Journal of Sports and Performance Vision

GAZE BEHAVIOR OF ATTACKING KARATE ATHLETES IN-SITU

Nicole Bandow*, Kerstin Witte

Faculty of Human Sciences, Otto-von-Guericke University Magdeburg, Magdeburg, Germany

Received: 26 October 2020; Accepted: 12 November 2020; Published: 2 February 2021.

***Corresponding Author: Nicole Bandow: nicole.bandow@ovgu.de**

ABSTRACT

Previous studies have analyzed the gaze behavior of defending karate athletes using video-based attacks. The results show that karate athletes use a gaze anchor around the opponent's head and chest. An analysis of gaze behavior of a karate athlete performing an attack in-situ has not been realized, yet. The aim of this study is, therefore, to analyze the gaze behavior of 11 karate athletes immediately before they perform an attack in-situ. The number of fixations, fixation duration, and fixation location were analyzed over the last 2000 ms before the athletes executed one of four instructed attacks. The results show no significant differences in gaze parameters with respect to the type of attack. The main finding revealed a gaze anchor around the opponent's head, chest, and leading arm, confirming previous studies of defending karate athletes while viewing video-based attacks.

Keywords: *attacker; gaze anchor; in-situ; karate*

INTRODUCTION

To perform sports, one is mostly reliant on vision. In this regard, visual perception plays an important role, especially in time-constrained sports, such as cricket, volleyball, or ice hockey. Here, the detection of relevant visual information is crucial for good performance.[1] This information is particularly used by skilled athletes to anticipate the upcoming action, and hence select an appropriate response,[2]for example, in tennis,[3,4] badminton,[5] baseball,[6] cricket,[7,8] fencing,[9] hockey,[10] soccer,[11] rugby,[12] and karate.[13–15]

In order to gain a better insight into the used visual information, the athlete's gaze behavior is analyzed. Gaze behavior mainly depends on the type of sports, their task demands, time-constraints, and stimulus presentation.[16] In order to gain gazespecific information for different groups of athletes (e.g., for different skill levels) within a certain field of sports, it is necessary to analyze gaze behavior for each group and within their familiar sports environment. This is underpinned by the fact that especially skilled athletes can only use their superior skills in the environment they are familiar with.[17,18]

Nevertheless, studies have revealed that the level of performance of skilled athletes is related to explicit tasks in their respective domains.[19]

Moreover, there are several theories that explain what influences the gaze behavior. The first theory, the long-term working memory, explains that to encode information of the visual field quickly, information stored in the long-term memory is being used. Through this, faster information processing and hence shorter fixation durations were found in expert players.[20] A meta-analysis of Gegenfurtner et al.[16] revealed, on the contrary, that there were no differences in the number of fixations between different levels of expertise. The information reduction hypothesis from Haider and Frensch[21] describes the extraction of visual information that is important for the specific task, and at the same time the suppression of irrelevant information. This leads to fewer fixations of shorter duration on task-redundant areas, and more fixations of longer duration on task-relevant areas. In order to apply this method, extensive training and learning processes are needed. The holistic model of image perception by Kundel et al.[22] describes longer saccades and shorter times to the first fixation on relevant areas. Through this method, the visual span is extended and the usage of peripheral information is enhanced.

Ripoll et al.[23] analyzed French boxers and Williams and Elliot[24] analyzed karate athletes in defense position. Both found out that less-skilled often use a more search-driven gaze behavior and are more attuned to vigilance while they aim at an object or respond to a video-based karate attacker. Skilled athletes, on the other hand, use a more schema-driven visual search method, as was also confirmed in findings in badminton by Abernethy[25] and Russell. This is concurrent to the two theories of long-term working memory and information suppression and leads to a more efficient gaze behavior, meaning that gaze is directed according to the sport-specific situation. Studies in badminton,[25] shooting,[26] and soccer[27] show that this sort of gaze behavior led to fewer fixations of longer durations, especially in skilled athletes. The same results were reported by Milazzo et al.,[13] who analyzed the gaze behavior of expert and novice karate athletes while they had to defend karate attacks. Other studies in combat sports, especially in karate, reported no differences between novice and expert karate athletes in gaze behavior (number of fixations, fixation duration, fixation location, and the total number of fixations) while they were in defense.[15,28]

Looking into team sports, studies revealed that experts had fewer fixations of longer duration and on other locations compared to novices. This leads to the assumption that experts use a more analytical search strategy.[29] Besides, in team sports, the gaze is often also fixated between two or more relevant objects (e.g., players) in order to gain more peripheral information (e.g., of tactical movements[30]).

The phenomenon of a visual pivot or a gaze anchor is also reported in non-team sports. Therefore, athletes mainly fixate on central parts of the body, so they can perceive movements of distal body parts (e.g., [27,31,32]). Through this, more relevant information can be extracted and used to predict the opponent's or other player's movements.[33–36] Moreover, Hausegger et al.[37] found out that the gaze-anchoring strategy depends on the location of cues that are used. In combat sports, for example, where the attacks are most performed by the upper body limbs, the gaze anchor lies on the upper body (in shoulder line). In sports where the legs are frequently used to attack, the gaze anchor lies lower, more around the middle of the attacker's body.

Studies analyzing the athlete's gaze and defense position in karate also reported the use of a visual anchor (e.g.,[13,15,28]). Both, skilled and less-skilled, direct their gaze more on pivotal body regions (head and chest) than on peripheral body regions (e.g., shoulder, arm/fist, and leg/foot). Schorer et al.[38] found only small differences between different levels of expertise in karate. Although these differences were not significant, it was obvious that skilled athletes paid more visual attention to the head and pelvis, while less-skilled ones directed their gaze more towards the chest and arm/fist. The authors assume that, based on a previous study by Piras et al.,[39] skilled athletes use the visual anchor, to conceal their attention and to process the perceived peripheral information faster. Moreover, under stress, less-skilled karate athletes seemed to experience a peripheral narrow-ing or predisposition for peripheral information. In compliance with Abernethy and Russel,[40] it is evident that skilled karate athletes use situational probability information and the opponent's postural cues for anticipation. Moreover, Rosalie and Muller[15] found out that skilled athletes use earlier and multiple visual information compared to novices.

On the whole, there is no clear consent about the differences in gaze behavior between skilled, less-skilled, and novice karate athletes. Although studies

DOI: https://doi.org/10.22374/jspv.v3i1.8
J Sports Perf Vis 3(1):e1–e11; 2021.

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 only scarcely known which specific body parts are used to anticipate an attack in karate.[13,24] A clear lack in these studies is the analysis of athletes who perform an attack themselves and in-situ. The only study that analyzed the gaze behavior of attacking judo athletes was conducted by Piras et al.[39] In this context, the question arises whether it is possible to foresee the upcoming attack by the attacker's gaze behavior.

To shed more light on this topic, the aim of this study is, therefore, to examine the gaze behavior of karate athletes immediately before executing attacks in-situ. We firstly wanted to examine, whether there is a difference in the number of fixations and fixation duration related to the fixation locations that could indicate the type of attack. When learning karate kumite, the athletes are generally instructed to hide their intentions when and where to attack, hence to focus only on one part of the body (mainly the head and/or chest, as we know from several karate coaches). Therefore, we hypothesize that there is no relation between gaze behavior and the performed attack, hence all athletes use a gaze anchor around the head and chest as in other combat sports.[39] A minor topic which we want to examine is, whether there is a difference between skilled and less-skilled karate athletes with regard to the number of fixations, fixation duration, and fixation location out of the perspective of the attacker. Previous studies[15,28] did not find differences, but this was only with regard to athletes in defense. We assume that, due to the small differences in expertise, and based on the mentioned studies, there are no differences in gaze between the two levels of expertise.

METHODS

Participants

Eleven karate athletes, who were recruited from a local karate dojo, participated in the study. They were categorized as skilled or less-skilled karate athletes based on their years of training and experiences in competitions and had a normal or corrected-to-normal vision. The skilled group (n = 6) consisted of four male and two female athletes (M = 15.5 (SD 1.8) years of age) with an average of 9.1 (SD 2.3) years of karate experience and participated at 5.2 (SD 1.5) international competitions per year in average. The less-skilled (n = 5) group consisted of four male and one female athletes (M = 14.6 (SD 1.1) years of age) with an average of 8.7 (SD 2.1) years of karate experience and took part at about 5 (SD 0.7) national karate competitions per year.

All participants gave their informed consent to take part in the study.

Apparatus and type of attacks

All tests were conducted in the University's laboratory within a 6 m × 6 m sized area (Figure 1). To capture the participants' gaze behavior, a head-mounted mobile eye-tracking system (SensoMotoric Instruments, Teltow, Germany, Model Eye Tracking Glasses (ETG)) was used. 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 with relation to the field of view (resolution of 0.1° visual angle, the precision of 0.5°, visual range: 80° horizontals, 60° vertical). The ETG's field camera recorded the participant's visual environment with a frequency of 24 Hz and a resolution of 1280 × 960 px (field of view: 60° horizontal, 46° vertical). To prevent the ETG to slip or move during the tests, the device was fastened to the head with additional straps.

FIG. 1 Experimental set-up. Right: The defending karate athlete. Left: The attacking karate athlete wearing the ETG.

DOI: https://doi.org/10.22374/jspv.v3i1.8
J Sports Perf Vis 3(1):e1–e11; 2021.

The participants' movements were recorded with an additional external digital video camera (Casio Exilim EX-F1; frequency: 25 Hz; resolution: 640 × 480 px) which was located at a 6.5 m distance from the participants. To synchronize the ETG's field video and external video, an optical trigger was used at the beginning of every recording.

For the study, the four most frequently used attacks in competitions were chosen: gyaku tsuki (jodan) (GZJ), gyaku tsuki (chudan) (GZC), kizami tsuki (KZ), and mawashi geri (MG). The gyaku tsuki is a straight forward punch, executed with the rear arm towards the opponent's head (jodan) or chest (chudan), while the opposing leg is in the anterior. The kizami tsuki, also a straight forward punch of the leading arm towards the head, is executed with the equilateral leg standing in the anterior. The kicking technique, mawashi geri, is characterized by a kick towards the opponent's side at height of the head (jodan) by bringing the bent, rear leg forward up. The hip is then rotated inwards, to execute a snapping movement with the rear lower leg.[41]

Test procedure

Before the test, all participants had time for a self-instructed warm-up. After that, the attacking athletes were fitted with the ETG. To ensure a precise gaze measurement, a three-point calibration of the ETG was conducted before and after each trial, when needed. The calibration points were arranged in a triangle shape (the left and the right point just above floor level; the middle point at 2 m height), located behind the defender, and just outside the combat area. To synchronize the ETG and external camera, an optical trigger (red LED light) appeared at the beginning of each trial.

For the test, pairs were matched according to their skill levels. In the skilled group, one male athlete had to participate twice as a defender, while fighting against the only female.

The attacking athletes were instructed to attack the defending athlete with one of the four defined karate attacks (GZJ, GZC, KZ, and MG) out of the stepping movement. They could choose the type of attack according to the situation and positioning to the defender. After each attack, a recalibration was conducted and the athletes got back into position and started with the stepping movements again until the attacker performed the next attack. The participants were allowed to take breaks as they needed. The test ended, when each attack was executed 10 times (on the whole 40 attacks). To ensure this, the attackers were informed about how many attacks of each type they had already performed during the test. The defender's task was only to respond in a natural and an appropriate way. He/she was not allowed to attack themself.

Data coding

For further analysis, the number of fixations, fixation duration, and fixation locations were defined for the last 2000 ms before the attacking movement started. The last 2000 ms were chosen to ensure standardized data analyses within the same period of time. Moreover, the authors do not assume relevant gaze information before that point in time. To define the beginning of each attack, within the external video footage, the definitions according to Bandow[42] were used. For the gyaku tsuki, this was defined as when the back leg was exposed and the punching arm was taken near the body, or when the front leg took a big step forward. The interrater reliability using the Bravais-Pearson correlation showed a high effect ($r = 0.956$, $P = 0.000$, $n = 110$) for the two raters analyzing the beginning of each attack. Fixations were only coded when the gaze stayed within 3° of the visual angle of a body part of the opponent for a minimum duration of 99 ms.

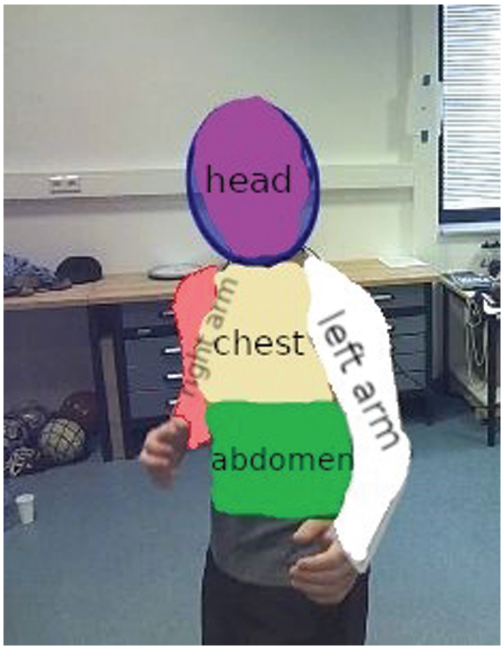
Based on the actual eye-tracking data, four fixation locations were coded: head, chest, left shoulder, and right shoulder. While the other body regions (e.g., abdomen, hands, hip) were not or hardly fixated, they were not considered and excluded in the analysis (Figure 2).

Data analysis

Statistical analysis was undertaken by the Shapiro–Wilk test to control normal distribution. To analyze the mean number of fixations (MNOF) and fixation duration for each fixation location per type of attack, a two-way ANOVA with the type of attack and fixation location as between-subject factors were used. To analyze possible differences between both skill levels, skill level as an inner subject factor was also integrated. The level of significance was set to α =

DOI: https://doi.org/10.22374/jspv.v3i1.8
J Sports Perf Vis 3(1):e1–e11; 2021.

FIG. 2 Screenshot from the field camera of the ETG. It shows the defending athlete during the stepping movements and shortly before he had to defend an attack. The fixation locations head, chest, abdomen, left arm, and right arm are marked as areas of interest (AOIs).



0.05. Levene's test was used to control the homogeneity of variances. Greenhouse Geisser corrections were used when sphericity was violated. Bonferroni post hoc test corrections were used to analyze differences between fixation locations.

RESULTS

Number of fixations

The data with regard to MNOFs were normally distributed for all data sets except for the attacks with fixation location as left shoulder and right shoulder, as assessed by Shapiro–Wilk test ($P > 0.05$), due to the small number of fixations. Nevertheless, we conducted the two-way ANOVA for our analyses.

The results of the two-way ANOVA for analyzing the MNOF (n = 11) for each fixation location and type of attack, reveal no significant effects ($F(9,81) = 0.373$; $P = 0.421$; $\eta p^2 = 0.103$). Figure 3 shows that the mean number of fixations for each attack with regard to the fixation location are similar for all types of attacks. There were no significant differences between the mean number of fixations among the types of attacks, e.g., head GZ_C and GZ_J.

Looking more into the differences between the single fixation locations regardless of the attacks (n = 44), the athletes mostly fixate the head (M = 4.6, SD = 0.08) and chest (M = 1.22, SD = 0.26), then the left (M = 0.2, SD = 0.08) and right arm including their shoulders (M = 0.07, 0.08). The differences among the fixation locations were found to be significant ($F(3,27) = 156.527$; $P < 0.000$; $\eta p^2 = 0.946$). Bonferroni corrected post hoc tests reveal significant differences ($P < 0.05$) in the MNOF between all fixation locations for each attack, except between left and right shoulder, when both were only fixated rarely.

The analysis for our subtopic (differences between skilled and less-skilled) shows a statistically significant interaction effect between skill, type of attack, and fixation location for the mean number of fixations ($F[9,81] = 2.015$, $P = 0.048$; $\eta p^2 = 0.183$), but not for type of attack and fixation location ($F[9,81] = 1.034$; $P = 0.421$, $\eta p^2 = 0.103$), fixation location and skill level ($F[3,27] = 0.1.532$; $P = 0.229$; $\eta p^2 = 0.145$), or type of attack and skill level ($F[3,27] = 2.090$; $P = 0.125$; $\eta p^2 = 0.188$). No significant differences were found between the types of attacks ($F[3,27] = 1.308$; $P = 0.292$; $\eta p^2 = 0.127$). The results of the ANOVA with regard to differences between skill levels for the MNOF show no significant effect, ($F[1,9] = 0.838$; $P = 0.478$; $\eta p^2 = 0.057$) (see Table 1).

Fixation duration

The fixation durations of the attacking athletes show no significant effects between types of attacks (Greenhouse-Geisser: $F(1.765,27) = 1.095$; $P = 0.351$, $\eta p^2 = 0.109$), type of attack and fixation locations (Greenhouse-Geisser: $F(2.785,81) = 0.524$; $P = 0.657$, $\eta p^2 = 0.055$), or type of attack, fixation location, and skill level (Greenhouse-Geisser: $F(2.785,81) = 1.419$; $P = 0.261$, $\eta p^2 = 0.136$) (Figure 4). The fixation duration for each fixation location is similar for each attack. In average, the duration for the fixations is longest on the left arm and shoulder (M = 277.04 ms, SD = 114.24 ms), the head (M = 214.94 ms, SD = 41.55 ms), and the chest (M = 207.22 ms; SD = 82.33 ms). Only on the right arm and shoulder, short durations

DOI: https://doi.org/10.22374/jspv.v3i1.8
J Sports Perf Vis 3(1):e1–e11; 2021.

FIG. 3 The mean number of fixations from all karate athletes (n = 11) on the four fixation locations (head, chest, re arm: right arm, le arm: left arm) for each type of attack (GZ_C: gyaku zuki chudan; GZ_J: gyaku zuki jodan; KZ: kizami zuki; MG: mawashi geri) within the last 2000 ms before each attack was performed.

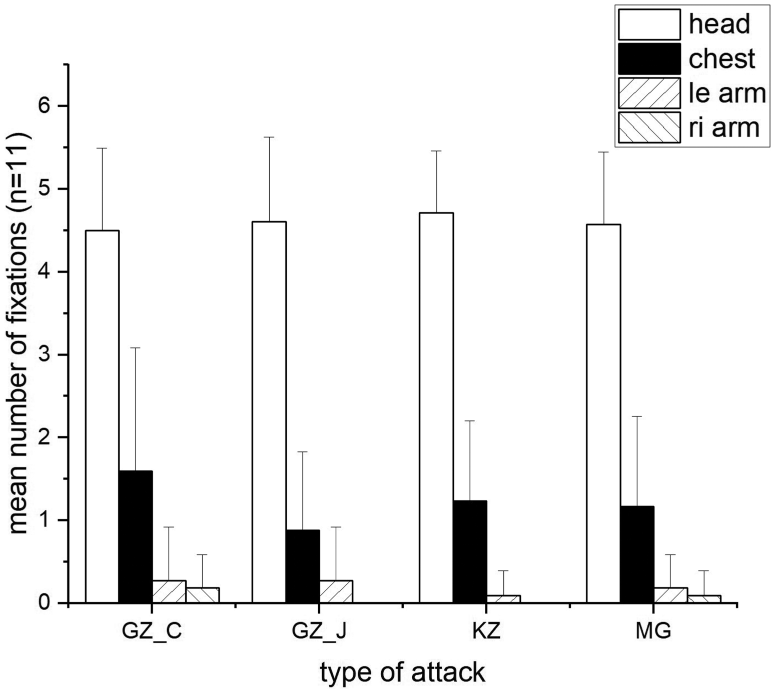


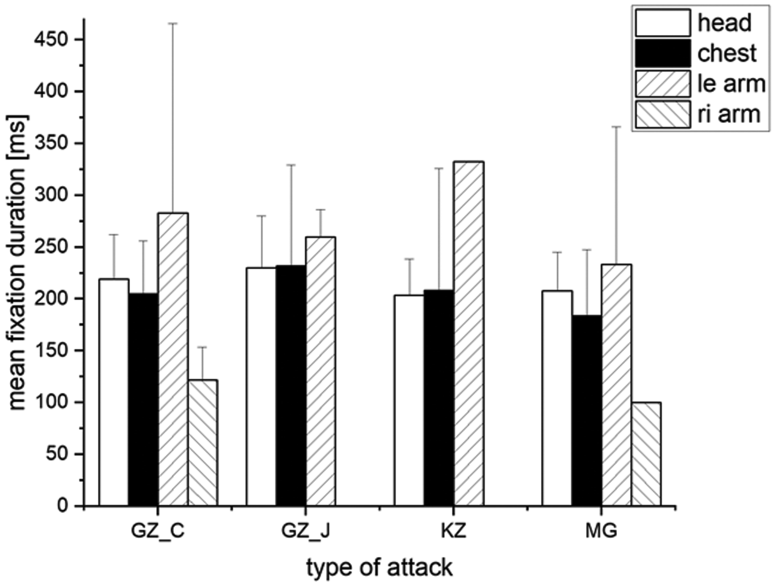
TABLE 1 The Mean Number of Fixations for Each Type of Attack and Fixation Location Displayed for Skilled (N = 6) and Less-Skilled (N = 5) Karate Athletes

Type of attack	Fixation location	Skilled	Less-skilled
GZ_C	Head	4.55 (0.76)	4.43 (1.32)
	Chest	1.19 (0.37)	2.56 (1.66)
	Left arm	1.5 (0.71)	0 (0)
	Right arm	0 (0)	1 (0)
GZ_J	Head	4.67 (0.99)	4.53 (1.16)
	Chest	1.55 (1.1)	1.16 (0.29)
	Left arm	2.0 (1.0)	1 (0)
	Right arm	0 (0)	0 (0)
KZ	Head	4.79 (0.92)	4.6 (0.53)
	Chest	2.25 (0.66)	1.36 (0.41)
	Left arm	0 (0)	1 (0)
	Right arm	0 (0)	0 (0)
MG	Head	4.63 (0.77)	4.5 (1.07)
	Chest	1.8 (1.13)	1.85 (0.69)
	Left arm	1 (0)	1 (0)
	Right arm	1 (0)	1 (0)

GZ_C: gyaku zuki chudan; GZ_J: gyaku zuki jodan; KZ: kizami zuki; MG: mawashi geri.

DOI: https://doi.org/10.22374/jspv.v3i1.8
J Sports Perf Vis 3(1):e1–e11; 2021.

FIG. 4 The mean number of fixations (ms) from the fixations of all karate athletes (n = 11) on the four fixation locations (head, chest, ri arm: right arm, le arm: left arm) for each type of attack (GZ_C: gyaku zuki chudan; GZ_J: gyaku zuki jodan; KZ: kizami zuki; MG: mawashi geri) within the last 2000 ms before each attack was performed. (For a better overview the single significant results are not displayed.)



are observed (M = 110.97 ms, SD = 31.37 ms). The only significant differences in the fixation durations are found between fixation locations (Greenhouse-Geisser: $F[1.503,27] = 40.988$; $P < 0.000$, $\eta p^2 = 820$). Bonferroni corrected post hoc tests reveal significant differences ($P < 0.05$) in the duration within all attack except MG between the fixation location right arm and shoulder and the other fixation locations.

Considering fixation duration between the two skill levels, no statistically significant difference is found (Greenhouse-Geisser: $F(1.503,27) = 1.684$; $P = 0.194$, $\eta p^2 = 0.158$) (see Table 2).

DISCUSSION

The aim of this study was to examine the gaze behavior of skilled and less-skilled karate athletes over the last 2000 ms before they executed a karate attack in-situ. For this, the number of fixations, fixation duration, and fixation locations of 11 karate athletes were analyzed. Based on the main findings, the hypothesis, that there is no relation between gaze behavior (number and duration of fixations and fixation locations) and the type of attack is confirmed. Although, to our knowledge, no literature exists for the practical instructions on how to hide one's intentions, meaning to fixate on the head and the chest, we can underpin the use of this gaze anchor. Considering the results, firstly out of a practical view, it can be said that these findings confirm previous studies that analyzed athletes who were in defense. To a certain skill level gaze is mostly directed towards the head and chest, while novice karate athletes more often look at other more distal body parts.[24] Our results show that this is also the case for athletes who are in the attacking position. Although, in real combat situations, the athletes embody both the attacker and the defender, no influence of the task demands (being attacker or defender) are existent.[16]

There are significant differences in the mean number of fixations and the fixation durations with respect to the fixation locations. The head and chest were the most frequently fixated body parts before the attacks were performed. However, the chest was fixated second mostly. The arms including the shoulders were only seldomly fixated. Regarding the fixation durations, we observe the longest duration on the left arm and

DOI: https://doi.org/10.22374/jspv.v3i1.8
J Sports Perf Vis 3(1):e1–e11; 2021.

TABLE 2 The Mean Fixation Duration (ms) for Each Type of Attack and Fixation Location (Head, Chest, Left Arm and Shoulder, Right Arm and Shoulder) Displayed for Skilled (N = 6) And Less-Skilled (N = 5) Karate Athletes

Type of attack	Fixation location	Skilled	Less-skilled
GZ_C	Head	217.37 (40.82)	220.82 (51.10)
	Chest	189.63 (72.62)	217.50 (38.22)
	Left arm	0	121.93 (38.42)
	Right arm	282.95 (258.87)	0
GZ_J	Head	241.22 (64.29)	216.31 (37.06)
	Chest	234.08 (112.67)	228.67 (118.48)
	Left arm	232.9 (0)	286.22 (0)
	Right arm	0	0
KZ	Head	201.65 (33.30)	205.35 (44.86)
	Chest	197.34 (36.18)	214.51 (100.98)
	Left arm	0	332.65 (0)
	Right arm	0	0
MG	Head	210.65 (25.26)	203.89 (54.79)
	Chest	151.41 (25.9)	196.91 (78.27)
	Left arm	100 (0)	366 (0)
	Right arm	100 (0)	100 (0)

GZ_C: gyaku zuki chudan; GZ_J: gyaku zuki jodan; KZ: kizami zuki; MG: mawashi geri.

shoulder, then on the head and chest, but only a little on the right arm and shoulder. Looking at the number of fixations and fixation durations, no interaction between both parameters was found. Nevertheless, the most frequently fixated body limb is not the one that is fixated longest. Looking at the results, out of the theoretical view, they are only partly following the information reduction hypothesis by Haider and Frensch,[21] which says that only relevant and important visual information is fixated more frequently and longer than unimportant visual information. For the fixation duration, this theory seems to fit but not for the number of fixations, but on the other hand, confirming the results of Abernethy and Russel,[40] who found out that fewer fixations of longer durations are used by a schema-driven search behavior. In this case, it can be assumed that the karate athletes gain the most information from the left arm and shoulder, then following from head and chest, and only a few from the right arm (which was not the leading arm and held more at the backside of the body) or other distal body parts. In this coherence, only the number of fixations can be related to the gaze anchor strategy, with the head being the main anchor together with the chest and left arm, which is mostly positioned before the torso. Through this, the athletes can also take in the whole-body movement and perceive for him/her relevant information. This phenomenon has already been reported in karate,[13–15] where the athletes were then able to predict the opponent's movements and adapt their own movements accordingly. Looking at the mean number of fixations in more detail between the left and right arm and shoulders, it can be seen that the left arm is more often and longer fixated than the right arm. This is due to the fact that, firstly, the left arm is positioned in front of the chest or torso, and because it is the body limb that is nearest to the athletes. This phenomenon was already found in karate athletes in defense position in a video-based karate study by Bandow and Witte.[43] It seems that the distance plays a major role with regard to gaze behavior in karate in both positions, that is, in the role of the attacker and the defender. In conversations with the athletes in previous studies,[42] an opponent is only seen as a threat when a certain distance is undercut. Nevertheless, differences in the results between this

DOI: https://doi.org/10.22374/jspv.v3i1.8
J Sports Perf Vis 3(1):e1–e11; 2021.

study and the study that used 2D-video attacks[43] are evident. In the study using 2D-video attacks, more fixations on more distal body parts were found, for example, the pelvis. In this study, only the head, the chest, and left arm and shoulder were mainly fixated confirming the finding of Hausegger et al.,[37] who reported that the gaze anchor depends on the type of sports and the most frequently used body limbs to perform an attack. In karate kumite, most attacks are performed with the arms[42] and hence the gaze anchor lies around the upper body part. This is in line with using probability information that has been gained through the training experience.[13] While both levels of expertise are clearly above the novice level, this is likely to have occurred.

In this relation, no differences between the gaze behavior of skilled and less-skilled were found, confirming previous results by Mori et al.[28] and Rosalie and Muller.[15]

CONCLUSIONS

This study aimed at analyzing the gaze behavior of attacking karate athletes in-situ. The results underpin the hypothesis that gaze provides no information about what sort of an attack will be performed. A reason, therefore, could be the task demand itself, but while other studies that analyzed karate athletes in defense, show the same results, this had no effect on gaze behavior. Moreover, the findings confirm the results of training experience, particularly that athletes try to hide their intentions and use covert attention.[44] Using the gaze anchor strategy is therefore a reasonable explanation. The confirmation of the second, but a subordinate hypothesis, regarding the lack of skill differences, due to similar training experiences, shows that as of a certain skill level a schema-driven gaze behavior dominates. It would be of interest to analyze two or more groups with bigger differences in skill, especially novices and in this respect differences over time while karate is learnt, in future studies. Lastly, this study could have provided more information if the performance of the attacking athlete was also analyzed. Moreover, a more detailed analysis of the movements of both athletes, the attacker and the defender, could provide better insight, but is extremely costly and requires excellent knowledge of the raters. Nevertheless, these aspects are interesting topics in further investigations of karate kumite.

ACKNOWLEDGMENTS

The authors thank Linus Braun, Fabian Kort, Elise Reichert, Julian Schröder, and Raphael Splanemann for their support in conducting and analyzing the results of this study.

REFERENCES

1. Panchuk D, Vickers JN, Hopkins WG. Quiet eye predicts goaltender success in deflected ice hockey shots. Eur J Sport Sci. 2017;17:93–9. http://dx.doi.org/10.1080/17461391.2016.1156160
2. Müller S, Abernethy B. Expert anticipatory skill in striking sports: A review and a model. Res Quart Exerc Sport. 2012;83:175–87. http://dx.doi.org/10.1080/02701367.2012.10599848
3. Farrow D, Abernethy B, Jackson RC. Probing expert anticipation with the temporal occlusion paradigm: Experimental investigations of some methodological issues. Motor Control. 2005;9:332–51. http://dx.doi.org/10.1123/mcj.9.3.330
4. Huys R, Cañal-Bruland R, Hagemann N, et al. Global information pickup underpins anticipation of tennis shot direction [Internet]. J Motor Behav. 2009;41:158–70. Available from: http://content.ebscohost.com/pdf23_24/pdf/2009/MBH/01Mar09/36419496.pdf?T=P&P=AN&K=36419496&S=R&D=pbh&EbscoContent=dGJyMNLr40Sep7E4v%2BvlOLCmr0ueprdSr6i4SK%2BWxWXS&ContentCustomer=dGJyMPGptU%2B0qrZOuePfgeyx44Dt6fIA
5. Hagemann N, Strauss B, Canal-Bruland R. Training perceptual skill by orienting visual attention. J Sport Exerc Psychol. 2006;28:143–58. http://dx.doi.org/10.1123/jsep.28.2.143
6. Ranganathan R, Carlton LG. Perception-action coupling and anticipatory performance in baseball batting. J Motor Behav. 2007;39:369–80. http://dx.doi.org/10.3200/JMBR.39.5.369-380
7. Müller S, Abernethy B, Reece J, et al. An in-situ examination of the timing of information pick-up for interception by cricket batsmen of different skill levels. Psychol Sport Exerc. 2009;10:644–52. http://dx.doi.org/10.1016/j.psychsport.2009.04.002
8. Müller S, Abernethy B, Farrow D. How do world-class cricket batsmen anticipate a bowler's intention?

Quart J Exp Psychol. 2006;59:2162–86. http://dx.doi.org/10.1080/02643290600576595
9. Hagemann N, Schorer J, Canal-Bruland R, et al. Visual perception in fencing: Do the eye movements of fencers represent their information pickup? Atten Percept Psycho. 2010;72:2204–14. http://dx.doi.org/10.3758/BF03196695
10. Clatworthy R, Holder T, Graydon J. An investigation into the anticipation of field hockey penalty flicks using an ecologically valid temporal occlusion technique. J Sports Sci. 1991;9:439–40.
11. Diaz GJ, Fajen BR, Phillips F. Anticipation from biological motion: The goalkeeper problem. J Exp Psychol Hum Percept Perform. 2012;38:848–64. http://dx.doi.org/10.1037/a0026962
12. Jackson RC, Warren S, Abernethy B. Anticipation skill and susceptibility to deceptive movement. Acta Psychol. 2006;123:355–71. http://dx.doi.org/10.1016/j.actpsy.2006.02.002
13. Milazzo N, Farrow D, Ruffault A, et al. Do karate fighters use situational probability information to improve decision-making performance during on-mat tasks? J Sports Sci. 2016;34:1547–56. http://dx.doi.org/10.1080/02640414.2015.1122824
14. Mori S, Shimada T. Expert anticipation from deceptive action. Atten Percept Psychophys. 2013;75:751–70. http://dx.doi.org/10.3758/s13414-013-0435-z
15. Rosalie SM, Muller S. Timing of in situ visual information pick-up that differentiates expert and near-expert anticipation in a complex motor skill. Q J Exp Psychol (Hove). 2013;66:1951–62. http://dx.doi.org/10.1080/17470218.2013.770044
16. Gegenfurtner A, Lehtinen E, Säljö R. Expertise differences in the comprehension of visualizations: A meta-analysis of eye-tracking research in professional domains. Educ Psychol Rev. 2011;23:523–52. http://dx.doi.org/10.1007/s10648-011-9174-7
17. Dicks M, Button C, Davids K. Examination of gaze behaviors under in situ and video simulation task constraints reveals differences in information pickup for perception and action [Internet]. Atten Percept Psychophys. 2010 [cited 2013 March 18];72:706–20. Available from: http://han.med.uni-magdeburg.de/han/10106/download.springer.com/static/pdf/482/art%253A10.3758%252FAPP.72.3.706.pdf?auth66=1364920570_7d11294847545329f6b7aa7483d4f241&ext=.pdf
18. Mann DTY, Williams AM, Ward P, et al. Perceptual-cognitive expertise in sport: A meta-analysis. J Sport Exerc Psychol. 2007;29:457–78. http://dx.doi.org/10.1123/jsep.29.4.457
19. Ericsson KA, Lehmann AC. Expert and exceptional performance: Evidence of maximal adaptation to task constraints. Ann Rev Psychol. 1996;47:273–305. http://dx.doi.org/10.1146/annurev.psych.47.1.273
20. Ericsson KA, Kintsch W. Long-term working memory. Psychol Rev. 1995;102:211–45. http://dx.doi.org/10.1037/0033-295X.102.2.211
21. Haider H, Frensch PA. Information reduction during skill acquisition: The influence of task instruction. J Exp Psychol Appl. 1999;5:129–51. http://dx.doi.org/10.1037/1076-898X.5.2.129
22. Kundel HL, Nodine CF, Conant EF, et al. Holistic component of image perception in mammogram interpretation: Gaze-tracking study. Radiology. 2007;242:396–402. http://dx.doi.org/10.1148/radiol.2422051997
23. Ripoll H, Kerlirzin Y, Stein J-F, et al. Analysis of information processing, decision making, and visual strategies in complex problem solving sport situations. Hum Movement Sci. 1995;14:325–49. http://dx.doi.org/10.1016/0167-9457(95)00019-O
24. Williams AM, Elliot D. Anxiety, expertise, and visual search strategy in karate. J Sport Exerc Psychol. 1999;21:362–75. http://dx.doi.org/10.1123/jsep.21.4.362
25. Abernethy B. Anticipation in sport: A review. Phys Educ Rev. 1987;10:5–16.
26. Causer J, Bennett SJ, Holmes PS, et al. Quiet eye duration and gun motion in elite shotgun shooting. Med Sci Sports Exerc. 2010;42:1599–608. http://dx.doi.org/10.1249/MSS.0b013e3181d1b059
27. Helsen W, Pauwels JM. A cognitive approach to visual search in sport. In: Brogan D, Gale A, Carr K, editors. Visual search 2. Bristol, PA: Taylor & Francis; 1993. p. 379–88.
28. Mori S, Ohtani Y, Imanaka K. Reaction times and anticipatory skills of karate athletes. Hum Movement Sci. 2002;21:213–30. http://dx.doi.org/10.1016/S0167-9457(02)00103-3
29. Roca A, Ford PR, McRobert AP, et al. Perceptual-cognitive skills and their interaction as a function of task constraints in soccer. J Sport Exerc Psychol. 2013;35:144–55. http://dx.doi.org/10.1123/jsep.35.2.144
30. Piras A, Vickers JN. The effect of fixation transitions on quiet eye duration and performance in the

DOI: https://doi.org/10.22374/jspv.v3i1.8
J Sports Perf Vis 3(1):e1–e11; 2021.

soccer penalty kick: Instep versus inside kicks. Cogn Process. 2011;12:245–55. http://dx.doi.org/10.1007/s10339-011-0406-z
31. Abernethy B, Gill DP, Parks SL, et al. Expertise and the perception of kinematic and situational probability information. Perception. 2001;30:233–52. http://dx.doi.org/10.1068/p2872
32. Williams AM, Davids K. Assessing cue usage in performance contexts: A comparison between eye-movement and concurrent verbal report methods. Behav Res Methods Instruments Comp. 1997;29:364–75. http://dx.doi.org/10.3758/BF03200589
33. Davids K, Savelsbergh G, Bennett SJ, et al., editors. Interceptive actions in sport: Information and movement. London: Routledge; 2002.
34. Savelsbergh GJP, Van der Kamp J, Williams AM, et al. Anticipation and visual search behaviour in expert soccer goalkeepers. Ergonomics. 2005;48:1686–97. http://dx.doi.org/10.1080/00140130500101346
35. Smeeton N, Huys R. Anticipation of tennis-shot direction from whole-body movement: The role of movement amplitude and dynamics. Hum Movement Sci. 2011;30:957–65. http://dx.doi.org/10.1016/j.humov.2010.07.012
36. Williams A, Huys R, Cañal-Bruland R, et al. The dynamical information underpinning anticipation skill. Hum Movement Sci. 2009;28:362–70. http://dx.doi.org/10.1016/j.humov.2008.10.006
37. Hausegger T, Vater C, Hossner E-J. Peripheral vision in martial arts experts: The cost-dependent anchoring of gaze. J Sport Exerc Psychol. 2019;41:137–45. http://dx.doi.org/10.1123/jsep.2018-0091
38. Schorer J, Rienhoff R, Fischer L, et al. Foveal and peripheral fields of vision influences perceptual skill in anticipating opponents' attacking position in volleyball. Appl Psychophysiol Biofeedback. 2013;38:185–92.
39. Piras A, Pierantozzi E, Squatrito S. Visual search strategy in Judo fighters during the execution of the first grip. Int J Sports Sci Coaching. 2014;9:185–98. http://dx.doi.org/10.1260/1747-9541.9.1.185
40. Abernethy B, Russell DG. The relationship between expertise and visual search strategy in a racquet sport [Internet]. Hum Movement Sci. 1987;6:283–319. Available from: http://han.med.uni-magdeburg.de/han/2859_0/www.sciencedirect.com/science?_ob=MImg&_imagekey=B6V8T-45WHTS0-2V-1&_cdi=5879&_user=9710723&_pii=0167945787900017&_origin=&_coverDate=12%2F31%2F1987&_sk=999939995&view=c&wchp=dGLbVzW-zSkzk&md5=555833986b5d00926c84d0fc6b201236&ie=/sdarticle.pdf
41. Grupp J. Shotokan Karate-Kumite. 2nd ed. Aachen: Meyer & Meyer; 2009.
42. Bandow N. Bestimmung der Antizipationsfähigkeit im Karate-Kumite unter Nutzung der virtuellen Realität. Dissertation. 1. Auflage. Berlin: epubli; 2016.
43. Bandow N, Witte K. Gaze behaviour of skilled and less-skilled Karate athletes while viewing occluded video attacks. J Martial Arts Res. 2020.
44. Vater C, Williams AM, Hossner E-J. What do we see out of the corner of our eye? The role of visual pivots and gaze anchors in sport. Int Rev Sport Exerc Psychol. 2019;11:1–23. http://dx.doi.org/10.1080/1750984X.2019.1582082

DOI: https://doi.org/10.22374/jspv.v3i1.8
J Sports Perf Vis 3(1):e1–e11; 2021.