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Gaze Behaviour of Skilled and Less-Skilled Karate Athletes While Viewing Occluded Video Attacks

Abstract

Perceiving relevant visual information at an early stage, and choosing an appropriate response is vital in karate kumite. Up to date, it is not known which visual cues are used in karate kumite. The analysis of gaze behaviour while viewing occluded attacks could give more insight into this topic. The aim of this paper is therefore the analysis of karate athletes' gaze behaviour, while seeing occluded (n=18) and not occluded (n=6) karate attacks of the gyaku tsuki (GZ) and mawashi geri (MG) on a video screen. First, we examined the influence of visual occlusion on the athlete's gaze behaviour. Second, we analysed whether there were differences in number of fixations, fixation duration, and fixation locations between skilled (n=16) and less-skilled (n=10) karate athletes. Gaze behaviour was recorded up to the main punching or kicking performance by a mobile eye tracking device. No significant effects of occlusion on gaze behaviour were found. Significant differences in number of fixations between skill levels were found for the GZ with occluded pelvis, and for the MG with occluded rear leg and without occlusion. The left arm was significantly more often fixated by skilled compared to less skilled for the GZ. This study confirms the use of a visual pivot to perceive peripheral information and relying on covert attention. Moreover, the results show the impact of distance in karate kumite, which is a searchable topic for the future.

Keywords

gaze behaviour, karate, occlusion, distance

Contact

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1 Introduction

Perceptual-cognitive skills are important in time-constrained sports, e.g. cricket batting, volleyball serve reception, or ice hockey (Panchuk, Vickers, & Hopkins, 2017). Although information processing and motor responses require a certain amount of time, skilled athletes are able to respond fast and with a high accuracy to certain visual information. This information has to be extracted before the opposing action starts (e. g. Jones & Miles, 1978). Therefore, skilled athletes seem to inherit a task dependent ability to perceive cues occurring before a movement is performed, and hence to anticipate the upcoming action (Müller & Abernethy, 2012). This has already been observed in tennis (Farrow, Abernethy, & Jackson, 2005; Huys et al., 2009), badminton (Hagemann & Strauß, 2006), baseball (Ranganathan & Carlton, 2007), cricket (Müller et al., 2009; Müller & Abernethy, 2006), fencing (Hagemann, Schorer, Canal-Bruland, Lotz, & Strauss, 2010), hockey (Clatworthy, Holder, & Graydon, 1991), soccer (Diaz, Fajen, & Phillips, 2012), rugby (Jackson, Warren, & Abernethy, 2006), and in karate (Milazzo, Farrow, Ruffault, & Fournier, 2016; Mori & Shimada, 2013; Rosalie & Muller, 2013; Scott, Williams, & Davids (1993).

In order to analyse which visual information (cues) are being used for anticipation, the athlete's gaze behaviour and their responses can be examined. Studies show that gaze characteristics are not generalizable for all fields of sports, but depend on the type of sport, their task demands, their time-constraints, and also how the stimulus is presented (Gegenfurtner, Lehtinen & Saljo, 2011). Especially, expert performance has been found to be related to specific tasks in a specific domain (e.g. Ericsson & Lehmann, 1996). Moreover, different theories exist that have an impact on eye tracking results. The first theory is based on the usage of the long-term working memory to encode information of the visual field quickly, hence leading to a faster information processing and therefore to shorter fixation durations in experts (Ericsson and Kintsch, (1995). Gegenfurtner and colleagues (2011) found out that in relation to the number of fixations no differences could be found between different levels of expertise. The information reduction hypothesis by Haider & Frensch (1999), which is based on the extraction of relevant visual information and suppression of irrelevant information, leads to fewer fixations of shorter duration on task-redundant areas and more fixations of longer duration on task-relevant areas. This skill can only be gained through extensive training and learning processes. The holistic model of image perception by Kundel, Nodine, Conant, and Weinstein (2007) leads to longer saccades and shorter times to the first fixation on relevant areas and is based on the extension of the visual span and the usage of peripheral information.

While gaze behaviour is influenced by all these factors, it is recommended to analyse gaze behaviour in each field of sports for itself, and preferably in-situ (Dicks, Button, & Davids, 2010; Mann, Williams, Ward, & Janelle, 2007). Nevertheless, certain gaze characteristics have been found to be similar across different types of sports and different task demands. Studies revealed that less-skilled often have a more search driven gaze behaviour and are more attuned to vigilance (Ripoll, Kerlirzin, Stein, & Reine, 1995; Williams & Elliot, 1999), while skilled athletes use a more schema driven visual search method (Abernethy & Russell, 1987) which relates to the long-term working memory and information suppression theories. The latter method is based on learnt situation probability information, that has been gained over several years of experiences. It leads to a more efficient gaze behaviour, meaning that gaze is directed depending on the sport specific situation. This phenomenon was found, e.g. in karate (Milazzo, Farrow, & Fournier, 2014; Mann et al., 2007). Studies in badminton (Abernethy & Russell, 1987), shooting (Causer, Bennet, Holmes, Janelle, & Williams, 2010), and soccer (Helsen & Pauwels, 1993) show that this sort of gaze behaviour led to fewer fixations of longer durations, especially in skilled athletes. In combat sports, respectively in karate, experts showed no significant differences in gaze behaviour (number of fixations, fixation duration, fixation location, and total number of fixations) compared to novice karate athletes (Milazzo et al., 2016; Mori, Ohtani, & Imanaka, 2002; Rosalie & Muller, 2013).

In team sports, on the other hand, experts have fewer fixations of longer duration. They also fixate different locations, compared to novices, assuming that experts use a more analytical search strategy (e.g. Roca, Ford, McRoberts, & Williams, 2013). Moreover, gaze is also fixated not only onto certain objects, but between two or more relevant objects (e. g. players), to extract more information by peripheral vision (e.g tactical movements of team mates; Piras & Vickers, 2011). This phenomenon of using a visual pivot or a gaze anchor is also reported in non-team sports. The athletes mainly fixate central parts of the body, so they can perceive movements of distal body parts (e. g. Abernethy et al., 2001; Helsen & Pauwels, 1993; Williams & Davids, 1997). The extracted visual information, e.g. movement, via foveal or peripheral vision is then used to detect cues that are used to anticipate the opponent's or other player's future movements (Savelsbergh, Williams, Van der Kamp, & Ward, 2002; Savelsbergh, Van der Kamp, Williams, & Ward, 2005; Smeeton & Huys, 2011; Williams, Huys, Cañal-Bruland, & Hagemann, 2009). Moreover, Hausegger et al. (2019) found out that in combat sports the gaze-anchoring strategy depends on the cues that are being used, e.g. in a combat sport where mostly the upper body limbs are used for an attack, the gaze anchor lies on the upper body part (in shoulder line), and in sports where the legs are commonly used for an attack, the gaze anchor lies lower, more in the middle of the attackers body.

The use of a visual anchor is also reported in karate (e.g. Milazzo et al., 2016; Mori, et al., 2002; Rosalie & Muller, 2013). Skilled as well as less-skilled directed their gaze more on pivotal body regions (head and chest) than on peripheral body regions (e.g. shoulder, arm/fist and leg/foot). Slightly different results in regard to fixation locations of karate athletes are reported by Schorer, Rienhoff, Fischer, & Baker (2013). Although no significant differences between both skill levels were found, skilled payed more visual attention to head and pelvis, while less-skilled directed their gaze more towards chest and arm/fist. The Bandow suggest, that skilled athletes use the visual anchor firstly, to conceal their peripheral attention, and secondly to process the perceived peripheral information more rapidly. Moreover, less-skilled karate athletes seemed to experience a peripheral narrowing or predisposition for peripheral information under stress. In compliance with Abernethy and Russell (1987), it is evident that skilled karate athletes use situational probability information and the opponent's postural cues for anticipation. Moreover, Rosalie & Muller (2013) found out, that skilled athletes use earlier and multiple visual information compared to novices.

In this context overt (foveal information) and covert attention (peripheral information) are important factors in gaze behaviour and hence in anticipation. Vater, Williams and Hossner (2019) claim that it is not possible to differentiate the use of overt or covert information based only on gaze data. To overcome this issue occlusion methods are needed to be used. When using the occlusion method certain visual information can be withheld. Whether important visual information is missing can then be seen through the athlete's response or performance, the more important the information the worse the performance or at least the bigger the differences to normal responses (Bandow, 2016; Williams & Ward, 2003). In this regard it is possible to analyse the athlete's responses or performance in relation to the visual information that is provided or missing. A study from Vine, Lee, Walters-Symons, & Wilson (2017), therefore, analysed the impact of gaze behaviour on a golf putt performance by occluding visual information before initiating, and during a putt. Although the ball was occluded at certain time points, the athlete's gaze strategy did not differ from the control condition: the gaze was directed to the invisible ball as if it was visible. A further study by Williams, Davids, & Burwitz (1995) used spatial occlusion to demonstrate that the gaze behaviour of skilled athletes is more effective than that of novices. They showed that skilled extract more visual information through peripheral vision, compared to their less skilled counterparts. Furthermore, Rosalie & Muller (2013) analysed anticipation skills of expert, near-expert, and novice karate athletes towards temporally occluded blocks and attacks in an in-situ study. They found differences in the timing of visual information pick-up between all three skill levels.

On the whole, there is no clear consent about the differences in gaze behaviour between skilled, less-skilled and novice karate athletes. Although studies show that skilled use a visual anchor located around the opponent's head and upper torso, and hence gain visual cues at an early stage, it is still not known which specific body parts are actually used to anticipate an attack (Milazzo et al. 2016; Williams and Elliot, 1999). A combined analysis of gaze behaviour and the occlusion technique, as used by e.g. Rosalie and Muller (2013), Salb, Splitt, Bandow, and Witte (2015), or Williams and Davids (1997), could provide more information about the cues used for anticipating an attack. Through the manipulation (occlusion of specific information) in the visual field it is possible to analyse the impact of gaze behaviour, when comparing the results with not manipulated conditions, or even analyse in which professional stage the athletes are, whether they already acquainted a certain gaze strategy (e.g. as in the gulf study by Vine et al., 2017). Moreover, using this specific manipulation (occlusion) of visual stimuli in regard to its temporal and spatial appearance could lead to an impact on gaze behaviour and performance, and hence provide information about anticipatory cues.

In regard to shed more light in the usage of anticipatory cues in karate, this study is the first step with the main aim on the question, whether occlusion has an impact on gaze behaviour of skilled and less-skilled karate athletes while viewing video-based karate attacks.

For the analysis we chose the most frequently used attacks used in competitions, based on previous studies (Author, 2014, 2016). Based on previous results by Abernethy and Russell (1987), we hypothesize that occlusion of certain visual information has an impact on gaze behaviour of less-skilled athletes, due to their more search driven gaze behaviour and smaller knowledge in regard to situational probability information than skilled karate athletes. Moreover, we assume that, based on the results in a previous eye tracking study in karate using the occlusion method (Salb et. al., 2015) and in golf putting with occluded vision (Vine, et al., 2017) skilled have attained a more stable gaze behaviour and are not influenced by occlusion that much. In this respect, we expect that less-skilled karate athletes therefore use a higher number of fixations of shorter duration, and different fixation locations to gather the needed visual information. Moreover, we assume that skilled karate athletes make more use of a visual anchor around the head and chest compared to less-skilled that also fixate the left more often (Schorer, Rienhoff, Fischer, & Baker (2013).

2 Materials and Methods

Participants

Twenty-six karate athletes voluntarily participated in this study. They were categorized as skilled or less-skilled karate athletes on the basis of their experiences and competition level. The skilled group consisted of 16 karate athletes (M = 22.5 (SD 5.3) years of age, 11 males, 4 females) and had an average of 14.7 (SD 3) years of training experience, and experiences in national and international competitions. The group of less-skilled consisted of ten karate athletes (M = 15.8 (SD 2.4) years of age, 4 males, 6 females) with training experiences on a recreational level of an average of 6.8 (SD 2) years, and without experiences in competitions. The study was conducted under the ethical guidelines of the academic institution; all participants gave their consents.

Stimulus

For this analysis the two most frequently used attacks, the gyaku tsuki and mawashi geri (kicking movement with the rear leg), were used, based on an analysis of attacks performed in a national competition by an expert coach and sports scientist (Bandow, 2016). The attacks were presented from an opponent's perspective of view on a life size video scene. The attacks were recorded by a video camera standing fixed in 4 m distance at the attackers' eye level. The choice of using a video screen was due to methodical limitations: to occlude specific information. The attacks were performed by a female karate athlete with experience in national and international competitions. Her movement executions were rated as representative for the mentioned attacks by the mentioned expert.

The first attack used, a gyaku tsuki, is a straight forward punch performed with the rear arm, targeting the opponent's chest (chudan). The second attack, mawashi geri, is a kicking technique, where the knee of the rear leg is brought forward up while the pelvis is rotated inwards. The rear leg then performs a snapping movement with the lower leg to strike the opponent on his side with the ball of the foot at head level (jodan). Before the execution of each attack different stepping movements (the athletes jumping forward, backward, and in place before executing an attack) were shown to make the scene more realistic. This resulted in different video durations for each attack: 1280 ms for the gyaku tsuki and 2720 ms for the mawashi geri. More specifically, the video footage for each attack was created by showing the stepping movements and the preparation phases of the attacks up to a defined frame (based on a previous study by Bandow, 2016). For the gyaku tsuki this was the last frame before the punching arm started the punching movement, and for the mawashi geri the last frame before the rear leg started with the kicking movement.

In order to analyse the impact of occlusion on gaze, three spatial occlusion conditions were created for each attack. The occlusions concealed key movement characteristics of each attack based on a previous movement analysis by an expert (Bandow, 2016). Therefore, the pelvis, punching arm, and leading leg were occluded in the videos showing the gyaku tsuki, and the feet, kicking leg, and leading arm were occluded while showing the mawashi geri (Fig. 1). To compare the athlete's gaze behaviour while viewing attacks without occlusion, both attacks were also presented without occlusions, resulting in four different sequences for each attack. All sequences were presented three times resulting in 12 attacks for the gyaku tsuki and 12 attacks of the mawashi geri.

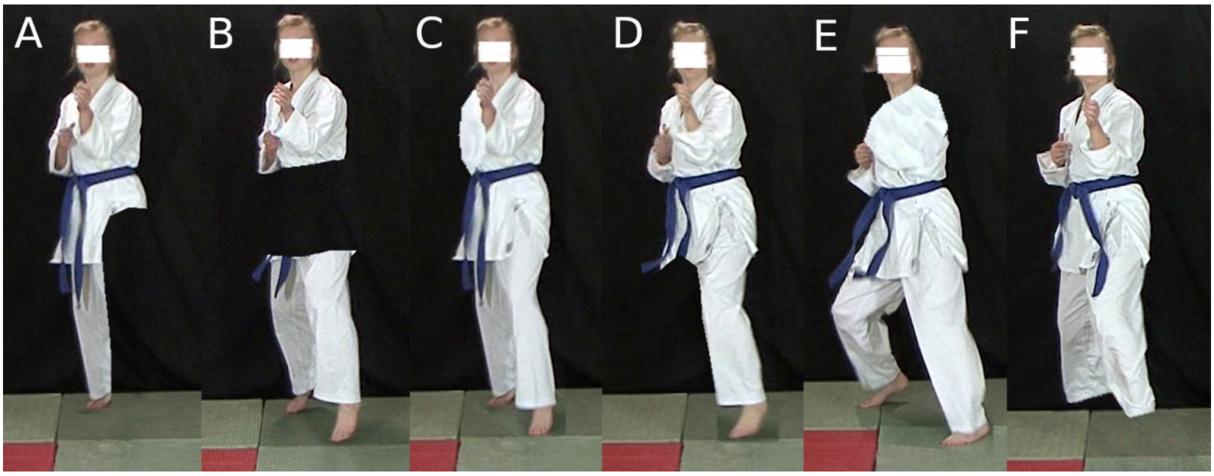

Fig. 1: Single frames taken out of the video attacks showing the occlusions for the gyaku tsuki (A-C) with occluded front leg (A), hip (B), and punshing arm (C) and occlusions for the mawashi geri (D-F) with occluded kicking leg (D), leading arm (E), and feet (F).

To minimize a learning effect and the probability to anticipate the upcoming attack, the sequences were randomly distributed over six blocks , each containing four attacking sequences of the gyaku tsuki or mawashi geri (marked italic in the example at end of the paragraph), and three other attacking sequences (kizami tsuki and mawashi geri (performed with the front leg)) that were not part of the analysis (e.g. gyaku tsuki with occluded pelvis, kizami tsuki with occluded leading arm, gyaku tsuki with occluded punching arm, mawashi geri front leg with occluded feet, mawashi_geri_back leg with occluded feet, gyaku tsuki with occluded pelvis, kizami tsuki with occluded back leg). Before each attack a dot in the middle of the screen with its colour turning from red to green was presented, indicating the next attack.

Study Design & Procedure

All attacking sequences were shown in life size on a back-projection screen (Samsung SP-D400, 25 Hz; 1024×768 px). The participants stood two meters away from the screen on mats. To track their eye movements, the participants wore a mobile eye tracking system (SensoMotoric Instruments; Teltow, Germany, Model Eye Tracking Glasses (ETG)). The ETG allows binocular eye tracking up to 30 Hz sampling rate and uses corneal reflection and dark pupil method to measure eye-line-of-gaze in relation to the field of view (resolution of 0.1° visual angle, precision of 0.5°, visual range: 80° horizontals, 60° vertical).

The ETG was calibrated (three-point calibration) for each participant and before each examination. To verify a valid calibration during the test, the participants had to fixate three points after each attacking sequence, and conduct a recalibration when necessary. In order to get familiar to the ETG and the video-based attacks, the participants observed 15 to 20 attacks that were not part of the study.

The participants were instructed to act as defender, hence they were only allowed to respond to attacks, but not to attack. To maintain a near-to high ecological validity, there were no restrictions in regard to the type of response.

Data Analysis

Before the actual analysis two independent raters assigned each fixation (only fixations with a minimum duration of 100 ms that were reported by the eye tracking analysis software SMI BeGaze Version 3.4a) frame-by-frame to the following predefined areas of interest (in a modified version from Williams & Elliot, 1999): head, chest, pelvis, abdomen, right shoulder, left shoulder, leading arm, and rear arm. The legs were not considered, because they were not fixated in this study. This procedure was conducted by the two raters from the first frame of the attacking sequence up to the end of the video presentation. The results of the Cohen's Kappa test for interrater-reliability between the two raters show a high reliability of $\kappa = 0.9$ ($p = .000$; CI: 0.88 to 0.92).

To analyse the impact of occlusion on mean relative fixations (number of fixations/video duration in ms*100) and mean fixation duration between skilled and less-skilled, a mixed ANOVA with repeated measures on the last factor with skill level (2) as the independent between-subject factor and occlusion (4) as dependent variables was used for each attack. Independent t-tests as post-hoc tests were conducted to analyse the differences of mean relative fixations and mean fixation durations between skill levels for each occlusion condition. A one way ANOVA with repeated measures on occlusion (DVs) was conducted to analyse differences within each skill level. To analyse the influence of fixation locations a two-way ANOVA with repeated measures on the last factor with skill as independent between-subject factor and fixation location and occlusion as dependent in-between-factors was used.

The level of significance was set to α = .05. The Levene's-test was conducted to analyse the quality of variances and the Kolmogorov-Smirnov test to control normal distribution. Greenhouse Geisser corrections were used when sphericity was violated. Bonferroni post-hoc test corrections were used to analyse differences between occlusion conditions and fixation locations.

3 Results

Number of relative Fixations

A significant interaction effect between skill level and occlusion condition was found for the GZ in relation to relative mean fixations ($F(3,72)=3.042$, $p = .034$, $\eta p^2 = .113$). The results of the t-test, to analyse the main effects between skilled and less-skilled for each occlusion condition, reveal only a significant difference for occlusion condition hip ($t(11) = 2.45$, $p = .032$), with skilled (M = .29, SD = 0.04) attaining higher mean relative fixations than less-skilled (M = 0.20, SD = 0.11) (Fig. 2A).

No interaction effect between skill level and occlusion condition was found for the MG (Greenhouse Geiser $F(2.04,48.86) = 1.64$, $p = .205$, $\eta p^2 = .064$) (Fig. 2B).

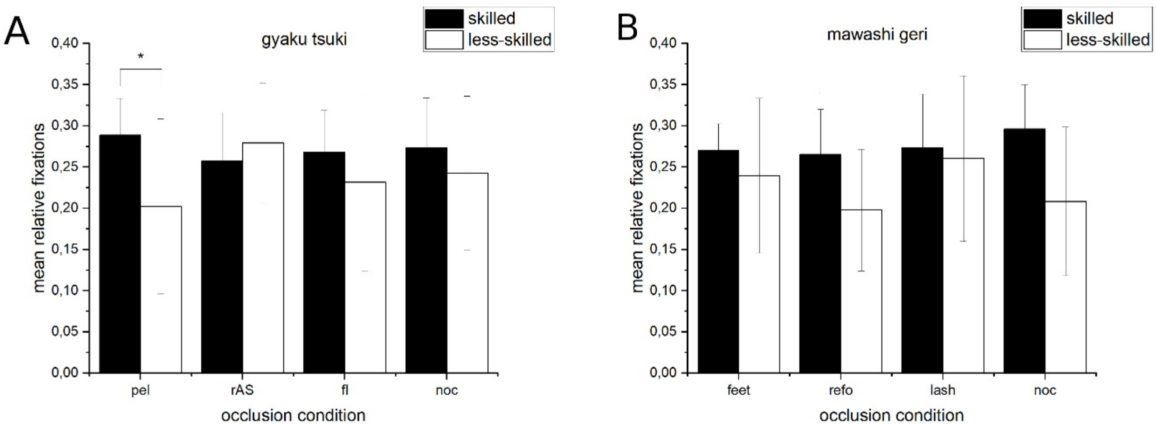

Fig. 2: Mean relative fixations of skilled (n=16) and less-skilled (n=10) per occlusion condition (pel: pelvis, rAS: right arm and shoulder, fl: front leg, feet: feet, refo: rear leg, lash: left arm and shoulder, noc: no occlusion) while viewing attacking sequences of the gyaku tsuki (A) and mawashi geri (B).

Fixation duration

Fig. 3 shows the mean fixation durations for each skill level and occlusion condition. The results of the mixed ANOVA showed no interaction effect for fixation duration between skill level and occlusion for the GZ (Greenhouse Geisser $F(1.9,45.67) = 963$, $p = .385$, $\eta p^2 = .039$).

The mixed ANOVA for fixation duration of the MG revealed no interaction effect between skill level and occlusion ($F(3, 69) = .4.32$, $p = .730$, $\eta p^2 = .018$) (Fig. 3B).

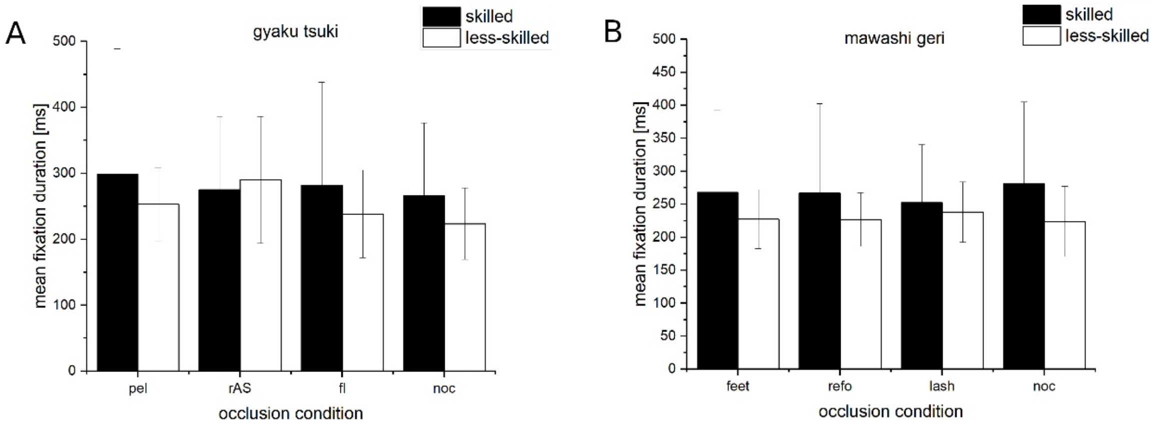

Fig. 3: Mean fixation durations (ms) of skilled (n=16) and less-skilled (n=10) per occlusion condition (pel: pelvis, rAS: right arm and shoulder, fl: front leg, feet: feet, refo: rear leg, lash: left arm and shoulder, noc: no occlusion) while viewing attacking sequences of the GZ (A) and MG (B).

Fixation Locations

The ANOVA with skill level as between-subject factor and the inner subject factors fixation locations (8) and occlusion (4) with repeated measures on the last factor showed no interaction effect for occlusion, fixation location and skill (F(7.5,181.8) = .677, p = .704, $\eta p2$ = .027), occlusion and fixation location (F(7.5,181.8) = 1.528, p = .154, ηp^2 = .060), skill and fixation location (F(2.15,51.5) = .935, p = 405, ηp^2 = 038), but a significant effect for fixation locations (Greenhouse Geisser F(2.146,51.51) = 22.048; p=.000; ηp^2 = .479) for GZ. Bonferroni corrected post-hoc analyses revealed significant differences for mean number of fixations (p < .05) between fixation locations head (M = 22.6), chest (M = 18.8), abdomen (M = 13.9), and leading arm (M = 26.4) compared to right shoulder (M = 4.7), left shoulder (M =4.6), rear arm (M = 3.2), and pelvis (M = 3.4). This means, the athletes predominantly fixated the attacker's head, chest, abdomen, and leading arm, independent of the occlusion and skill level (Fig. 4).

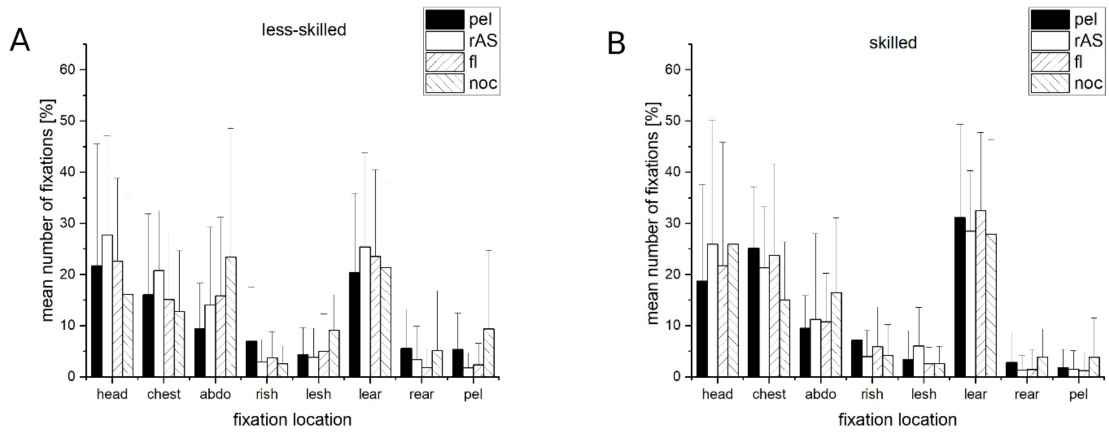

Fig. 4: Mean fixations (%) of skilled (A) and less-skilled on specific areas of interest (head: head, chest: chest, abdo: abdomen, rish: right shoulder, lesh: left shoulder, lear: left arm, rear: right arm/punching arm, and pel: pelvis/hip) while viewing the occluded attacks (pel: pelvis/hip, rAS: punching arm, fl: front leg, and noc: not occluded) of the gyaku tsuki.

Similar results are found for the MG (Fig. 5). No significant interaction effect of occlusion, fixation location and skill (F(3,72) = .1.442, p = .238, ηp^2 = .057), or skill and fixation location (F(2.6, 64.6) = .668, p = 559, $\eta p2$ = .027), but a significant effect for occlusion and fixation location (Greenhouse Geisser F(8.7,209) = 2.076, p = .035, ηp^2 = .080), and fixation locations (Greenhouse Geisser F(2.7, 64.6) = 12.43; p=.000; ηp^2 = .341). No significant effects were found for skill level (F(1,24) = 0.89, p = .768, ηp^2 = .004). Bonferroni corrected post-hoc test for each fixation location revealed a significant difference between occlusion conditions (p < .05) for *abdomen* and *lear* for skilled.

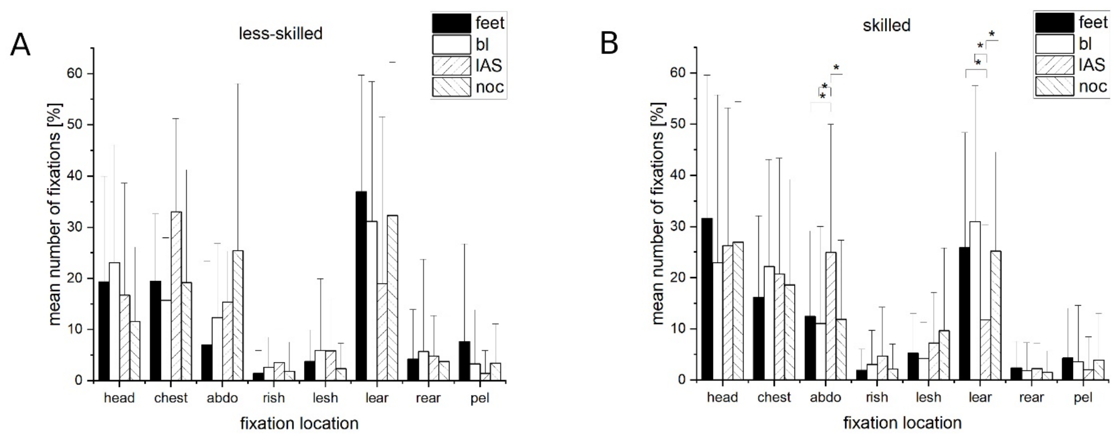

Fig. 5: Mean fixations (%) of skilled (A) and less-skilled on specific areas of interest (head: head, chest: chest, abdo: abdomen, rish: right shoulder, lesh: left shoulder, lear: left arm, rear: right arm/punching arm, and pel: pelvis/hip) while viewing the occluded attacks (pel: pelvis/hip, rAS: punching arm, fl: front leg, and noc: not occluded) of the mawashi geri.

4 Discussion

Gaze behaviour of a defending athlete in karate kumite has only scarcely been analysed and led to diverse results. This study tracked the gaze of skilled and less-skilled karate athletes while viewing spatially occluded and not occluded karate attacks of the gyaku tsuki and mawashi geri. One aim of this study was to examine whether gaze behaviour differs when body parts of the attacker are occluded, especially between different expertise. We hypothesized, that, due to their more search driven gaze behaviour (Abernethy & Russel, 1987) and based on the information reduction hypothesis (Haider & Frensch, 1999), less-skilled athletes would show different gaze characteristics between occluded and not occluded attacks, compared to skilled athletes that would not be influenced by occlusions (Vine et. al., 2017), leading to more fixations of shorter duration of less-skilled. Moreover, we assumed that skilled athletes make more use of a visual anchor, that is directed towards the head and chest to receive additional peripheral information about the attacker's whole movement.

The results of our study show in summery that our hypothesis, showing that less-skilled and skilled differ in gaze characteristics between occluded and not occluded attacks, has to be rejected. No overall significant differences in gaze behaviour of less-skilled nor skilled while watching occluded and not occluded attacks were found for both, the gyaku tsuki or mawashi geri. Moreover, these results are in line with Salb et al. (2015) and Vine et. al. (2017), where the athletes do not change their gaze characteristics, when visual information is withheld. Although karate is, contrary to golf, a time-constrained sport, occlusion does not seem to have an impact on the learnt gaze strategy. A distraction through occlusion of only one possible cue does therefore not have an effect on gaze behaviour, confirming previous findings of Milazzo et al. (2016) and Salb et. al. (2015). The results assume that both levels of expertise have already achieved an acquired gaze strategy, which is not influenced by the occluded visual information in general. Nevertheless, these results confirm the fact, that in karate the athletes use a schema driven search method (Milazzo et al., 2016), based on learnt situational probability information (Abernethy & Russell, 1987) and hence additionally using information reduction method to direct their gaze. As already found out by Rosalie and Muller (2013), karate athletes not only use one or two visual cues to anticipate the opponent's actions, but multiple. This allows them to recognize the opponent's actions, although information is missing.

In general, no differences in regard to the number of fixations between occluded and not occluded attacking sequences within each expertise were found for the mawashi geri. Although, less-skilled used fewer fixations compared to skilled at the occlusion of the rear leg and the with no occlusion, these were not significant. Looking at the results of the number of fixations to attacks of the gyaku tsuki, skilled had a significantly higher number of fixations compared to less-skilled for occlusion condition pel (pelvis). Although the pelvis might not be directly fixated (see chapter fixation locations), it is likely that this information is used peripherally underlining the use of a gaze anchor as already found out in Hausegger et al. (2019). The number of fixations only rises when looking at task relevant information, but these might be occluded and lead to a reduction of visual information. Independently of the type of attack, the pelvis plays a major role for performing rapid movement within the upper, but also lower body limbs, and hence gives important information about the initiation of an attack (Schorer, Rienhoff, Fischer, & Baker, 2013).

Although not significantly visible, when looking at the mean relative number of fixations of the gyaku tsuki with occluded right arm and shoulder (rAS), a reverse phenomenon of the number of fixations and fixation duration between skilled and less-skilled athletes is found. Here, less-skilled have a higher number of fixations of shorter duration. It is likely that less-skilled, as being more attuned to salient peripheral information, are irritated by the missing right arm and shoulder, although this cannot be underpinned by the number of fixations directed at the right arm and right shoulder. Here too, less-skilled might use the information of the missing arm and shoulder via peripheral information. In regard to fixation durations, no differences between skill levels or occlusion conditions were found, confirming previous results from Milazzo et al. (2016), Mori, Ohtani, and Imanaka, (2002), and Rosalie and Muller (2013). Our hypothesis, that we will observe fixations of less duration in less-skilled, can therefore also be dismissed.

The results of number of fixations in regard to fixation location under occlusion conditions revealed significant differences only for skilled in regard to fixation location abdomen and leading arm of the MG. Here, significant differences of number of fixations (%) between occlusion condition (lAS) leading arm and shoulder compared to the other occlusions (feet, back leg, and no occlusion) were found for both fixation locations, with significantly higher number when viewing the abdomen and significantly lower numbers when looking at the leading arm. This can be explained through the usage of a visual anchor around the abdomen, when the leading arm is visible, while they are physically next to each other. The lowest number when the leading arm is occluded, also underpins this theory of skilled using gaze anchors dependent of the evolving situation (Hausegger, et al., 2019). The skilled could have anticipated that a kicking attack would come, and directed their gaze anchor more towards the lower body.

When looking at the overall results of the athlete’s fixation locations, it can be said that they are in accordance with Milazzo et al. (2016) and Williams and Elliot (1999) and Hausegger et al. (2019): combat athletes mostly focus on pivotal body parts, such as the head and chest, and less to distal body parts, assuming the use of a visual gaze anchor (e.g. Milazzo et al., 2016; Mori, et al., 2002; Rosalie & Muller, 2013). Especially, in this time-constrained sports such as karate, it is utterly important to disguise one’s intentions, and hence the focus of attention. The results underpin the use of covert attention from skilled, but also from less-skilled in karate (Vater, et. al., 2019). Other studies in karate came to the same results, that gaze is mostly anchored between several cues and visual information, hence using and changing covert attention than changing overt attention in order to gain a lot of visual information (Vater, Kredel, & Hossner, 2016; Vater et al. 2017). Moreover, this underlined the use of the interaction of foveal and peripheral vision resulting in situation dependent gaze-anchoring that can also change over time or in regard to the evolving combat situation (Hausegger et al. 2019). This is also reflected in gaze behaviour on both attacks, where the left arm, head, chest and abdomen are fixated most, comparable to the results of Williams and Elliot (1999). According to the results of Milazzo et al. (2016) the punching arm was fixated more by less-skilled than by skilled. In this study the attackers' left arm was held right in front of the body, which makes it to a proximal body part, or better, a perfect visual anchor on the hand, or a threatening situation on the other hand. That certain body parts may be a greater threat than others because of their short distance to opponents has only scarcely been discussed, but has a major effect on fight interaction in karate kumite (Bandow, Witte, & Masik, 2012; Bandow, 2016, Petri et al., 2016). In these video-based attacks, the left arm (or punching arm in case of the gyaku tsuki) covered the smallest distance to the participants. This means that the execution of a punch with this arm would be very likely and hard to anticipate. In this case anticipation deeply relies on the use of situations probability information (Abernethy & Russell, 1987).

A further reason for the athletes, which is in line with previous results reported by Hausegger, Vater and Hossner (2019) is that in combat sports the response to an attack performed by the arm is faster while directly looking at it, compared to receiving this information via peripheral vision.

In general, the lack of further significant differences in gaze behaviour between the two skill levels can be caused by the differences between experimental settings (video-based attacks vs. in-situ attacks) (Dicks et al., 2010). While experts often can only use their superior skill in their familiar environment (Craig et al., 2009), the setup using video attacks likely have influenced their natural gaze behaviour. Moreover, this issue could be addressed to the task itself. In a real competition the athletes are both, defender and attacker, depending on the on-going situation. So, we do not have a dynamic situation with changing roles as attacker or defender, but a fixed task that breaks down the complexity of the sports itself. While in less complex situations the load of information processing is more limited, less-skilled are able to process this information faster than in complex situations. That can lead to better performance and similar gaze behaviour and reduce the difference to skilled athletes (Hausegger et al., 2019; Kato & Fukuda, 2012). A second possible reason for the small skill differences could be caused by both groups already gained skills being above novice skill level.

5 Conclusion

This study shows that gaze behaviour is not affected in general by the occlusion of visual information while viewing karate attacks. This concerns not only skilled, but also less-skilled karate athletes. All participants seem to use a gaze anchor confirming the results of previous studies in combat sports (e. g. Hausegger et al., 2019) and their learnt situational probability information while performing karate (e.g. Milazzo et al., 2016; Mori, et al., 2002; Rosalie & Muller, 2013). While karate is a time-constrained sport, there is not much time to use a search driven gaze behaviour. Additionally, a lot of visual information is perceived by peripheral attention, that cannot be measured through gaze behaviour (e.g. Vater, Williams & Hossner, 2019). Moreover, the method of eye tracking itself has limitations in giving indicators of expertise differences, which has to be taken in account in regard to analysing differences between different levels of expertise (Hyönä, 2010). The variety of attacks in this study is also held quite low (only four different attacks), which could have led to a near-to learning effect, that only these attacks would come and no other gaze strategy would have to be used by the athletes. A not to neglectable aspect is the level of reality given by the video-based attacks. Although the Bandow try to provide near to real size attacks on a big screen, an influence of the missing depth perception and interaction exists. Here the Bandow had to do the splits between level of reality and the methodical issue, to occlude the visual information. Clearly, this had an impact on the results.

The lack of an effect of occlusion on gaze can, on the one hand, be, because only single body parts were occluded (Rosalie & Muller, 2013), or on the other hand, because this information was not important for guiding gaze. Future studies should therefore analyse the occlusion of several body parts at the same time. This could be a reasonable way to identify anticipatory cues in karate in combination with gaze behaviour.

A further limitation of this study is clearly the skill levels that were chosen. In this study we did not analyse novice karate athletes, which might have led to different results in their gaze behaviour (e.g. Rosalie & Muller, 2013). The karate expertise of our group of less-skilled was certainly above those of clear novices. A further issue in regard to the skill groups is their age and their all membership in the karate club. The high deviation in their age as well as the belonging to the same karate club could also have led to missing significant differences in gaze behaviour. Especially for the latter, having the same trainer and hence the same training instructions, can lead to similarly learnt gaze strategies. Moreover, moderator effects could have led to an impact on the results, which is often seen by high standard deviations that are an indicator for heterogeneity in the effect sizes.

A rather novel result when analysing gaze in karate is the participant's focus on the left arm. In this case the front arm was mostly positioned in front of the attacker's body, hence in front of proximal body regions. One the one hand, this gave a perfect visual anchor to perceive all body movements, but on the other hand, it was also the part of the body that covered the smallest distance to the participants. This makes it a potential threat for an attack. This leads to the recommendation to conduct further studies in regard to the impact of the distance between two karate athletes. Therefore, in-situ or virtual reality test environments should be used, providing depth perception (Bandow, 2016; Bandow, Emmermacher, Stucke, Masik & Witte, 2014; Bandow, Masik & Witte, 2012).

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