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Role of Gender, Age and Ethnicities on Visual Reaction Time and Visual Anticipation Time of Junior Athletes

Kuan Yau Meng, Nurul Atikah Zuhairi, Faudziah Abd Manan, Victor Feizal Knight, Mohd Nizar Ahmad Padri, Rokiah Omar

[1]*Optometry & Vision Science Program, School of Healthcare Sciences, Faculty of Health Sciences, Universiti Kebangsaan Malaysia, 50300 Kuala Lumpur, Malaysia*
[2]*Faculty of Medicine & Defence Health, National Defence University of Malaysia, Kem Sungai Besi 57000 Kuala Lumpur, Malaysia*
[3]*Center for Research in Exercise and Physical Activity, National Sports Institute of Malaysia, Bukit Jalil, 57000 Kuala Lumpur, Malaysia*

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ABSTRACT

Visual reaction time (VRT) measures how fast one responses to a visual stimuli while visual anticipation time (VAT) measures prediction of an arrival of a stimulus and time required to response to the emergence of an object. This study investigated the VRT and VAT in a sample of junior athletes as well as evaluating the role of gender, age and ethnicities differences. 57 males and 51 females, comprising of 40.7% Malays, 47.2% Chinese and 10% Indian ethnicities participated in the study. The VRT tests include simple visual reaction time (SRT) test, two multiple-choice visual reaction time (2CRT) test and four multiple-choice visual reaction time (4CRT) test. VAT was evaluated using Bassin Anticipation Timer at stimulus speeds of 5 mile per hour (mph), 10 mph and 15 mph. Between gender, males had faster SRT and 2CRT as compared to females. However for 4CRT, faster response time in females was noted. VAT test at 15 mph showed faster response in males with higher consistency and less variability as compared to females ($p = 0.02$). Age comparison in VRT within the age group of 13 to 16 years old showed statistically no significant difference. As age increases, a decrease in all magnitude of errors was observed in VAT. Chinese athletes showed faster VRT responses, however not clinically significant. The VAT for Chinese athletes was significantly more accurate than non-Chinese athletes especially at speed of 5 mph ($p = 0.01$). The VRT differences between SRT, 2CRT and 4CRT were statistically significant [$F(2,105) = 63.84$, $p < 0.01$], suggesting that the VRT became slower as the number of visual stimuli increased. VAT speed showed statistically significant influence on all magnitude of errors ($p < 0.001$), with higher errors as speed increases. In conclusion, gender, age and ethnicities may influence the VRT and VAT responses.

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INTRODUCTION

Visual reaction time (VRT) and Visual anticipation time (VAT) are higher order perceptual abilities. The VRT test measures how quick an individual response to a sudden visual stimulus. Commonly agreed measurement of VRT according to Luce (1986) measures the simple visual reaction time (SRT) and multiple-choice visual reaction time (CRT). The SRT is the time required for an athlete to respond to the presence of a single stimulus while CRT measures multiple stimuli responses. VAT is the measurement of accuracy in performance of motor behaviour. It is defined as the estimation or prediction on arrival of a stimulus and time required to response to coincide with the moment of arrival (Schmidt, 1968). One aspect of anticipation in sports is coincidence anticipation timing (CAT). Anticipation makes up for the physiological limitations of reaction time, which is affected by visual skills.

Previous studies have shown faster VRT and higher accuracy in VAT among athletes as compared with non-athletes (Akarsu *et al*., 2009; Lyons *et al*., 2008; Tenenbaum *et al*., 2000; William and Starkes, 2002). VRT and VAT differences between genders show faster response in males as compared to females (Brady, 1996; Der and Deary, 2006; Heirani *et al*., 2012). Brady (1996) found that male athletes outperformed female athletes in magnitude and direction of errors. Faster and more accurate response was noted in VRT and VAT measurement as the age of an athlete increases (Vänttinen *et al*., 2010). Evidence suggesting inequality of age on

Corresponding Author: Datuk Dr Rokiah Omar, Optometry & Visual Science Program, School of Healthcare Sciences, Faculty of Health Sciences, Universiti Kebangsaan Malaysia, Jalan Raja Muda Abdul Aziz, 50300 Kuala Lumpur, Malaysia.
E-mail: r_omar@ukm.edu.my; Phone: +603-92898058

VAT task was controversial (Brady, 1996; Rodrigues *et al*., 2009; Millslagle, 2004; Vänttinen *et al.* 2010).

Most sports require athlete's to possess high perceptual abilities that can impact on their response accuracy and sports performance. Open skills sports such as soccer, badminton and basketball are externally paced tasks. These sports are performed in a temporally and spatially changing environment, requiring athlete's fast reaction to sensory stimuli before initiation of physical action. Poor visual performance in reaction response and anticipation ability may be a barrier to high sports achievement. Athletes' performance and perceptual abilities have always been a topic of interest. Researchers believed that better understanding in VRT and VAT among athletes could unlock the key towards more successful sports performance (Ward and Williams, 2003; Magill, 2004). However, little information is available on the VRT and VAT among junior athletes. Hence, the purpose of this study was to investigate the visual reaction time and visual anticipation time among junior athletes as well as evaluating the role of gender, age and ethnicities differences.

MATERIALS AND METHODS

One-hundred and eight students (57 males, 51 females) from the Bukit Jalil Sports School (BJSS), aged between 13 to 16 years, participated in this study. The mean age of the study population was 14.86±1.03 years. This study begun with visual functions screening, which includes general observation of the anterior eye, refraction, stereopsis, colour vision, ocular alignment, ocular dominancy and hand dominancy tests. None showed any clinical signs of colour vision, stereopsis or strabismic problems. The ethnic proportions in this study were Malays 40.7%, Chinese 47.2%, Indians 9.3% and other ethnicities 2.8%. Corrected monocular visual acuity of athletes was 0 logMAR or better on each eye. Written consent was obtained prior to examination. This study complies with the tenets of the Declaration of Helsinki in research on human subjects and received approval code UKM 1.5.3.5/244/NN-081-2013 from University Kebangsaan Malaysia Research Ethics Committee.

The apparatus used to measure VRT and VAT was the Choice Reaction Time (Model 63035) and Bassin Anticipation Timer (Model 35575), Lafayette Instruments Co., Lafayette, USA respectively. All visual measurements were obtained binocularly. Each athlete was required to stand during the testing procedure. They were presented with 3 trials before commencing the test procedure for purpose of familiarisation. The trial scores were recorded in milliseconds (msec). Standardised instructions regarding the general nature of the experiment were verbally explained to each athlete prior to the commencement of the test.

The VRT measurement employed three different tests namely Simple Reaction Time (SRT), 2 Choice Reaction Time (2CRT) and 4 Choice Reaction Time (4CRT) tests. The differences between these were the number of LEDs initiated during each procedure. Junior athletes were required to immediately respond to the visual stimulus presented by pressing the corresponding response (stop) button. The response time was recorded as displayed on the electronic timer. VAT measurements involved three common error scores, which are absolute error (AE), constant error (CE) and variable error (VE). AE characterized the magnitude of error in response while CE signified the direction of error and VE represented the consistency of response (Millslagle, 2004). The speed of the stimulus presented during the test was initially a slower speed, i.e. 5 mph then progressing to a faster speed of 10 and 15 mph respectively. Anticipation time was measured and categorized as early, when athlete depresses the stop button before the stimulus arrives at the target location, or late, when the junior athlete depresses the stop button after the stimulus arrives at the target location.

Results:

All VRT and VAT results were displayed as mean and standard deviations, recorded in milliseconds (msec). The VRT comparison was measured for dominant hand SRT, 2CRT and 4CRT. The mean VRT respond increases from SRT (371.98±98.19) to 2CRT (422.45±75.26) and 4CRT (530.62±60.46). Data analysis using the F-test indicated statistically significant difference between SRT, 2CRT and 4CRT [F (2,105) = 63.84, $p < 0.01$]. As the number of visual light stimuli increased from one stimulus to two followed by four stimulus LEDs, the mean VRT response became slower. As shown in Figure 1, there was an increasing trend of slower VRT response recorded as the number of visual stimuli increased.

Comparison between males and females VRT and VAT scores was also done in this study. The mean SRT response for males was 366.32±94.29 while for females was 378.32±102.94 (t = -0.63, $p >$ 0.05), indicating male responded faster by 12.0 msec. As for mean 2CRT response, the males response was 421.44±69.75 and the females was 423.58±81.68 (t = -0.15, $p > 0.05$). Males were found to have 2.14 msec faster responses compared to the females in 2CRT response. However, mean 4CRT response for males, 533.29±60.09, was slower by 5.65 msec when compared to females. Female 4CRT response showed a value of 527.64±61.33 (t = 0.48, $p > 0.05$). Although statistically not significant for VRT, male athletes showed faster responses in SRT and 2CRT than female athletes. Conversely, female athletes showed faster VRT response in 4CRT in comparison to male athletes.

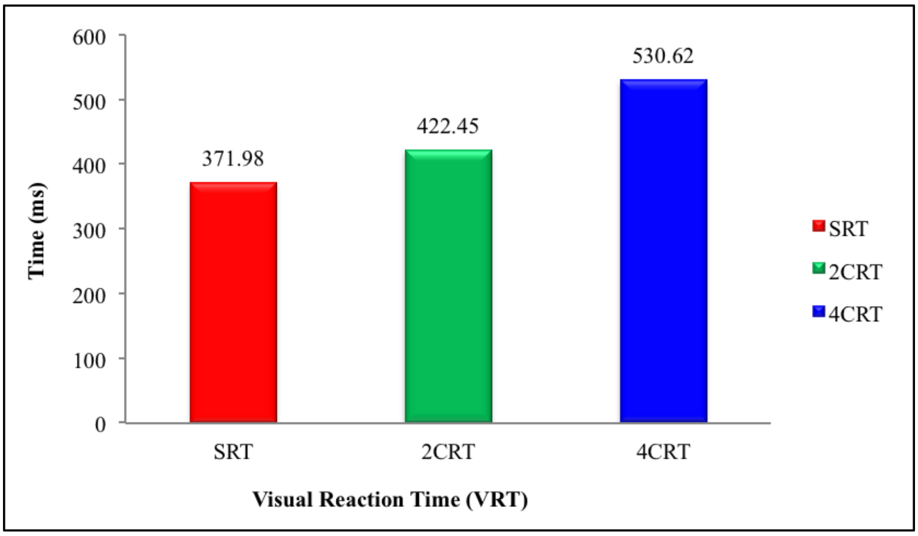

Fig. 1: Mean VRT for dominant hand response for SRT, 2CRT and 4CRT response of junior athletes

Across the age group, overall VRT for 13 years old junior athletes showed faster response compared to the 14, 15 and 16 year old age groups (Figure 2). As the athlete's age increases from 13 to 15 years old, junior athlete VRT response became slower for SRT, 2CRT and 4CRT. The VRT for 16 years old junior athlete showed overall improvement in VRT response. However, data analysis showed no statistical significant difference in SRT, 2CRT and 4CRT across these age groups [F (3,104) = 1.33, 1.71, 2.51, $p > 0.05$]. These results suggested response across age groups showed similar VRT values.

For VAT, the mean CE at the speed of 15 mph for male was 72.43±37.91 while for females, it was 92.52±48.38 (t = -0.46, $p > 0.02$). The mean VE at the speed of 15 mph for male was 144.87±75.82 while for females, it was 185.04±96.76 (t = -2.41, $p > 0.05$). Generally, males performed with higher accuracy and consistency with less bias at all speeds when compared to females, except for the AE errors at the speed of 5 mph. Male (mean 92.10±40.99) junior athletes were found to be slower than female (mean 80.03±36.06) only at the speed of 5 mph for AE. However, as the speed increases, the mean differences between gender increases.

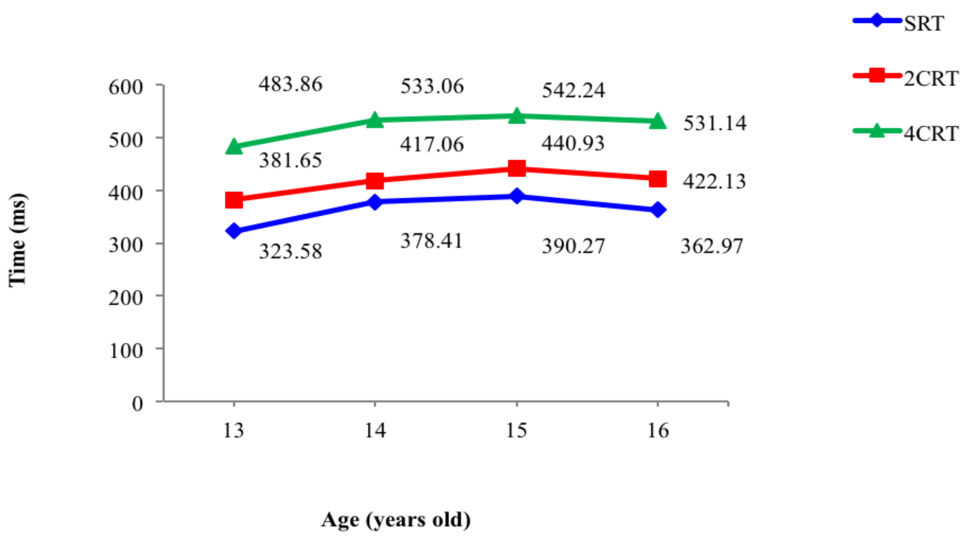

Fig. 2: Mean value of SRT, 2CRT and 4CRT across 13, 14, 15 and 16 years old age group junior athletes

Although not statistically significant for VAT using the Chi-square test, there was a declining trend in magnitude of errors, AE, CE and VE for the three speeds, 5, 10 and 15 mph as the age increases. Athletes at the age of 16 years performed faster with higher accuracy and less bias than the younger age groups for all magnitude of error across the three speeds. Older age groups athletes performed with more consistency across the stimulus speeds of 5, 10 and 15 mph. However, at speed of 15 mph, mean VE becomes inconsistent across all the age groups.

Australian Journal of Basic and Applied Sciences, 9(5) March 2015, Pages: 129-134

Malaysia is a multi-racial country, which includes Malay, Chinese, Indian and other ethnicities. In this study, the junior athletes were categorized into Chinese and non-Chinese ethnicities for a better comparison. The mean difference in SRT (362.96±97.73 vs 380.06±98.75), 2CRT (422.05±88.86 vs 422.81±61.43) and 4CRT (526.98±72.20 vs 533.87±48.02) response among Chinese ethnic junior athletes was faster when compared to non-Chinese ethnic, using t-test. However, there was no statistically significant difference noted for all VRT response tested ($p > 0.05$). These results suggest that ethnicity do not influence the VRT respond and the results showed almost similar scores when compared.

Nevertheless, the findings for VAT were inconsistent with VRT observations, whereby it was found that Chinese ethnic athletes performed more accurately with less directional error compared to the non-Chinese ethnic athletes. Only the Chinese ethnic junior athletes (mean 76.71±34.84) VAT at speed of 5 mph test had significantly lower AE scores as compared to the non-Chinese ethnic (mean 95.07±40.81), t (106) = -2.50, p = 0.01. At other magnitude of errors across different stimulus speed, there were no statistically significant findings between the Chinese and non-Chinese ethnicities junior athletes.

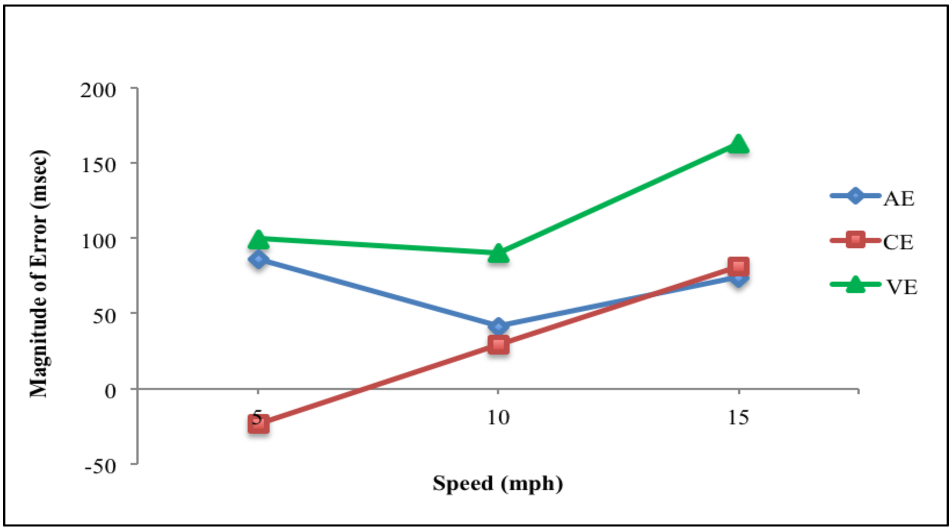

Fig. 3: Magnitude of errors i.e. AE, CE and VE (msec) for AE, CE and VE against speed 5, 10 and 15 mph

In the VAT test, magnitude of error AE, CE and VE were compared against speed. There was a statistically significant difference observed in AE, CE and VE at the speed of 5, 10 and 15 mph, $p < 0.001$ using the one-way ANOVA test. As shown in Figure 3, CE has the lowest magnitude error followed by AE and VE. Higher magnitude of error in CE and VE was noted as the speed becomes faster.

Post-hoc analyses using Bonferroni criterion for significance indicated that the average number of AE and VE was significantly lower in the speed of 10 mph than at the speed of 5 mph and 15 mph, $p < 0.001$. However, CE was significantly lower with speed of 5 mph than in the other two conditions, speed of 10 mph and 15 mph.

Discussion:

In investigating the effects of visual stimuli quantities on response time, this study suggests VRT became slower as the number of visual stimuli increases. The SRT was significantly faster [F (2,105) = 63.84, $p < 0.01$] than 2CRT and 4CRT. As the number of response buttons increase relative to the number of visual stimuli, athletes took longer time to decide on the correct visual response. This was in congruence with studies by Wood and Abernethy (1997) and Karia Ritesh and Ghuntla (2012).

Gender comparison in general showed faster VRT and VAT measurements among male athletes. SRT and 2CRT measures for males were faster than female athletes. However, the results for 4CRT tests demonstrated faster response in female athletes than in male athletes. Past literature reports believe that VRT among the male population was faster compared to the female population for reasons related to their respective hormonal variations (McEwen, 2001). The SRT, 2CRT and 4CRT comparison between males and females did not however show any statistically significance difference ($p > 0.05$).

The VAT comparison for magnitude of errors, AE, CE and VE across stimulus speed of 5, 10 and 15 mph between genders showed consistent results, whereby males performed with higher accuracy and less bias than female athletes. However, only at the faster speed of 15 mph, was it statistically significantly that males performed better than females for magnitude of error, CE and VE, (t = -2.41, p = 0.02). Current literature indicates that males outperform females in CAT with higher accuracy and consistency (Meeuwsen *et al*., 1995; Payne and Michael, 1990; Schiff and Oldak, 1990; Wrisberg *et al*., 1979). Gender differences in CAT were possibly due to the greater risk-taking propensities and visuomotor skills of males.

The VRT and VAT scores across age group was compared these among junior athletes. Our research showed that as age increases from 13 to 15 years old, the junior athletes' SRT response became slower. At 16 years of age however, the SRT was faster than the 15 years old group. A similar trend was also observed for 2CRT and 4CRT test scores. The SRT for 13, 14, 15 and 16 years old however showed no statistically significant difference ($t = 0.27$, $p > 0.05$). Faster SRT scores as age advances is claimed to be influenced by years of continuous sports training (Vänttinen *et al.* 2010). This was not proven in our study.

A decrease in magnitude of error, AE, CE and VE across all stimulus speeds occurred as age increases except for VE errors at the speed of 5 mph. The mean magnitude of error, VE increased at the age groups of 13 to 16 years old. These results were however non-statistically significant ($p > 0.05$). On the contrary, the mean magnitude of error, AE and CE at the speed of 5, 10 and 15 mph decrease as the athletes became older. This declining trend was also noted for magnitude of error, VE at the speed of 10 and 15 mph. The older age groups were found to have lower magnitude of errors, which was consistent with studies done by Vänttinen *et al*. (2010). The findings indicated that as athletes became older; their anticipation skills became more accurate, with less directional bias and higher consistency. The mean VE was however more variable at a faster velocity, i.e. 15 mph across all age groups.

To our knowledge, there have been no prior studies on VRT and VAT among different ethnicities in Malaysia or in other countries. VRT measured between Chinese and non-Chinese ethnicities athletes suggest that Chinese ethnic athletes have faster SRT, 2CRT and 4CRT as compared to non-Chinese ethnic athletes. However the mean SRT, 2CRT and 4CRT for Chinese ethnic athletes was not significantly faster ($p > 0.05$) than their non-Chinese ethnic athlete counterparts. Similarly VAT findings showed earlier anticipation response in Chinese ethnic athletes as compared to non-Chinese ethnic counterparts. It is postulated these differences could be due to cultural, enviromental and genetics influence (Albaity and Rahman, 2012; Mcinnis, 1996).

In VAT measurement, the effects of stimulus velocity at all magnitude of errors: AE, CE and VE were statistically significant ($p < 0.001$). As stimulus speed increases for stimulus velocity, CE the magnitude of error also increases. Mean magnitude of error for AE and VE was found to have a declining trend at the speeds of 5 and 10 mph but subsequently increased in error from the speed of 10 mph to 15 mph. Post-hoc Bonferroni analysis for CE was significant across the stimulus speed of 5, 10 and 15 mph respectively. These findings showed that the magnitude of error increases as speed increases. In our study, it is postulated that high velocity condition allowed less time for feedback control among the athletes leading to a higher magnitude of errors. Athletes would need to rely more on preprograming responses and thereby have higher magnitude of error as stimulus speed increases (Ball and Glencross, 1985; Schmidt and Russell, 1972; Williams, 2000).

Conclusion:

This study found that the mean SRT, 2CRT and 4CRT became slower as the number of visual stimuli increased. The result shows significantly slower SRT as compared to 2CRT and 4CRT. Generally, male athletes were found to outperformed female athletes with faster response, higher accuracy and less variability, especially at higher speed, 15 mph. The VRT when compared across age groups showed a faster VRT response in the 13 years old age group of junior athletes compared to the older age groups, but it was vice versa for VAT. Statistically, the age differences for VRT and VAT were found to be non-significant. The comparison between Chinese ethnic junior athletes to non-Chinese ethnic suggests faster responses, higher accuracy and better consistency among the Chinese ethnic junior athletes as compared to non-Chinese ethnic. The VAT data showed that there was significant influence of stimulus speed on VAT. Further studies on VRT and VAT between athletes and non-athletes are necessary for a more detailed understanding on the role of sports expertise in motor performance.

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