DOES OCCLUSION ALTER THE VISUAL-PERCEPTUAL-MOTOR SKILLS OF ELITE SILAT ATHLETES WHEN RESPONDING TO VIDEO-BASED PROJECTED COMBAT SITUATIONS?

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This study investigated if occlusion of attacks affects the visual search behaviour (VSB), quiet eye, and reaction time (RT) of Silat athletes. Occlusion (OC) refers to the spatial occlusion of the trunk of a video-projected opponent. It was hypothesized that (i) there would be higher number of fixations in OC, (ii) despite OC, the trunk will remain the primary fixation point, and (iii) longer RT to respond to projected attacks with OC due to the reduction in visual information. Seven male elite Silat athletes performed an evasion followed by a counterattack in response to an opponent projected in two-dimensions for both non-occluded (NOC) and OC conditions. A Dikablis eye tracker and a 12-camera VICON MX system were used to determine the variables of interest. Results indicated fewer number of fixations in OC while the trunk remains the area of interest regardless of occlusion conditions. No differences in RT were observed. Occlusion may have decreased the need for visual scanning and reiterates the trunk as the primary area of focus. Occlusion may be used as a training tool for sub-elite athletes, cueing them to reduce cognitive load on less crucial information, mimicking the VSB of elite athletes thus potentially improving performance.

KEYWORDS: Silat, visual search behaviour, quiet eye, reaction time, occlusion.

INTRODUCTION: Silat is a Southeast Asian martial art which has evolved into a competitive combat sport across various countries. In competitive combat Silat, two athletes duel each other in unarmed combat and the victor is determined by scoring the highest number of points or knocking the opponent out. The ability to perceive sport-specific information and respond with the appropriate motor responses is crucial for success in combat sports such as Silat. The potential of an athlete to perceive affordances in an environment using visual information is referred to as the visual-perceptual-motor skill and can be inferred from an athlete's visual search behaviour (VSB), quiet eye (QE) and reaction time (RT) (Jackson & Farrow, 2005; Vickers, 2007). Visual search behaviour is able to determine an athlete's gaze fixations from which the quantity, location and durations of these fixations provide pivotal insight into the visual information processed by athletes (Piras & Vickers, 2011). The QE defined as the final fixation on a specific location within the task space before the initiation of a motor response can help explain the skill disparities between elite and non-elite athletes based on its duration (Vickers et al., 2019). Analysis of VSB, QE, and RT have been conducted across various sports studies via video-based projections of sport-specific scenarios that require athletes to react using skilled technique (Lee et al., 2013). A prior video-based projection study concluded that elite Silat athletes tend to focus on the trunk region more than other body parts of an opponent prior to an oncoming attack. (Lee et al., 2020). The athletes in the aforementioned study could have employed the visual pivot strategy and utilized peripheral vision to perceive oncoming attacks faster; an advantage that could be a contributor to their high expertise levels (Klostermann et al., 2020). However, there is limited research on the importance of visual fixation on the trunk despite it being a common occurrence amongst elite Silat athletes. Can this be trained to benefit sub-elite Silat athletes? Visual occlusion is one measure which removes critical visual cues from an athlete to evaluate how performance is affected (Hagemann et al., 2006). Past studies of visual occlusion in sports found that expert or elite athletes were able to consistently detect predictive kinematic information to produce a desirable performance outcome (Hagemann et al., 2006). While visual occlusion has been widely investigated in racquet and ball sports, there is a paucity of research in combat sports. Thus, this present study aims to investigate how the VSB, QE, and the outcome measure of

RT of elite Silat Athletes is affected when faced with trunk occluded Silat specific attack conditions (OC) versus non-occluded Silat specific attacks conditions (NOC). With trunk occlusion, it is hypothesized that (i) there will be higher number of fixations in OC due to differences in visual information, (ii) despite occlusion, the trunk region will remain the primary fixation as it still provides a visual pivot to other parts of the body, and (iii) longer RT to respond to projected attacks in OC due to the reduction in visual information.

METHODS: Seven male elite Silat athletes (age = 20.12 ± 3.04 years; height = 1.75 ± 0.24 m; mass = 72.5 ± 3.83 kg) who have previously represented the nation at international competitions were recruited. A written consent was obtained before undergoing one testing session at the Singapore Sport Institute Sport Biomechanics laboratory. The techniques used for the development of the projection system followed as detailed previously in (Lee et al., 2013). For this study, an opponent was projected over a large stereoscopic screen over two occlusion conditions (i) NOC and (ii) OC, and in each condition, the opponent executed attacks which consisted of three unique single attacks; side kick, roundhouse kick and a takedown, each performed three times with either the left or the right limb. For the OC, 18 pre-recorded videos underwent trunk occlusion editing. The videos adapted from the database of Lee et al. (2020) were imported into Adobe After Effects 18.0 (Adobe, California, United States) whereby the Roto Brush tool was used to occlude the trunk region. A Dikablis Essential eye tracker V3 (Ergoneers, Geretsried, Germany) were used to measure VSB and QE while-specific motor responses performed by the participants were captured using a 12-camera Vicon 3D MX motion analysis system (VICON Peak, Oxford, UK) sampling at 200 Hz. All participants were fitted with polarized glasses and a head-mounted eye tracker synchronized using infrared timing gates. In addition, four retro-reflective markers were affixed to the participants' pelvis. Prior to the commencement of the test, participants were given familiarisation trials that included a pre-randomised set of videos, which were kept constant throughout. For the test itself, a randomised video playlist was designated to each participant and the order of the projected attacks were randomised without duplications unless there was an inappropriate response. The assessor manually cuts the timing gates which would trigger the projection of the virtual opponent thereby projecting the attack scenarios. All participants performed an evasion followed by a counterattack from an on-guard position approximately one leg's length away from the stereoscopic screen, in response to an attack from a projected opponent in both NOC and OC. The combat situations for which the participants had responded inappropriately were replayed at the end of the initial 36 trials. The test ceased when three successful trials per attack, performed bilaterally and in NOC and OC, were recorded (18 combat situations x 2 occlusion conditions). This study assessed VSB from one second before the initiation of attack by the projected attacker to the initiation of response by the participant, determined by a shift of the pelvis by more than five standard deviations from the mean measure by the motion analysis system. The VSB was inferred from (i) total number of fixations, (ii) total fixation duration from the instance the projection appeared to the instance when a response was elicited, and (iii) average fixation duration per area of interest (AOI) as a percentage of the total duration from the instance the projection appeared to the initiation of a response. The QE was determined by looking at the duration defined as gazes on a specific location for a minimum duration of 120 ms. The number and fixation duration, and QE duration were coded based on 11 AOIs. Nine AOIs are located on the attacker's body (head, left shoulder, right shoulder, left arm, right arm, trunk, pelvis, left leg, right leg) (Lee et al., 2013). Outcome of performance measure; RT data, were obtained through 3D motion data of which the mid-pelvis marker trajectories were filtered at 10 Hz using a low-pass Butterworth filter. Due to natural movement fluctuations of the pelvis, the first lateral shift of the mid-pelvis was determined only when its position exceeds five standard deviations from the mean. Statistical analysis was performed using SPSS 24 (IBM, Armonk, NY, UWA). Two-way repeated measures analysis of variance (ANOVA) was conducted to investigate differences in the VSB, QE, and RT between NOC and OC. When normality was violated but homogeneity of variance maintained, ANOVAs were used. Next, an independent samples t-test was performed to investigate differences in the VSB and QE variables between the trunk and other AOIs, regardless of the type of attack separately in NOC and OC (alpha value of <.05).

RESULTS: Regardless of attacks the athletes had a statistically significantly lower mean number of fixations of ~ 13% when responding to OC compared to NOC ($p < .05$). No significant differences were found across RT or the remaining VSB or QE variables (Table 1).

Table 1. Mean VSB and QE variables between occlusion conditions

	Non-Occluded	Occluded
Number of fixations	2.103 ± .104*	1.841 ± .193*
Fixation duration (Seconds)	1.316 ± .015	1.302 ± .017
Percentage fixations (%)	95.331 ± 1.194	94.456 ± 1.448
QE duration (Seconds)	0.115 ± .003	0.121 ± .004
Reaction time (Seconds)	0.398 ± .035	0.393 ± .012

* Statistical significance, $p < .05$.

Table 2 compares differences in VSB and QE between non-trunk and trunk regions regardless of attacks. For NOC, there were significant differences in fixation duration (seconds), percentage fixations (%), and QE duration (seconds) (Table 2). All three variables had significantly higher mean values in the trunk compared to the non-trunk AOIs, 40.5%, 105.7% and 58.1% respectively (Table 2). Similarly for OC, there were significant differences in fixation duration (seconds), percentage fixations (%), and QE duration (seconds) (Table 2). All three variables had significantly higher mean values in the trunk compared to the non-trunk AOIs, 31.3%, 94.4% and 83.3% respectively (Table 2).

Table 2: Mean VSB and QE variables across AOIs

	AOI	Non-Occluded	Occluded
Number of fixations	Non-Trunk	1.080 ± .031	1.010 ± .014
	Trunk	1.060 ± .032	1.070 ± .399
Fixation duration (Seconds)	Non-Trunk	.555 ± .047*	.603 ± .054*
	Trunk	.780 ± .058*	.792 ± .065*
Percentage fixations (%)	Non-Trunk	19.770 ± 1.970*	23.400 ± 2.830*
	Trunk	40.660 ± 3.890*	45.500 ± 4.210*
QE duration (Seconds)	Non-Trunk	.031 ± .003*	.030 ± .003*
	Trunk	.049 ± .007*	.055 ± .006*

*: Statistical significance, $p < .05$.

DISCUSSION & CONCLUSION: It was hypothesized that when the elite Silat athletes respond to the projected attacks, there would be higher number of fixations in OC compared to NOC. However, it was found that the number of fixations in OC was lower compared to the NOC (Table 1). As the fixation duration between NOC and OC had no significant differences, the findings suggest that the elite Silat athletes spent the duration of time fixating more on the trunk in the OC conditions (Table 2). Emami and Chau (2020) observed that higher visual load from task-irrelevant stimuli increased cognitive load and was predictive of decreased goal-specific performance. This was deduced from a brain-computer interface tasks which required participants to concentrate on a given stimuli, assessing attentional focus with and without irrelevant visual information. We postulate that lesser number of fixations during OC indicated a lower cognitive load as visual information was more concentrated on crucial information i.e., trunk which thus may be indicative of higher attentional focus in responding to the projected attacks. This is a characteristic of elite athletes in various sports such as golf and basketball whereby elite athletes of their respective sports had lower number of fixations with longer durations (Vickers, 2007). The reduced visual information i.e., lower number of fixations may have decreased the need for visual scanning. Expert levels of perception may not require every detail of an image as the human perceptual system can integrate information from several areas/regions based on past experiences (Williams & Ericsson, 2005). Furthermore, while occlusion was meant to restrict available information, it may have instead accentuated the trunk region resulting in a clearer distinction between individual body parts, enabling the identification of crucial anticipatory information more effectively, leading to more concentrated fixations from the athletes. It was expected that regardless of occlusion conditions, the trunk would remain the primary AOI when the elite Silat athletes responded to the projected attacks. The results supported the hypothesis as all variables except for number of fixations had significantly higher values in the trunk compared to non-trunk AOI. Despite the absence of the trunk, the occluded region may have still provided a centralized, static point in which athletes can pick up pertinent information from the peripheral limbs (Piras & Vickers, 2011). Ando et al. (2001) concluded that elite athletes have a shorter RT compared to sub-elite athletes due to a more developed central and peripheral vision. Furthermore, elite athletes were able to receive more contextual information regarding the task, making decisions quicker and easier. As the stimulus presented comes in the form of simple RT tasks, despite the occlusion of the trunk area, we postulate that the elite Silat athletes were able to receive adequate visual information from the non-occluded body parts (e.g., pelvis and lower limbs) to execute the required response, thus resulting in a non-statistically significant finding between occlusion conditions on RT (Hagemann et al., 2006). The results support the study by Lee et al. (2020) which found that elite Silat athletes had longer fixation duration and QE durations on the trunk. This suggest that the athletes were maintaining their gaze on a central location of the opponent's body, in this case the trunk, which the athletes may have picked up pertinent information from in order to respond to the projected attacks (Piras & Vickers, 2011; Klostermann et al., 2020). The findings explored areas that could provide a strategy to assist athletes of varying skill competencies in increasing their ability to pivot their gaze to relevant locations of the body for the purpose of responding appropriately. Occlusion training in combat sports could guide athletes in focusing their attention with the aim of reducing the visual load, which may then reduce the cognitive load needed to respond to an attack. The lower number of fixations in the OC compared to NOC suggests that occlusion may be used as a training tool for sub-elite athletes by cueing them to reduce cognitive load on less crucial information and fixate primarily on the trunk, mimicking the VSB of elite athletes. The trunk being the main AOI regardless of occlusion conditions provides further support for coaches and athletes to focus on this region of the body in Silat which may also have relevance to similar combat sports i.e., Taekwondo, Sambo, Muay Thai.

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