain Research,1453*(0), 87-101. doi: 10.1016/j.brainres.2012.02.068

Dane, Ş., & Erzurumluoğlu, A. (2003). Sex and handedness differences in eye-hand visual reaction times in handball players. *International Journal of Neuroscience,* 113(7),923-929. doi: 10.1080/00207450390220367

Duncan, M.J., Al-Nakeeb, Y., & Nevill, A.M. (2005). Influence of Familiarisation on a backward, Overhead Medicine Ball Explosive Power Test. *Research in Sports Medicine: An International Journal*, 13(4),345-352. doi: 10.1080/15486205003599950

Du Toit, P.J., Kruger, P.E., Mahomed, M., Kleynhans, M., Jay-Du Preez, T., Govender, C., & Mercier, J. (2011). The effect of sports vision exercises on the visual skills of university students. *African Journal for Physical Education, Recreation and Dance*, 17(3),429-440. Retrieved from http://0-search.ebscohost.com.library.edgehill.ac.uk/login.aspx?direct=true&db=s3h&AN=67621045&site=eds-live&scope=site

Edwards, B., Waterhouse, J., & Reilly, T. (2008). Circadian Rhythms and Their Association with Body Temperature and Time Awake when Performing a Simple Task with the Dominant and Non-Dominant Hand. *Chronobiology International*, 25(1),115-132. doi: 10.1080/07420520801921614

Hopkins, W.G. (2012). *A new view of Statistics. Calculations for Reliability. Reliability Spreadsheet*. Retrieved June 11, 2012, from: http://www.sportsci.org/resource/stats/relycalc.html#excel.

Hopkins, W.G. (2000). Measures of reliability in sports medicine and science. *Sports Medicine*, 30(1), 1-15. Retrieved from http://articles.sirc.ca/search.cfm?id=S-656907 http://0-search.ebscohost.com.library.edgehill.ac.uk/login.aspx?direct=true&db=s3h&AN=SPHS-656907&site=ehost-live&scope=site http://articles.sirc.ca/search.cfm?id=S-656907http://www.adis.com

Laurent, E., Ward, P., Williams, A.M., & Ripoll, H. (2006). Expertise in basketball modifies perceptual discrimination abilities, underlying cognitive processes, and visual behaviours. *Visual Cognition*, 13(2),247-271. doi:10.1080/13506280544000020

Morrow, J.R., & Jackson, A.W. (1993). How "significant" is your reliability? *Research Quarterly for Exercise and Sport* 64(3),352-355. Retrieved from http://articles.sirc.ca/search.cfm?id=327699 http://0-search.ebscohost.com.library.edgehill.ac.uk/login.aspx?direct=true&db=s3h&AN=SPH327699&site=eds-live&scope=sitehttp://articles.sirc.ca/search.cfm?id=327699 http://www.aahperd.org/

Nachar, N. (2008). The Mann-Whitney U: a test For Assessing Whether Two Independent Samples Come from the Same Distribution. *Tutorials in Quantitative Methods for Psychology*, 4(1),13-20. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=edsdoj&AN=1e6527a94a521cda50e1a46aed9aa7c8&site=eds-live&scope=site

Nagano, T., Kato, T., & Fukuda, T. (2004). Visual Search Strategies of Soccer Players in One-On-One Defensive Situations on the Field. *Perceptual & Motor Skills*, 99(3),968-974. Retrieved from http://0-search.ebscohost.com.library.edgehill.ac.uk/login.aspx?direct=true&db=s3h&AN=15532210&site=eds-live&scope=site

NHS. (2012). Statistics and Data Collections. Health Survey for England 2010 Trend tables. Retrieved June 11, 2012, from: http://www.ic.nhs.uk/statistics-and-data-collections/health-and-lifestyles-related-surveys/health-survey-for-england/health-survey-for-england--2010-trend-tables.

Paillard, J. (1990). *Brain and space (*Knowing where and knowing how to get there, Chapter 5). Oxford: Oxford UP.

Sports Vision. (2012). Retrieved June 11, 2012, from: http://www.sportsvision.com.au/home/ .

Tabachnick, B.G., & Fidell, L. (2001). *Using Multivariate Statistics* (Cleaning up your act: screening data prior to analysis, Chapter 4, 4th ed)., Boston: Allyn and Bacon.

Vincent, W.J. (2005). *Statistics in Kinesiology* (Analysis of Variance with Repeated Measures , Chapter 10, 3rd ed). Campaign IL:Human Kinetics.

Wallman, K.E., Morton, A.R., Goodman, C., & Grove, R. (2005). Reliability of Physiological, Psychological, and Cognitive Variables in Chronic Fatigue Syndrome. *Research in Sports Medicine: An International Journal*, 13: 231-241. doi: org/10.1080/15438620500222562

Williams, M.A., Davids, K., & Williams, J.G.P. (2005). *Visual perception and action in sport* (Visual search Strategies in Sport, Chapter 1) London:E & FN Spon.

Zupan, M., Arata, A., Wile, A., & Parker, R. (2011). Eyes On The Prize. Training & Conditioning, 21(2),11-15. Retrieved from http://0-search.ebscohost.com.library.edgehill.ac.uk/login.aspx?direct=true&db=s3h&AN=59707952&site=ehost-live&scope=site

Tables

Table 1. Descriptive statistics of mean performance times achieved in each Schedule (mean ± SD)

			T1		T2		T3		T4	
	Participants	***Age (yrs)***	***Mean+ (s)***	***Threshold*(s)***	***Mean(s)***	***Threshold(s)***	***Mean(s)***	***Threshold(s)***	***Mean(s)***	***Threshold(s)***
S1	M (n=51)	20.8±4.9	**11.39**±1.57	**0.56**±0.07	**10.53**±1.55	**0.52**±0.07	**10.2**±1.35	**0.51**±0.68	**9.80**±1.15	**0.48**±0.05
	F (n=13)	20.1±2.1	12.08±1.50	**0.60**±0.07	**11.53**±1.80	**0.57**±0.88	**11.15**±1.52	**0.55**±0.07	**10.72**±1.39	**0.53**±0.06
	Total (n=64)	20.4±4.4	**11.53**±1.57	**0.57**±0.07	**10.74**±1.64	**0.53**±0.08	**10.39**±1.42	**0.52**±0.07	**9.992**±1.24	**0.50**±0.06
S2	M (n=46)	20.8±4.9	**11.25**±1.7	**0.56**±0.08	**10.53**±1.74	**0.52**±0.08	**10.29**±1.51	**0.51**±0.07	**9.98**±1.40	**0.49**±0.07
	F (n=14)	20.1±2.1	11.76±1.05	**0.58**±0.05	11.12±1.18	**0.55**±0.05	10.92±1.37	**0.54**±0.06	10.75±1.48	**0.53**±0.07
	Total (n=60)	20.85±4.3	**11.37**±1.58	**0.56**±0.07	**10.67**±1.64	**0.53±0.08**	**10.43**±1.50	**0.52**±0.07	**10.16**±1.44	**0.50**±0.07

+ Mean (±) SD proactive time to hit twenty light sequences

*Threshold: Mean proactive reaction time for 20 lights

S=Schedule, T=Trial

Table 2. Reliability (Coefficient of variation, CV),Intraclass correlation coefficient (ICC),Pearson's r, Standard error measurement (SEM) and Bonferroni post hoc comparisons between trials.

	S1					S2				
TRIALS	***Typical Error CV**	**ICC**	**Pearson's r**	**Bonferroni Adjustment**	**SEM**	***Typical Error CV**	**ICC**	**Pearson's r**	**Bonferroni Adjustment**	**SEM**
1-2	7.30	0.74	0.76	P=0.001	9.1	6.21	0.74	0.82	P=0.001	7.8
2-3	7.14	0.75	0.77	P=0.255	7.4	6.43	0.80	0.83	P=0.803	6.6
3-4	4.94	0.86	0.87	P=0.004	5.7	4.76	0.81	0.89	P=0.019	5.1

*95% confidence interval) for all trials

Figure Legends

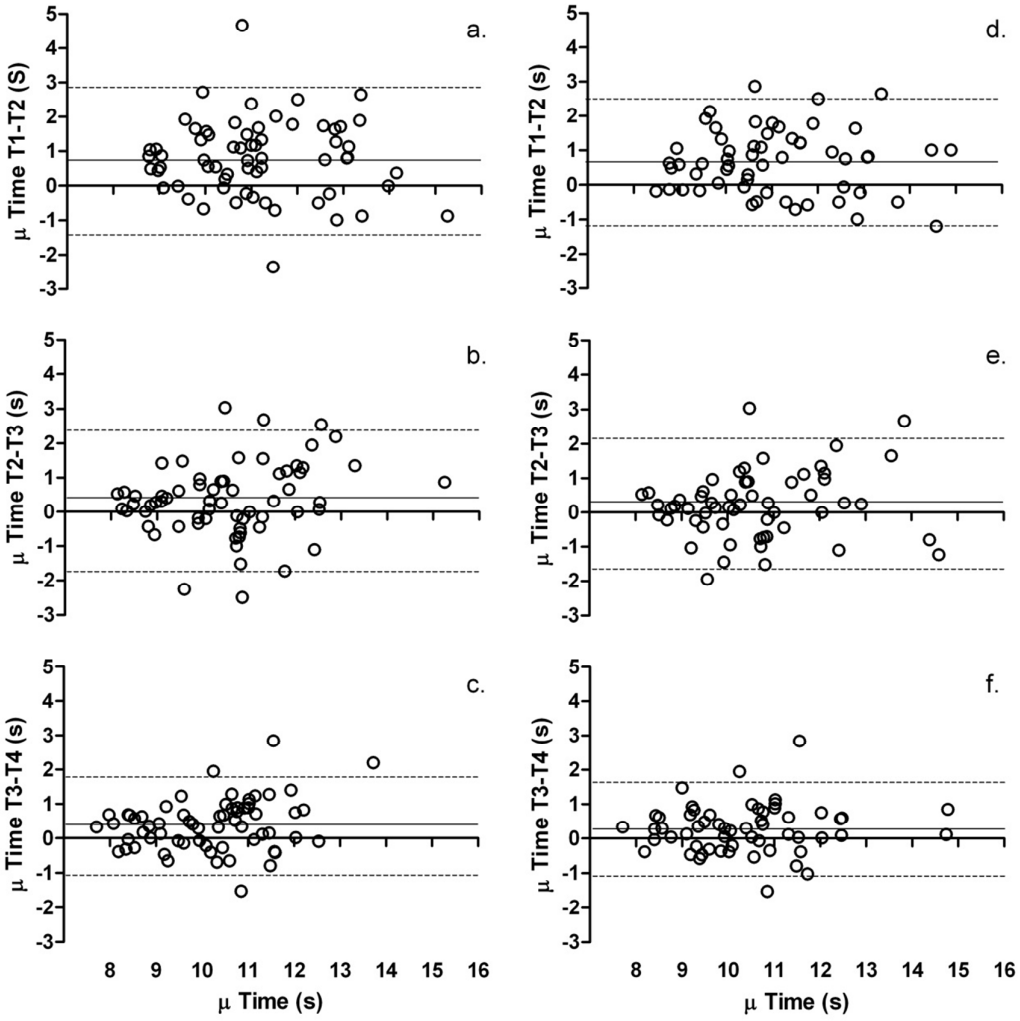

Figure 1: Bland Altman plots showing differences between tests against each individual mean for Schedule 1; (a) *trial 1-trial 2,(b) trial 2-3 and (c) trial 3- trial 4*, and Schedule 2; (d) *trial 1-trial 2, (e) trial 2-3 and (f) trial 3- trial 4*. Solid lines represent mean bias; dashed lines represent 95% limits of agreement.