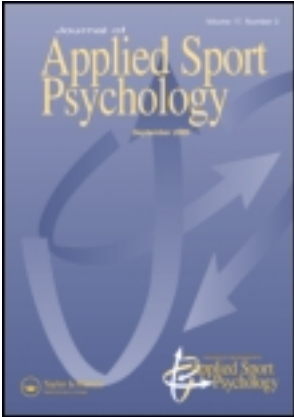


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Finding the Happy Medium: An Analysis of Gaze Behavior Strategies in a Representative Task Design of Soccer Penalties

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In a field study, we conducted a soccer penalty experiment in which players had to detect the goalkeeper's movement during the run-up. We tested subjects under two conditions: the center-looking (perceiving both stimuli peripherally) and the free gaze strategy (foveal gaze on either the ball or the goalkeeper, or saccades). The center-looking strategy was superior when it came to detecting goalkeeper movements; with respect to the number of scored goals, no difference could be detected. Future research should investigate whether appropriate training in the use of the center-looking strategy might lead to a higher number of scored goals.

The ability to focus on a number of different objects or events at the same time is crucial in our everyday lives (e.g., jobs, traffic, sport). Several researchers provided evidence that we are able to simultaneously identify multiple objects (e.g., Awh & Pashler, 2000; McMains & Somers, 2004; Scharlau, 2004). Although most studies have explored the ways in which people simultaneously devote attention to multiple objects within a laboratory setting (e.g., Cavanagh & Alvarez, 2005; Fehd & Seiffert, 2008, 2010; Fortenbaugh & Robertson, 2011; Hüttermann, Bock, & Memmert, 2012; Iordanescu, Grabowecky, & Suzuki, 2009; Jans, Peters, & De Weerd, 2010), real-world scenarios were mostly neglected (Dunwoody, 2006). However, meta-analyses revealed differences between laboratory studies and natural experimental settings (e.g., Hogarth & Kareláia, 2007; Kareláia & Hogarth, 2008) so that the question arises whether observed effects can be generalized and validated outside the experimental laboratory setting. In the present study, we aimed to address the effectiveness and the assignability of gaze adjustment strategies that were found in laboratory task designs to a natural experimental setting capturing relevant features of a representative design (cf. Brunswik, 1955, 1956). As an adequate real-world design, we chose the penalty shootout in soccer (cf. Dicks, Button, & Davids, 2010).

In related research, Fehd and Seiffert (2008, 2010) examined the question of where people direct their gaze when multiple locations are of interest at the same time using a multiple tracking task. They compared a center-looking strategy requiring participants to look at a central point in between the targets with a “target-looking strategy” requiring participants to saccade from target to target. The data indicate that participants primarily applied the center-looking strategy; however, no statements were made regarding performance differences between the use of the gaze strategies. Subsequently, Hüttermann et al. (2012) evaluated

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performance differences when subjects fixated mid-between two tasks (peripheral gaze strategy) or were free to direct their gaze at either task (free gaze strategy). The results revealed superiority of the peripheral over the free gaze strategy. It was pointed out that stimuli in the free gaze condition triggered reflexive saccades (McDowell, Dyckman, Austin, & Clementz, 2008; Walker & McSorley, 2006), which bind neural processing resources (Mather & Putchat, 1983; Pashler, Carrier, & Hoffman, 1993) and eventually interfere with attentive processing. In a further study, Hüttermann, Memmert, Simons, and Bock (2013) compared performance of sport experts and novices when one object was at fixation and the other one in the periphery to a condition in which both objects were in the periphery and subjects fixated between them. Overall, performance was better with two peripheral stimuli than with one central and one peripheral task; furthermore, sport experts consistently outperformed novices in both fixation strategies. These findings pose a possibility to improve performance in tasks in which observers must pay attention to multiple objects across spatial regions; they also point out the advantages of skilled athletes when two objects have to be perceived simultaneously. Although Hüttermann et al. (2012, 2013) compared the different gaze strategies within laboratory settings, our research is novel in that it compares these strategies when used by experienced soccer players within the natural experimental setting of the penalty kick.

Brunswik (1955, 1956) proposed a methodological framework termed representative design. He emphasized the importance of studying organism-environment interactions. Experimental stimuli should be sampled from the organisms' natural environment to be representative of the environmental stimuli to which the organism has adapted, and to which findings are intended to be generalized (Brunswik, 1956). That means that generalized results require not only samples of participants being representative but also samples of situations or tasks. However, traditional approaches to behavioral sciences largely neglected the interactions between participants and the environment (Dunwoody, 2006).

For various reasons, the soccer penalty shootout is a suitable real-world situation offering a representative design to test the validity of gaze adjustment strategies examined in laboratory settings (e.g., Fehd & Seiffert, 2008, 2010; Hüttermann et al., 2012): as opposed to the generally very dynamic nature of the game, the static penalty scenario guarantees more consistent analysis due to higher comparability. Experiments are easier to conduct and standardize and most importantly, penalties are a highly relevant topic in terms of their practical application and media attention. Given that a soccer goal is 7.32 m long and 2.44 m high (which equals an area of 17.86 m²) and considering that the ball, which is not even in motion, reaches an average speed of 75 km/h after 500–600 ms (Morya, Ranvaud, & Pinheiro, 2003), it is somewhat surprising that 25% to 33% of penalty shots do not result in a goal (Franks & Hanvey, 1997; McGarry & Franks, 2000). Especially with regard to gaze adjustment strategies examined in laboratory settings (e.g., Fehd & Seiffert, 2008, 2010; Hüttermann et al., 2012), the question arises whether there is a chance to improve the shooters' success by optimizing their gaze behavior during penalties.

Button, Dicks, Haines, Barker, and Davids (2011), as well as Dicks et al. (2010) have previously researched penalty shootout settings with the intention to detect possible differences in subjects' gaze behavior. Both studies examined whether there are differences in goalkeeper's gaze behavior between video simulation conditions and in situ conditions. Results showed differences in information pickup for perception and action. The authors concluded that subjects make use of different visual search strategies and gaze behaviors depending on the experimental task constraints selected for empirical investigations. They suggested that further research of subjects' gaze behavior should be conducted in representative experimental conditions to allow for appropriate generalization of the findings. Although the studies of

Button et al. concentrated only on goalkeepers' gaze and movement behaviors, the current study has a different exploratory intention: the conduction of simultaneity judgment tasks in real-world environments. Here, the examination of penalty-takers' gaze behavior seemed more appropriate, especially when placing the emphasis on a kicking strategy that considers the goal-keeper movements during execution.

Similar to Kuhn's (1988) notions of the closed loop and the open loop, Van der Kamp (2006) identified two different ways of shooting penalties: the keeper-dependent strategy (KD strategy) and the keeper-independent strategy (KI strategy). When applying the KI strategy, the shooter chooses the target location in advance and ignores all movements by the goalkeeper before and during the run-up. As suggested by Van der Kamp (2006), concentration on the shot and optimal execution of movements while using the KI strategy allows the best approximation of coordinated gaze and aiming (cf. Vickers, 2007). However, goalkeeper movements are disregarded, regardless of how obvious and tempting they are. On the contrary, the KD strategy implies that the shooter focuses on the goalkeeper during the run-up and anticipates his or her movements in order to shoot the ball into the opposite corner. It can, but does not necessarily have to, include an initial choice of the target area by the shooter. This strategy is particularly advantageous when goalkeepers prematurely commit themselves. Morya et al. (2003) and Van der Kamp (2006) found that when goalkeeper's movements and their dives into one corner are detected less than 400 ms before ball contact, penalty takers might alter the direction of their shot. When the movements are detected closer to the kick, however, altering the intended direction is likely to reduce accuracy.

Recalling the significantly high number of missed penalties under relatively easy circumstances for the shooter, and considering the fact that the majority of the penalty takers make use of the KD strategy (Kuhn, 1988), we examined the differences of various gaze adjustment strategies when using the KD strategy. Moreover, we tried to validate the laboratory findings about the gaze strategies of skilled athletes by Hüttermann et al. (2012, 2013) in a representative task design. Since these gaze strategies corresponded to the ones in our natural experimental setting testing the KD strategy, we expected that penalty takers applying the KD strategy will be better able to detect goalkeeper movements when perceiving both, the goalkeeper and the ball peripherally (center-looking condition) instead of using saccadic eye movements. We tested our hypothesis in a KD penalty situation in which participants had to shoot half of the penalties in the center-looking condition and the other half without such instructions (free gaze condition). On the basis of previous research highlighting a better detection of two stimuli when applying the center-looking strategy in laboratory-based designs (e.g., Fehd & Seiffert, 2008, 2010; Hüttermann et al., 2012, 2013), we hypothesized that in natural experimental settings, a center gaze adjustment would also contribute to recognizing the goalkeeper's movements better than saccadic movements.

METHOD

Participants

Twenty-two male subjects participated in the study ($M_{\text{age}} = 19.82$, $SD = 3.42$ years, age range: 17–27 years). All of them were former ($n = 2$) or current outfield soccer players ($n = 20$) who regularly participated in organized competitions ($M_{\text{team sport experience}} = 10.86$, $SD = 4.13$ years) with intensive training effort of at least 4 hr per week. To make the results as consistent as possible, we chose the same goalkeeper (age = 18, competition experience: 13 years) for all participants. All subjects reported normal vision without need for corrective lenses and had not participated in any sensorimotor research within the preceding six months.

Written informed consent was obtained prior to commencing the experiment. The study was carried out in accordance with the Helsinki Declaration of 1975.

Data Collection

Eye position was monitored with a mobile eye-tracking system (Mobile Eye[®], Applied Science Laboratories, Bedford, Mass., USA), at a sampling rate of 30 Hz and a resolution of 1°. Whenever a subject failed to maintain the fixation on the designated area in the center-looking condition (i.e., gaze deviations of more than 5%), the respective shot was deleted from the analysis (<1%).

A Canon HD HG21 digital camera (25 Hz) was used to record all shots on video-tape in order to guarantee a correct assessment of the players' scores. The camera was positioned diagonally behind the shooter in order to make sure that the run-up, the goalkeeper, his movements and saves, as well as the shot directions of the player could be identified when revising the video.

Procedure

Prior to the study, participants were given a survey with questions about their soccer experience and asked to describe their preferred penalty kicking strategy with as much detail as possible. Subsequently, participants were familiarized with the materials and the procedure of the study. After calibration of the eye-tracking device, each participant was given the same oral instructions: overall, each participant had to take a total of 30 penalties, divided into two series of 15 shots per tested condition. Half of the penalties were shot with a free gaze alignment, that is, participants were not given any instructions or restrictions on how to shoot the penalty. We assumed that the shots in the free gaze condition were carried out in accordance with participants' preferred penalty-kicking strategy. The other half of the shots had to be taken with a peripheral gaze alignment (center-looking condition): shooters were required to direct their gaze to a 1 × 1 m area (indicated by a white sheet) with the center located equidistant between the penalty spot and goal line. This way, subjects would perceive the ball and the goalkeeper's movements peripherally. Participants were asked to maintain their foveal gaze on the sheet starting before the run-up until they hit the ball. For all 30 shots, subjects were asked to react to the goalkeeper's initial movement into one direction by shooting the ball into the opposite corner. Participants were not allowed to delay the shot during their run-up and if they did, the shot had to be retaken. The run-up had to start at least 3.5 m behind the ball. Shooters were asked to always identify the free corner of the goal, direct their shot towards it and score as many goals as possible.

Because our experiment measured the identification of the goalkeeper's movement and shooting the ball accordingly, we introduced a more sophisticated point system that we explained to the participants mainly for motivational reasons: when the shooter identified the correct corner and scored a goal, he was awarded two points. When the player correctly identified the corner but his shot missed the goal or the shot was saved by the keeper, the player was awarded one point. One point was also awarded when the player failed to identify the correct corner but scored a goal anyway; no point was awarded when the penalty taker missed the goal and failed to identify the correct corner. This way, we made sure that identifying the correct corner was taken as seriously by the shooter as was scoring goals. Most of the participants knew each other or played in the same soccer team and the prospect that the best scores were going to be announced after the experiment guaranteed not only that everybody gave their best effort, but also that the main aim of our task was not neglected: identifying the correct corner

while scoring goals. Participants were given a break of 1 min between the two series of shots in the different conditions.

The goalkeeper was instructed to make a quick movement into one direction, in other words, temporarily opening up the other corner for the penalty taker, either at an early stage, in the middle, or at the end of the shooter's run-up. Unknown to the penalty-takers, pylons with different colors were used to signal the goalkeeper when to start his movement, either 2.4 m (early condition), 1.6 m (middle condition) or 0.8 m (late condition) before the player had reached the ball. These distances were chosen in line with the findings of a pilot study by Van der Kamp (2006) which suggest that the shooter's kicking foot contacts the ground for the last time approximately 0.8 m before hitting the ball; this is also the point in time at which the instep kick begins. The same distance was added once or twice to simulate the middle and the late conditions, assuming that the size of the steps would not change significantly. Prior to each shot, the goalkeeper was given oral instructions by the experimenter at which point to move in which direction. He was asked to give his best effort to save all penalties, even though the quick initial movement in one direction made it more difficult to save the shot in the opposite corner. In addition, he was required to not distract the shooters and, thus, standardize his posture at the beginning of each shot.

The order of the two gaze conditions (free gaze, center-looking) as well as the order of the distance conditions (early, middle, late) and the initial movement directions of the goalkeeper (left, right) were randomized across all subjects within all trials. This way, learning effects were eliminated as much as possible. To familiarize themselves with the eye-tracking device, that is, the somewhat peculiar feeling of spectacles and a belt with weight around the waist, participants had two test shots per condition. The experiment was conducted outdoors, on an artificial turf on regular soccer goals with Derbystar balls that correspond to the professional soccer rules of the Fédération Internationale de Football Association.

Data Analysis

The mean number of corner identifications (i.e., penalty kicks which were shot in the correct corner) and the mean number of goals scored (i.e., penalty kicks that resulted in a goal) were submitted to a 2×3 multivariate analysis of variance (MANOVA) with repeated measures on both independent variables, strategy (free gaze, center-looking) and distance (0.8 m, 1.6 m, 2.4 m).

RESULTS

The questionnaires handed out prior to conduction of the experiment revealed that 12 out of 22 subjects (54.5%) usually take their penalty shots irrespective of the goalkeeper's movements, that is, they apply the KI strategy.

As expected, participants applied different gaze strategies in the free condition. During their run-up, three participants (13.63%) chose a foveal focus on the goalkeeper while two participants (9.09%) exclusively looked at the ball. All other participants ($n = 17$, 77.27%) used sequential focus on either the goalkeeper, the ball, or the space in the middle. These saccadic eye movements ranged from one up to four saccades during the run-up (e.g., ball-keeper-middle-keeper-ball saccade). A total number of 15 different saccade forms was found; the most frequently used being the keeper-ball saccade (27.77%). By means of the eye-tracking device, it could be assured that all participants fixated mid-between the goalkeeper and the ball in the center-looking condition.

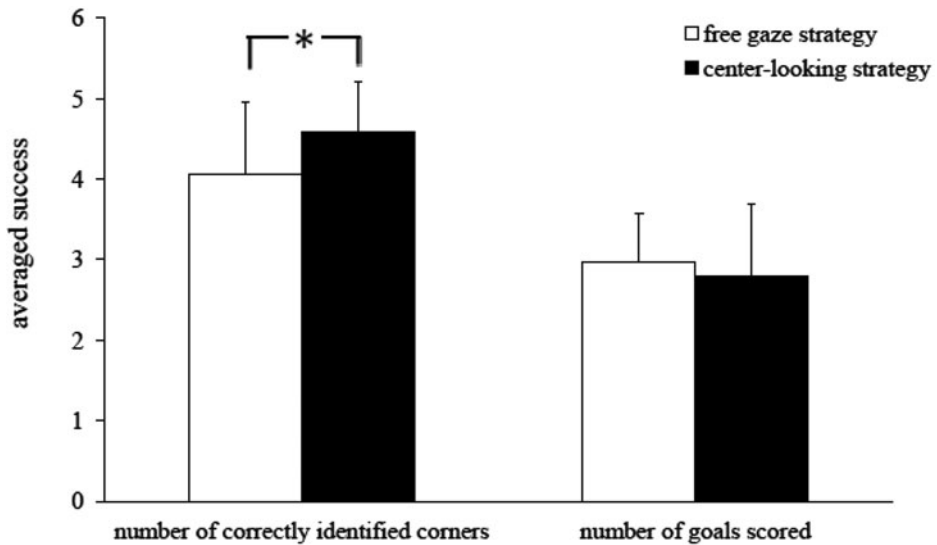


Figure 1. Mean values of the number of correctly identified corners and number of goals, averaged for the three distances 0.8 vs 1.6 vs 2.4, scored by the participants for both gaze strategies (free gaze, center-looking). Error bars indicate standard deviations. (* $p < 0.05$).

The MANOVA, using Pillai's trace, revealed a significant main effect of strategy, $V = .394$; $F(2, 20) = 6.504$, $p = .007$, $\eta_p^2 = .394$. No significant main effect was found for distance, $V = .094$; $F(4, 18) = .466$, $p = .760$, $\eta_p^2 = .094$. Likewise, we did not find a significant interaction between strategy and distance, $V = .127$; $F(4, 18) = 0.657$, $p = .630$, $\eta_p^2 = .127$.

Separate univariate analyses found a significant effect of strategy on identification of the keeper's initial movement in one corner, $F(1, 21) = 12.335$, $p = .002$, $\eta_p^2 = .370$, but not on goal scoring, $F(1, 21) = 0.541$, $p = .470$, $\eta_p^2 = .025$. Participants were able to identify the correct corner more often by using the center-looking strategy than by using the free gaze strategy; the goal success was equally good in both strategies (Figure 1).

DISCUSSION

The need to focus attention on two (or more) different objects at the same time is omnipresent in our daily lives: drivers have to focus on both their own car and the traffic around them, pedestrians devote attention on their path while avoiding obstacles (Chen et al., 1996), and professional chefs are just one example of professionals who must give their attention to a variety of tasks at the same time. Many studies have examined subjects' abilities to perceive different objects at once, mainly using multiple-tracking tasks (e.g., Cavanagh & Alvarez, 2005; Iordanescu et al., 2009), whereas only few (e.g., Fehd & Seiffert, 2008, 2010; Hüttermann et al., 2012) have explored differences in the gaze adjustment strategies applied. However, these studies are laboratory-based and refer to recent meta-analyses that revealed differences between laboratory and natural experimental settings (e.g., Kareláia & Hogarth, 2008; Mann, Williams, Ward, & Janelle, 2007). Therefore, it is still uncertain to what extent the laboratory findings are applicable to real-world scenarios. In the present study, we aimed to address this current empirical shortcoming by comparing different gaze behavior

strategies in a natural experimental setting and validated our theoretical assumptions based on laboratory findings (e.g., Hüttermann et al., 2012, 2013) in a penalty setting. In the KD strategy the penalty-taker must attend to both the goalkeeper and the ball; thus, this real-world situation represents a suitable design to validate laboratory findings in simultaneity judgment tasks.

We conducted a field study and compared two different gaze strategies via identification of the goalkeeper's movements in the KD penalty kicking strategy in soccer, namely a center-looking strategy requiring penalty-takers to fixate between the ball and the goalkeeper (instructed) and a free gaze strategy which allowed for the subjects to use their preferred gaze behavior (uninstructed). About 75% of the participants in the free gaze strategy used saccadic eye movements during their run-up to perceive the ball and identify the goalkeeper's movements. The remaining subjects that used the free gaze strategy achieved simultaneous attention to both stimuli by fixating one object foveally (either the goal or the ball) while attending to the other in the periphery. In accordance with the laboratory findings of Hüttermann et al. (2012, 2013), we found that subjects applying the center-looking strategy achieved the highest goalkeeper movement recognition rate compared to the other two gaze strategies. The finding that subjects performed worse when using saccadic eye movements can be ascribed to the fact that during eye movements, visual perception is impaired and, thus, prevents the simultaneous perception of two (or more) objects (Maruenda, 2004). The outcome that subjects that fixated one object while perceiving the other one peripherally performed worse than subjects using the center-looking strategy can be attributed to the fact that, even though the foveally perceived object had a high resolution on the retina, the perception of the peripheral object was obviously worse, and as a result, the total recognition rate decreased. The reason for the increased detection rate of the goalkeeper's movements in the center-looking strategy, however, can largely be seen in the fact that the eccentricity of both objects is reduced when both are perceived peripherally (Fehd & Seiffert, 2008; Hüttermann et al., 2012). An equal amount of attention prevents one object from attracting too much attention, thus, impairing performance by absorbing neural resources (Pashler et al., 1993).

However, because goal success was equally good in both conditions, we cannot automatically conclude that a greater ability to anticipate the goalkeeper's movements guarantees better scoring results. The fact that we did not yet find a significant interaction between strategy and number of scored goals could be seen, among others, in the generally high number of scored goals in penalties (70% and more, cf. McGarry & Franks, 2000). Furthermore, it can also be explained by the players' individual way of shooting penalties: during their career, most players have become accustomed to their very own kicking strategy and given the fact that more than half of the players in our experiment favored the KI strategy, it is no surprise that most subjects reported that they found it particularly difficult to become accustomed to directing their gaze to the indicated area in the center-looking condition. Assuming that this "odd" and "peculiar" feeling had a negative influence on the subjects' performance, it would therefore be interesting to see whether a direct effect of the center-looking condition on goal scoring can be reached by means of a training study. Penalty takers that are specifically trained to use the center-looking strategy are more likely to benefit from their advantage of better identifying the goalkeeper's movements. This training could be particularly promising for upper league players with a higher movement automaticity and less need to look at the ball. Moreover, if bottom-up training studies turned out to be the expected success and evidently reveal the possibility to optimize performance by changing the athletes' gaze behavior, this would imply great benefits also for referees and linesmen who often have to perceive the ball and several players simultaneously, for example, when judging offside situations.

However, the implications of our research are not restricted to sport: considering that our everyday life requires attentive processing under varying viewing conditions, specific training programs to optimize gaze behavior should be designed (e.g., Harle & Vickers, 2001; Vine & Wilson, 2011). Although, we could confirm previous laboratory findings (e.g., Hüttermann et al. 2012, 2013) showing that subjects perceive two objects more accurately when fixating between them, the decision of whether people should divide attention between the fixation and the periphery, between two peripheral locations, or make use of saccadic movements, depends strongly on the demands of the situation. The use of saccadic movements might, for instance, be advantageous in situations in which there is less time pressure (Maruenda, 2004). Whenever one stimulus requires more detailed processing than the other, directing fixation towards the more critical one will of course be beneficial (Nagano, Kato, & Fukuda, 2004). When both stimuli require equal attention, fixating between the targets will be beneficial to guarantee an optimal perception (e.g., Knudson & Kluka, 1997). As a matter of fact, people are often oblivious to their saccades and fixation patterns and unaware that their gaze direction tends to coincide with the focus of attention (Debner & Jacoby, 1994), so that the use of an attention-focusing strategy with the gaze directed to the center is somewhat counterintuitive to most people and consequently has to be practiced in order to guarantee the use of the optimal strategy in the respective situation. All things considered, the above-quoted assumptions have to be examined in more detail in future research and training studies. Perhaps, the amount of simultaneously perceived information could be increased by a few percent through the introduction of specific training programs which could, revisiting the issue of soccer, have a decisive impact on an important penalty shootout some day.

Based on previous findings that point out the advantages of applying the center-looking strategy for all subjects regardless of their sport experience (e.g., Hüttermann et al., 2013) or age group (e.g., Hüttermann et al., 2012) and given the fact that participants who usually apply the KI strategy did not perform worse in our study than those who normally apply the KD strategy, we assume to find comparable results for different subject groups in our study design as well. Nevertheless, future research should include female subjects and look into the gender-specific differences in spatial cognition tasks more deeply. This way, it could be determined whether or not to expect the same effects of gaze strategy in female soccer players.

CONCLUSION

A variety of investigations have revealed a superiority of peripheral attention adjustment when simultaneously identifying multiple objects that demand equal amounts of attention, that is, to be precise, when subjects fixate mid-between objects instead of using eye movement saccades or perceiving one object foveally and the other one peripherally. Yet, these observations were made in laboratory settings while real-world scenarios were mostly neglected. We compared these two gaze adjustment strategies via identification of the goalkeeper's movements in a real-world penalty setting. In total, subjects correctly identified the goalkeeper's movements more often when applying a peripheral gaze adjustment (center-looking strategy) instead of saccadic eye movements or fixating the ball. Goal success was equally good in both gaze strategies. Results indicate a need for the introduction of specific training programs that investigate whether the application of a peripherally adjusted gaze behavior improves not only the identification of the goalkeeper's movements but also whether that success can be measured in a higher number of scored goals.

REFERENCES

- Awh, E., & Pashler, H. (2000). Evidence for split attentional foci. *Journal of Experimental Psychology: Human Perception and Performance*, *26*, 834–846.
- Brunswik, E. (1955). Representative design and probabilistic theory in a functional psychology. *Psychological Review*, *62*, 193–217.
- Brunswik, E. (1956). *Perception and the representative design of psychological experiments* (2nd ed.). Berkeley, CA: University of California Press.
- Button, C., Dicks, M., Haines, R., Barker, R., & Davids, K. (2011). Statistical modelling of gaze behaviour as categorical time series: What you should watch to save soccer penalties. *Cognitive Processing*, *112*, 235–244.
- Cavanagh, P., & Alvarez, G. A. (2005). Tracking multiple targets with multifocal attention. *Trends in Cognitive Sciences*, *9*, 349–354.
- Chen, H. C., Schultz, A. B., Ashton-Miller, J. A., Giordani, B., Alexander, N. B., & Guire, K. E. (1996). Stepping over obstacles: Dividing attention impairs performance of old more than young adults. *Journal of Gerontology: Medical Sciences*, *51*, M116–M122.
- Debner, J. A., & Jacoby, L. L. (1994). Unconscious perception: Attention, awareness, and control. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *20*, 304–317.
- Dicks, M., Button, C., & Davids, K. (2010). Examination of gaze behaviors under in situ and video simulation task constraints reveals differences in information pickup for perception and action. *Attention, Perception, and Psychophysics*, *72*, 706–720.
- Dunwoody, P. T. (2006). The neglect of the environment by cognitive psychology. *Journal of Theoretical and Philosophical Psychology*, *26*, 139–153.
- Fehd, H. M., & Seiffert, A. E. (2008). Eye movements during multiple object tracking: Where do participants look? *Cognition*, *108*, 201–209.
- Fehd, H. M., & Seiffert, A. E. (2010). Looking at the center of the targets helps multiple object tracking. *Journal of Vision*, *10*(4), 1–13.
- Fortenbaugh, F. C., & Robertson, L. C. (2011). When here becomes there: attentional distribution modulates foveal bias in peripheral localization. *Attention, Perception & Psychophysics*, *73*, 809–828.
- Franks, I. M., & Hanvey, T. (1997). Cues for goalkeepers. *Soccer Journal*, *May-June*, pp. 30–38.
- Harle, S. K., & Vickers, J. N. (2001). Training quick eye improves accuracy in the basketball free throw. *The Sport Psychologist*, *15*, 289–305.
- Hogarth, R. M., & Kareláia, N. (2007). Heuristic and linear models of judgment: Matching rules and environments. *Psychological Review*, *114*, 733–758.
- Hüttermann, S., Bock, O., & Memmert, D. (2012). The breadth of attention in old age. *Ageing Research*, *4*, 67–70.
- Hüttermann, S., Memmert, D., Simons, D. J., & Bock, O. (2013). Fixation strategy influences the ability to focus attention on two spatially separate objects. *PLoS ONE*, *8*(6), e65673.
- Iordanescu, L., Grabowecy, M., & Suzuki, S. (2009). Demand-based dynamic distribution of attention and monitoring of velocities during multiple-object tracking. *Journal of Vision*, *9*, 1–12.
- Jans, B., Peters, J. C., & De Weerd, P. (2010). Visual spatial attention to multiple locations at once: The jury is still out. *Psychological Review*, *117*, 637–682.
- Kareláia, N., & Hogarth, R. M. (2008). Determinants of linear judgment: A meta-analysis of lens model studies. *Psychological Bulletin*, *134*, 404–426.
- Knudson, D., & Kluka, D. A. (1997). The impact of vision and vision training on sport performance. *Journal of Physical Education, Recreation and Dance*, *68*, 17–24.
- Kuhn, W. (1988). Penalty-kick strategies for shooters and goalkeepers. In T. Reilly, A. Lees, K. Davids & W.J. Murphy (Eds.), *Science and football*. (pp. 489–492). London: E & FN Spon.
- Mann, D. T. Y., Williams, A. M., Ward, P., & Janelle, C. M. (2007). Perceptual-cognitive expertise in sport: A meta-analysis. *Journal of Sport & Exercise Psychology*, *29*, 457–478.
- Maruenda, F. B. (2004). Can the human eye detect an offside position during a football match? *British Medical Journal*, *329*, 1470–1472.

- Mather, J. A., & Putchat, C. (1983). Parallel ocular and manual tracking responses to a continuously moving visual target. *Journal of Motor Behavior, 15*, 29–38.
- McDowell, J. E., Dyckman, K. A., Austin, B. P., & Clementz, B. A. (2008). Neurophysiology and neuroanatomy of reflexive and volitional saccades: Evidence from studies of humans. *Brain and Cognition, 38*, 255–270.
- McGarry, T., & Franks, I. M. (2000). On winning the penalty shoot-out in soccer. *Journal of Sports Sciences, 6*, 401–409.
- McMains, S. A., & Somers, D. C. (2004). Multiple spotlights of attentional selection in human visual cortex. *Neuron, 42*, 677–686.
- Morya, E., Ranvaud, R., & Pinheiro, W. M. (2003). Dynamics of visual feedback in a laboratory simulation of a penalty kick. *Journal of Sports Sciences, 21*, 87–95.
- Nagano, T., Kato, T., & Fukuda, T. (2004). Visual search strategies of soccer players in one-on-one situations on the field. *Perceptual and Motor Skills, 99*, 968–974.
- Pashler, H., Carrier, M., & Hoffman, J. (1993). Saccadic eye movements and dual-task interference. *Quarterly Journal of Experimental Psychology, 46A*, 51–82.
- Scharlau, I. (2004). Evidence for split foci of attention in a priming paradigm. *Perception & Psychophysics, 66*, 988–1002.
- Van der Kamp, J. (2006). A field simulation study of the effectiveness of penalty kick strategies in soccer: late alterations of kick direction increase errors and reduce accuracy. *Journal of Sports Sciences, 5*, 467–477.
- Vickers, J. N. (2007). *Perception, cognition, and decision training: the quiet eye in action*. Champaign, IL: Human Kinetics.
- Vine, S. J., & Wilson, M. R. (2011). The influence of quiet eye training and pressure on attention and visuo-motor control. *Acta Psychologica, 136*, 340–346.
- Walker, R., & McSorley, E. (2006). The parallel programming of voluntary and reflexive saccades. *Vision Research, 46*, 2082–2093.