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Goalkeepers put their money where the coach's mouth is: Knowing kickers' preferences enhances anticipation of football goalkeepers

We investigated the influence of providing football goalkeepers with a kicker's prior preferences on anticipation and gaze behaviour to explore the interaction of top-down and bottom-up cognitive processing. Forty participants (20 experienced goalkeepers and 20 novices) were asked to anticipate the direction of penalty kicks in three experimental conditions: without information (control situation), with correct information (congruent condition), and with wrong information (incongruent condition) on a kicker's prior preferences. An eye-tracking device was used to analyse fixations on areas of interest. The participants anticipated the direction of the kick in congruent situations better than in the other two conditions (p = 0.001). Experienced goalkeepers were superior to novices in the incongruent and control conditions (p = 0.001). In those conditions, experienced goalkeepers also fixated more (p = 0.025) and longer (p = 0.046) on the trunk, and longer on the hips (p = 0.036), non-kicking leg (p = 0.001), and kicking leg (p = 0.001). We conclude that providing congruent information on a kicker's preferences positively impacts goalkeepers' anticipation. This confirms a model that expertise differences between experienced goalkeepers and novices are more prominent when the interaction of bottom-up and top-down processes is difficult.

Keywords: football, penalty kick, gaze behaviour, anticipation.

Introduction

Penalty kicks are important moments in football, often defining the outcome of matches and competitions. Those moments occur frequently in elite soccer such that 473 penalty shootouts and 223 in-game penalties were observed in the last ten years of World and European competitions (Brinkschulte et al., 2020). From the goalkeeper's perspective, researchers have demonstrated the need for goalkeepers to adequately interpret relevant information present in the environment to anticipate the direction of the shot (Loffing & Cañal-Bruland, 2017; Savelsbergh et al., 2002). Beyond the current information of the kicker, the goalkeeper receives prior information from the club's analyst or by the goalkeeper's coach. Such contextual priors seem to be relevant to the goalkeeper's success (Gredin, Bishop, et al., 2020). Thus, information on a kicker's prior kicks (e.g., the percentage of times in which the ball was kicked to a specific place in the goal in previous matches) is a relevant source of information that can contribute to facilitating anticipation in penalty kicks (Navia et al., 2013; Runswick et al., 2019).

In official matches, goalkeepers must integrate contextual priors and kinematic information to better predict the direction of a kick. Contextual prior information relates to any non-kinematic source of information utilised through domain-specific knowledge and enables a sophisticated understanding of situational probabilities (Gredin, Bishop, et al., 2020). For example, this could be the goalkeeper's knowledge of an opponent's preference regarding shot direction. On the other hand, it is well established that athletes can pick up and use advanced kinematic information, including information from kickers, to predict the ongoing action (Morris-Binelli & Müller, 2017; Williams & Jackson, 2019). In the penalty kick, this information can include the pattern of running, the position of the kicking leg, or the hip's position and angle (Causer et al., 2017; Gredin, Bishop, et al., 2020). Goalkeepers are faced with the need whether to rely on that information when deciding between jumping to one side (left or right) or staying in the middle of the goal. How can immediate perceptual (i.e., bottom-up) information and prior probability (i.e., top-down) information be integrated for action? The dynamic and probabilistic SMART-ER model (situation model of anticipated response consequences in tactical decisions—extended and revised; Raab, 2015) integrates those bottom-up and top-down processes and proposes four kinds of interactions (selective, competitive, consolidated, and corrective; for more details, see Raab, 2015) that differ in their reliance on parallel and sequential processing and the weighting of the two streams of information. Predictions from the model make it possible to test goalkeepers' anticipation behaviour and gaze strategies when the two sources of information are congruent (e.g., perceptual information and kicker's prior preferences both suggest a shot to the left) or incongruent (e.g., perceptual information suggests a shot to the left but kicker's prior preferences suggest a shot to the right). Specifically, the model predicts consolidated interactions (i.e., when both top-down and bottom-up processes are involved in a choice) if the prior information confirms the kicker's behaviour (congruent condition). Thus the models' prediction would explain why faster and more accurate responses are produced when top-down and bottom-up processes are consolidated. In contrast, delayed and erroneous behaviour is expected when incongruent conditions are present (Raab, 2015). Exploring the interaction between top-down and bottom-up processes in congruent and incongruent conditions in the soccer penalty kick may be useful to test this model and provide further information regarding how goalkeepers anticipate the direction of a kick in football. From a practical perspective, this information could support coaches to develop strategies for improving goalkeepers' anticipation and supporting scouting strategies for gathering relevant prior information that enhances the anticipation of the goalkeepers in penalties.

Previous research has reported that both prior knowledge and kickers' kinematics affect goalkeepers' anticipation. For instance, researchers investigated goalkeepers' anticipation in football penalty kicks when prior information about the kicker's preferences was provided (Causer et al., 2017; Navia et al., 2013; Wang et al., 2019). For example, Navia et al. (2013) tested the goalkeepers' anticipation without prior information, in an equal-probability condition (50% chance of kicking the ball to each side), and in a high-probability condition (80% chance of kicking the ball to the left side of the goal). The high-probability condition increased the goalkeepers' anticipation, although how providing incongruent prior information change goalkeepers' decisions is unknown from those studies. Therefore based on predictions of the SMART-ER model (Raab, 2015) we want to extend previous research that used congruent information.

Gredin, Broadbent, Findon, Williams, and Bishop (2020) showed that providing explicit prior information may impair the anticipation performance because of the difficulty in coupling this with kinematic information, but only congruent information was presented to the participants. Further evidence indicated that the integration of probability and visual trajectory information in baseball batting is demanding (Gray & Cañal-Bruland, 2018). In their experiment, the best performance occurred when the visual occlusion of the ball's trajectory was later and with a high probability condition (in which the contextual priors were based on higher probability values). However, the visual search was not evaluated, which limits the understanding of the underpinning processes of anticipated responses.

Two studies that are most relevant for our study design did investigate congruent and incongruent information. First, Runswick et al. (2019) investigated how congruent and incongruent information impacted anticipation in cricket batting and showed that experts performed better when congruent information was provided. Second, Helm et al.

(2020) conducted a study with avatars in a virtual reality scenario. Congruent and incongruent prior information was presented under different probabilities (25%, 50%, and 75%) of the launch movement being disguised during handball penalty kicks. The participants relied more strongly on non-kinematic (situational probability) information when the reliability of the observable movement kinematics becomes less certain. In that study, prior incongruent information was not provided and the visual search behaviour was not assessed.

There is growing evidence of the role of congruent contextual information for anticipation, although little is known about the role of incongruent information and even less in soccer penalty kicks, specifically. The abovementioned gaps address the need to further research on understanding how contextual priors and kinematic information are integrated during anticipatory tasks. Further, there are many eye-tracking studies (e.g., the meta-analysis of Gegenfurtner, Lehtinen, & Säljö, 2011) that systematically show differences between experts and novices in sports and other domains, but this gaze behaviour has not often been compared to manipulated prior information and thus cannot be used to test models of anticipation based on bottom-up and top-down processes and their interactions.

It is not surprising that explanations of expertise advantages have been attributed to visual attention and how it plays a significant role in athletes' anticipation as indicated in the SMART-ER model descriptions of visual search (bottom-up) processes. In the SMART-ER model, consolidated interactions of top-down and bottom-up processes are strongly dependent on expertise as experts have advanced search strategies compared to novices when interacting with prior contextual information (Raab, 2015, p. 2). Many studies have analysed the gaze behaviour of athletes regarding fixations (number and duration), such as in tennis (Triolet et al., 2013; Zhao et al., 2018), handball (Alsharji &

Wade, 2016), squash (Abernethy, 1990), football (Roca et al., 2012), and, more specific to the current study, football goalkeeping (Navia et al., 2013; Piras & Vickers, 2011; Savelsbergh et al., 2002, 2005; Woolley, Crowther, Doma, & Connor, 2015). For instance, Woolley et al. (2015) indicated that goalkeepers exhibited better anticipation than outfield players and a control group supported by a higher percentage of fixation location and viewing time of the kicking leg and ball. In addition, Savelsbergh et al. (2002) found that longer fixations on specific areas of interest (AOIs), such as the trunk, hips, and kicking leg, led to better anticipation. Together, previous findings suggest that the number fixations and fixations on AOIs provide useful information to comprehend the role of visual attention in perceptual-cognitive performance in sports and may lead to a better understanding of the underpinning mechanisms of goalkeepers' expert anticipation performance. Even if the eye might be the beholder to our mind and can partly explain goalkeepers' behaviour, it is theoretically (SMART-ER), empirically (Abernethy, 1990; Cañal-Bruland et al., 2010; Williams, Huys, Cañal-Bruland, & Hagemann, 2009), and anecdotally (e.g., Lehmann's list or "cheat sheet"[1]) evident that prior information contributes to the understanding of such a complex goalkeeper behaviour.

As we previously addressed, the knowledge of the kicker's preferences seems to impact the goalkeeper's anticipatory behaviour (see Cañal-Bruland & Mann, 2015, for an overview). Indeed, participants tended to move towards the actions that confirm the prior information explicitly provided (Gredin, Broadbent, Williams, & Bishop, 2019, but see Firestone & Scholl, 2015). Navia et al. (2013) demonstrated that goalkeepers commit themselves earlier to one side when prior information is available, even when this

[1] See https://www.fifa.com/worldcup/news/the-piece-of-paper-that-helped-germany-turn-the-page-2811265 (retrieved June 25, 2020).

information is less predictive. This result indicates that instead of broadly searching for relevant cues, goalkeepers use explicit prior information to guide the allocation of visual attention (Gredin et al., 2018), which reinforces the idea that prior and contextual information interact throughout the anticipatory behaviour. Finally, Gredin et al. (2018) confirmed that congruent prior information enhances the anticipation performance, whereas, for incongruent trials, the explicit priors harmed the final judgments of novices but not experts. However, in their case, the participants had to anticipate the direction of the player in possession-based on only two available options (right or left side), which may be simpler than the usual anticipatory context in football. Also, although the gaze behaviour was analyzed, only the time allocated in the player with or without the ball was accounted, which is not enough to understand how different AOIs (such as the kicking leg and the hip) might underlie the anticipation. Therefore, this study does not fully investigate the underpinning mechanisms of perceptual-cognitive performance when interactions between prior and contextual information are required.

In summary, previous studies showed that experienced players in time-constrained sports might benefit from contextual information when attempting to anticipate an opponent's action. But it remains unclear whether the pick-up of visual information and integration with contextual priors is impaired when congruent or incongruent prior information about the opponent is available. We argue that there is the need for theoretically motivated and well-designed studies providing evidence of how congruent and incongruent information in expert anticipation is used before practical recommendations can be made. Thus, the current study aimed to compare the anticipation performance and gaze behaviour (number and duration of fixations, and fixations on AOIs) between experienced goalkeepers and novices, and within each group, on three experimental conditions: without prior information on kickers' preferences (control condition), with congruent prior information on kickers' preferences, and with incongruent prior information on kickers' preferences. Based on the SMART-ER model (Raab, 2015), we expected to find (a) the main effect of expertise in all conditions, with higher anticipatory performance and time spent on AOIs observed in the expert group in comparison to novices, (b) the main effect of experimental condition, with more accurate anticipations when the information was congruent compared to when the information was incongruent, and (c) an interaction of expertise and congruency, because experts can use their experience to consolidate conflicting information much better than novices. Also, we expected congruent situations to be characterized by fewer but longer visual fixations on the AOIs.

Methods

Participants

The sample size was statistically determined using the software GPower 3.1.9 (Franz Faul, Universität Kiel, Germany), assuming a *p* of 0.05, an effect size of 0.628, and a power of 0.95. To this end, we conducted a pilot study with a similar expertise sample to determine the mean and standard deviation of the dependent variables. This pilot study was conducted with seven goalkeepers, from elite clubs (the same level of expertise as the final sample) and followed the same procedures of the main data collection. After the pilot study, the variable with the highest coefficient of variation was used to calculate the sample. The software suggested a minimum of 14 participants in each group (experienced goalkeepers and novices). Anticipating possible dropouts, we recruited 40 individuals (20 in each group). Therefore, the final sample comprised 20 experienced male goalkeepers (M_{age} = 18.9 years, *SD* = 0.8, and all with a minimum of 8 years of deliberate practice) recruited from the U-20 academy or the professional squad of clubs registered in a national football association who competed at the national level.

Considering the whole population of experienced goalkeepers in the national football association, we estimated that about a fifth of the available players was recruited, which reinforces the representativeness of the sample. Twenty age- and gender-matched university students made up the novice group (M_{age} = 19.2 years, *SD* = 1.1, and never registered in the national football association). The local ethics committee approved this study, and we followed all the guidelines of the Helsinki Declaration.

Procedures

All the procedures were laboratory-based. Although the perception-action coupling is reduced in this sort of experiment, it allowed a higher control of intervening variables. We ensured a minimum of ecological validity by adopting the first-view perspective on every video clip and using real penalty-kick footages. Each participant was individually positioned in front of an 18-inch screen in which the football penalty kick scenes were presented using the software Experiment Center 3.5 (SensoMotoric Instruments, Germany). The participants watched all the scenes from the goalkeepers' perspective (first person). The participants' position was standardized, and no head movements were allowed since a head fixator was used during data collection (see Figure 1). The eye-tracking device was calibrated at the start of the data collection, using the iViewX RED 500 software (SensoMotoric, Instruments, Germany). The experiment consisted of showing participants 38 pre-validated video clips of penalty kicks, which consisted of 36 test trials and two familiarization trials. These clips were validated by experts (see below in the section on instruments). Of the 36 test trials, 12 had no information about the kicker's prior shots, while 24 presented this prior information before the video (see Figure 1B). Of those 24 scenes, 12 had congruent information (i.e., the information provided would match the result of that specific penalty kick) and 12 had incongruent information (i.e., the prior information provided would not match the result of that particular penalty kick). The whole procedure lasted about twenty minutes and the participants had no feedback regarding their performance. These video clips were randomly presented to each participant, and they were not informed that congruent or incongruent situations were the main manipulation of the study. The participants watched all the video clips in Experiment Center 3.5 (SensoMotoric Instruments, Germany), which also allowed the recording of their eye movements. Each video lasted between 3 and 4 s, and the video was occluded when the kicking foot touched the ball, without any movement of the ball. After each trial, the participant was asked to answer in 5 s, "Where was the ball kicked?" (see Figure 1D), by clicking with the mouse on one of the six sections of the goal. All the shots were directed to one of the six goal sections. The Experiment Center 3.5 registered the clicks for further analysis.

INSERT FIGURE 1 HERE

Instruments

Football goalkeepers' anticipation assessment protocol

Five right-footed outfield players were recruited to simulate penalty kick situations in a real environment and generate a total of 81 video clips. These trials were recorded from the goalkeeper's perspective by a digital camera (GoPro Hero 3 silver edition) positioned on the goalkeeper's head in the middle of the goal. A second camera (Canon SX170) was positioned behind the kicker to allow us to check the direction of the ball. Twenty-seven videos were excluded because of poor quality. To analyse the content validity of the remaining scenes, we calculated the content validity coefficient (CVC) by checking the three dimensions proposed by Hernandéz-Nieto (2002): image clarity, practical pertinence, and theoretical relevance. These dimensions were evaluated by five experts (goalkeepers' coaches in professional clubs with a minimum of 5 years of experience in this function). The scenes that presented a CVC lower than 0.70 were excluded. The remaining 38 scenes showed values of 0.91 for image clarity, 0.84 for practical pertinence, and 0.84 for theoretical relevance. The final CVC of the instrument (0.86) was calculated considering the judges' error ($1/j^2$), and the value is deemed satisfactory in the literature (Hernandéz-Nieto, 2002; Ribas et al., 2020)

Eye Tracking SMI RED500

An eye-tracking device (SMI RED500, SensoMotoric Instruments, Germany) was used to analyse eye movements. The instrument adopted in the current study was reported to be valid and reliable (Hutton, 2019; Kredel et al., 2017; Moran et al., 2018). All eye-tracking variables were extracted after the data collection by the software BeGaze 3.5.7.4 (SensoMotoric Instruments, Germany). The AOIs adopted in the current investigation (head, trunk, hips, kicking leg, non-kicking leg, and ball) were determined based on previous studies (Navia et al., 2017). Visual fixation was counted every time the eye remained fixed within a 1.5º area for a time equal to or higher than 120 ms (Williams, Davids, & Williams, 1999). All the fixations were manually checked to assure which AOIs per video clip were considered by the participants.

Dependent variables

Correct answers: number of times (units) in which the participant provided the right answer to the anticipatory task.

Number of fixations: number of times (units) in which the participant fixated at a specific point in the video considering the maximum angle deviation of 1.5º and a minimum duration of 120 ms (Williams et al., 1999).

Duration of fixations on AOIs: duration (ms) of the fixations on each AOI identified in the study (head, trunk, hips, kicking leg, non-kicking leg, and ball).

Data Analysis

The data of each variable are reported as means and standard deviations. The normality (Shapiro–Wilk's test), homoscedasticity (Levene's test), and sphericity (Mauchly's test) assumptions were checked first. A mixed two-way analysis of variance (ANOVA; Experimental Condition × Group) was adopted to compare the data, and Tukey's 'Honest Significant Difference' post hoc test was used and p-adjusted value was reported to reduce the type I error when multiple comparisons are made. Partial eta-squared (η_p^2) was used as a measure of the effect size of the mixed two-way ANOVA and classified as small (< 0.09), medium (≥ 0.09 to < 0.25), or large (≥ 0.25) based on Mesquita, Franchini, Romano-Silva, Lage, and Albuquerque (2020). In addition, to sensitively access the differences in the pairwise comparisons, Cohen's *d* effect size (Cohen, 1988) was calculated and classified as small ($d = 0.2$), medium ($d = 0.5$), or large ($d = 0.8$). Finally, we compared the frequency of answers on each goal section (proportions) with the chi-square test. All analyses were conducted using $\alpha = .05$ and performed using RStudio Version 1.1.463 for Windows, which is an integrated development environment for R.

Results

The descriptive distribution of the predictions for each goal section is presented in Figure 2. Considering that the protocol had the same number of correct answers for each corner of the goal (two on each corner by experimental condition), we expected a non-biased distribution of the answers within the six areas. However, both experienced goalkeepers (χ^2=147.85, $p < 0.001$) and novices (χ^2=94.60, $p < 0.001$) chose the bottom corners more frequently. Experts performed better than novices $F(1,114) = 10.07$, $p = 0.002$, $\eta_p^2 = 0.081$ (small). More importantly, correct answers for congruent videos were higher than for incongruent videos (Figure 3), $F(2,114) = 3.81$, $p = 0.03$, $\eta_p^2 = 0.493$ (large). Interaction between group and condition, $F(2,114) = 6.65$, $p = 0.002$, $\eta_p^2 = 0.10$ (medium), for correct answers revealed significant differences as predicted. Post hoc analyses revealed that the number of correct answers was indeed higher for congruent than for incongruent conditions, p-adjusted < 0.001, $d = 1.78$ (large), as well as significantly different between congruent and control conditions, p-adjusted < 0.001, $d = 1.97$ (large), but not between incongruent and control conditions, p-adjusted $= 0.703$, $d = 0.16$ (small). The analyses of the interactions revealed that the effect was driven by experienced goalkeepers, who performed better than novices in the incongruent, p-adjusted $= 0.031$, $d = 0.98$ (large), and control, p-adjusted $= 0.007$, $d = 1.23$ (large), conditions, but not in the congruent condition, p-adjusted $= 0.867$, $d = 0.33$ (small).

FIGURE 2 HERE

FIGURE 3 HERE

We extended our investigation of anticipation choices to gaze behaviour. The number and duration of fixations differences between expertise groups and our conditions are presented in Figure 4. The experienced goalkeepers showed more, $F(1,114) = 450.14$, $p < 0.001$, $\eta_p^2 = 0.80$ (large), and longer, $F(1, 114) = 37.81$, $p < 0.001$, $\eta_p^2 = 0.25$ (large), fixations than novices (Figure 4A and B, respectively). However, no differences in fixations between congruent and incongruent conditions were reported (number of fixations: $F(2,114) = 1.36$, $p = 0.26$, $\eta_p^2 = 0.02$, duration of fixations, $F(1,114) = 0.66$, $p = 0.518$, $\eta_p^2 = 0.01$). Interaction effects were found for the number of fixations, $F(2,114)$

= 3.81, $p = 0.025$, $\eta_p^2 = 0.06$ (small), driven by the experienced goalkeepers who showed a higher number of fixations in the congruent than in the control condition, *p*-adjusted = 0.045, $d = 0.82$ (large), while no significant differences were reported between the conditions in novices. There was no effect of condition or Group × Condition interaction effect, $F(1, 114) = 0.12$, $p = 0.899$, $\eta_p^2 = 0.01$ (small).

FIGURE 4 HERE

The longer duration of the fixations observed in the experienced group was also evident for the AOIs previously reported as relevant for extracting kinematic information for anticipation (Figure 5). Experienced goalkeepers presented longer fixations on the trunk, $F(1,114) = 17.84$, $p < 0.001$, $\eta_p^2 = 0.135$ (medium); hip, $F(1,114) = 26.09$, $p < 0.001$, $\eta_p^2 = 0.186$ (medium); kicking leg, $F(1,114) = 20.82$, $p < 0.001$, $\eta_p^2 = 0.154$ (medium); and non-kicking leg, $F(1,114) = 10.34$, $p = 0.002$, $\eta_p^2 = 0.083$ (small), although no main effect for experimental condition was found. In addition, significant interactions between group and condition were found for trunk, $F(2,114) = 3.08$, $p = 0.050$, $\eta_p^2 = 0.05$ (small), and hip, $F(2,114) = 3.41$, $p = 0.036$, $\eta_p^2 = 0.06$ (small), driven by the experienced goalkeepers, who showed longer fixations in the congruent, *p*-adjusted = 0.004, $d = 1.39$ (large), and incongruent, *p*-adjusted = 0.026, $d = 0.86$ (large), conditions than novices. Furthermore, experienced goalkeepers showed longer fixation durations for the hip in the congruent, *p*-adjusted = 0.003, $d = 1.35$ (large), and control, *p*-adjusted < 0.001, $d = 1.52$ (large), conditions than novices.

FIGURE 5 HERE

Discussion

The study aimed to test a model of bottom-up and top-down interactions in which prior information on a penalty kicker's preferences was provided to goalkeepers. We found that experienced goalkeepers tended to outperform novices in correct anticipation and showed more and longer fixations on pertinent AOIs. Better performance on congruent in contrast to incongruent videos offers support for the consolidated interactions predicted by the SMART-ER model, which was most prominent in experienced goalkeepers based on the specific interaction effects of expertise and experimental conditions we found. Why was anticipation better in congruent conditions, as proposed by the SMART-ER model (Raab, 2015)? We argue that top-down processes channel one's perception and prepare one for action, at the cost of more errors in incongruent situations (Wang et al., 2019). In more difficult, that is incongruent situations, the integration of prior and current perceptual information causes conflicts for the choice, which might explain performance and biases in the decisions (Raab, 2015). When this integration caused a conflict (incongruent condition), the expert-novice differences in visual search behaviour were more prominent, adding behavioural support of the previous explanation on how experts simultaneously use contextual and kinematic information of the kicker. This result adds to the literature by reinforcing the role of integrating prior and current perceptual information in an expert-related explanation of performance in perceptual-cognitive tasks. This is important as previous studies have not shown or explain how expert-novice differences increase when competitive (incongruent) sources of contextual information are present.

Knowing where to search for the most relevant pieces of information seems to be more important than just fixating on every available cue. In the current study, longer duration of fixations on the AOIs indicated that experienced goalkeepers are more able to identify the most relevant pieces of information in the scene, which is in line with previous studies (e.g., Navia et al., 2013). Specifically, this result reinforces the idea that bottom-up processes play an important role in expert performance. In the current study, contrary to Mann et al. (2007), experts showed a higher number of fixations than novices, which contradicts the assumption that experts might know “where to search”, avoiding looking at many different (and less significant) cues. Further studies as well confirmed that for some tasks experts may use more fixations (Johnson & Raab, 2003; Williams et al., 2002). Recently a systematic review showed that studies on this topic present contradictory results when it comes to the fewer-fixations-longer-duration assumption about the expertise-related differences in visual search (Klostermann & Moeinirad, 2020). We argue that as the goalkeepers were not familiar with the kickers, they tended to adopt a more exploratory visual search behaviour, in contrast to more familiar contexts in which a few pieces of information might be enough to support the anticipation. However, as recommended in the literature, future studies with an optimal perception-action coupling are recommended to further develop such assumptions (Klostermann & Moeinirad, 2020).

Telling goalkeepers what area of the goal the kicker was likely to target facilitated the integration of top-down and bottom-up processes and thus experts can search for valid cues and use them appropriately. This was confirmed by better anticipation performance in congruent than in the incongruent and control conditions. In consolidated interactions, it is expected that bottom-up and top-down processes are equally important in a choice (Raab, 2015). Therefore, the congruent condition expressed the best scenario in which those processes consolidated and led to the correct anticipation. In contrast, in the incongruent condition, goalkeepers mistakenly relied on contextual prior information, which led to frozen or delayed behaviour and could explain the decrease in performance in comparison to the congruent condition. Further, experienced goalkeepers fixated more on the kicking and non-kicking leg than novices, which is in line with previous studies (Savelsbergh et al., 2002, 2005; Woolley et al., 2015) and indicates how expertise is characterized by gaze towards the AOIs that contain the most valid information. This may indicate that in the absence of prior information (e.g., the control condition in the present study), experts must increase the search for valid information and rely more on bottom-up processes. In summary, providing information about a kicker's preferences seems to contribute to the integration of bottom-up and top-down processes.

One possible limitation of the current study is that the video clips depicted only goalkeeper-independent situations. Goalkeeper-independent situations are those in which the kicker has a previous decision on where to kick and ignores the goalkeeper positioning to change the choice. We used goal-keeper independent situations to eliminate confounding variables. However, goalkeeper-dependent kickers that use goalkeeper positioning to decide where to kick to may demand a different strategy from the goalkeeper. How kinematic information in those situations is used and impacts interaction between bottom-up and top-down processes is fruitful for future studies to test. Furthermore, the results of the present study demonstrate that expert goalkeepers' anticipation performance is influenced by their ability to integrate bottom-up and top-down processes, although they do not allow any conclusions regarding training effects. Cross-sectional studies should be complemented based on interventions looking for the establishment of a causal effect, enhancing the quality of the process of talent development in soccer (Williams, Ford, & Drust, 2020). Also, the information gathered through eye-tracking instruments accounts only for the focal vision, which might neglect some information picked up by the athletes through parafoveal vision. Finally, as our protocol was video-based, future studies in real penalty-kick contexts are suggested for better understanding goalkeeping anticipation processes in more ecologically valid situations.

Coaches can use the results of the current study to better plan interventions with goalkeepers regarding the development of perceptual-cognitive skills. First, goalkeepers must be able to get the most relevant information during penalty kicks. For this reason, relevant cues must be learned, and their use must be optimized during training. One possible intervention, as previously addressed (Morris-Binelli et al., 2021), is to use video footages with time and kinematic occlusion to facilitate the pick-up of contextual information underlying anticipation. At the point of foot-ball contact, the kickers' lower body (kicking and non-kicking legs) provides the most useful information for anticipating the direction of the kick (Lopes et al., 2014), and goalkeepers must develop the ability to extract information from this cue. Second, clubs should provide goalkeepers with sufficient information to characterize the kickers' preferences and use contextual priors systematically to improve anticipation performance. It is important to note that the more congruent contextual information is with the actual action, the higher the odds of better anticipating the direction of the shot.

We conclude that in contexts of consolidated interactions between top-down and bottom-up processes, valid information about the kicker's preferences positively impacts the goalkeeper's anticipation performance. Thus, the quality of the given prior information impacts the underpinning process for anticipation as evident by differences in the visual search. A new result is that expert-novice differences are more prominent when the integration between prior and perceptual information is conflicted (competitive) and reflects therefore a more difficult anticipation context. Lehmann famously demonstrated the importance of recognizing the prior preferences of one's opponents. Coaches today who take note of such information may lead their own teams to victory—if their goalkeepers put their money where the coach's mouth is.

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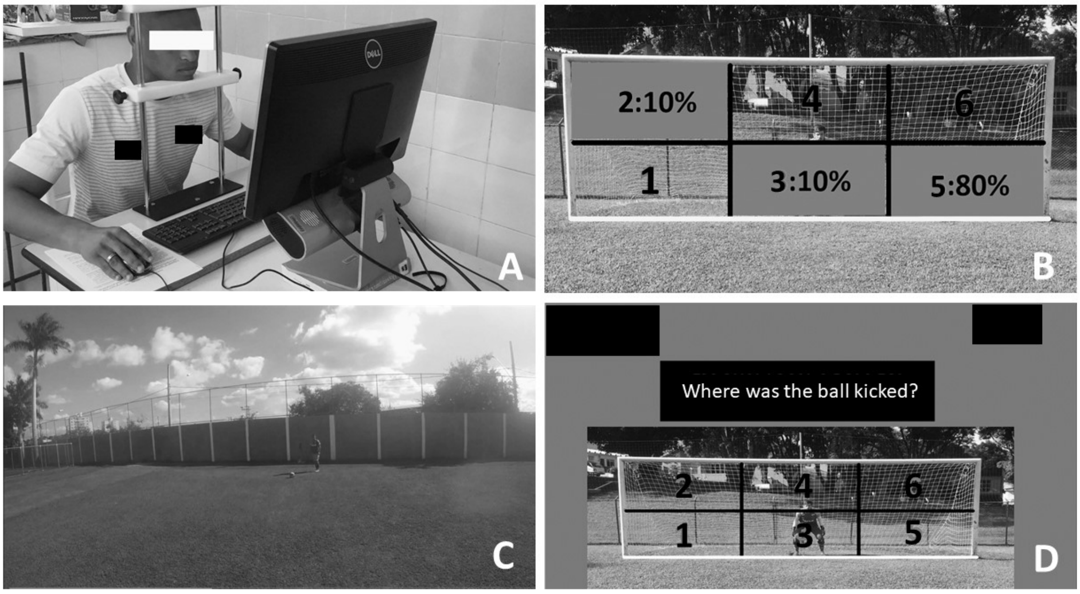
Figure 1: Steps of the data collection.



Note. (A) Start of the data collection; (B) representation of the values provided to the participants regarding the kicker's prior preference information. The percentages represent the probability of the ball being kicked to each area of the goal; (C) experimental trial from the goalkeeper's perspective; (D) screen with the available options.

Figure 2: Distribution of the answers of the experienced goalkeepers (A) and novices (B) for each section of the goal.

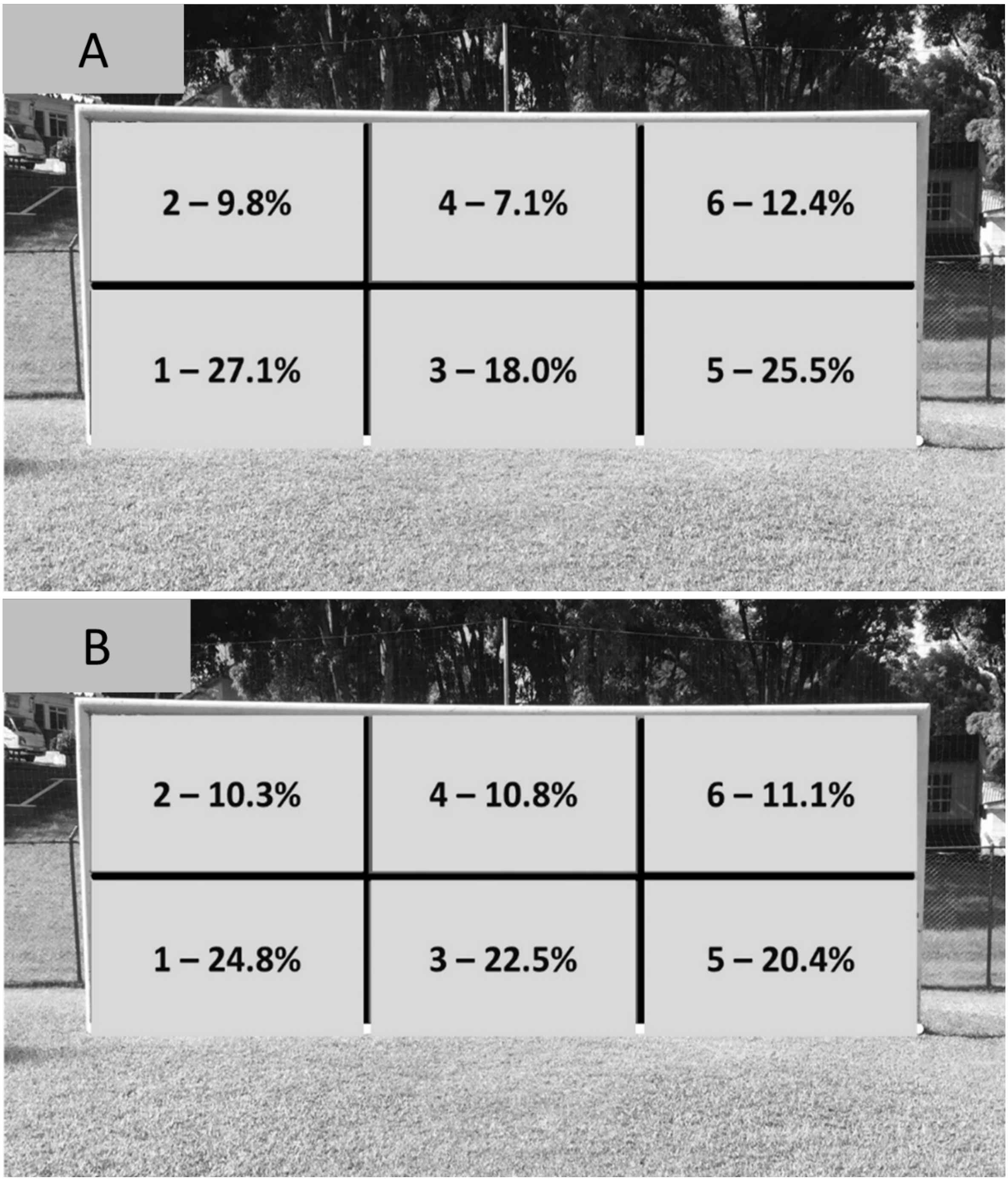
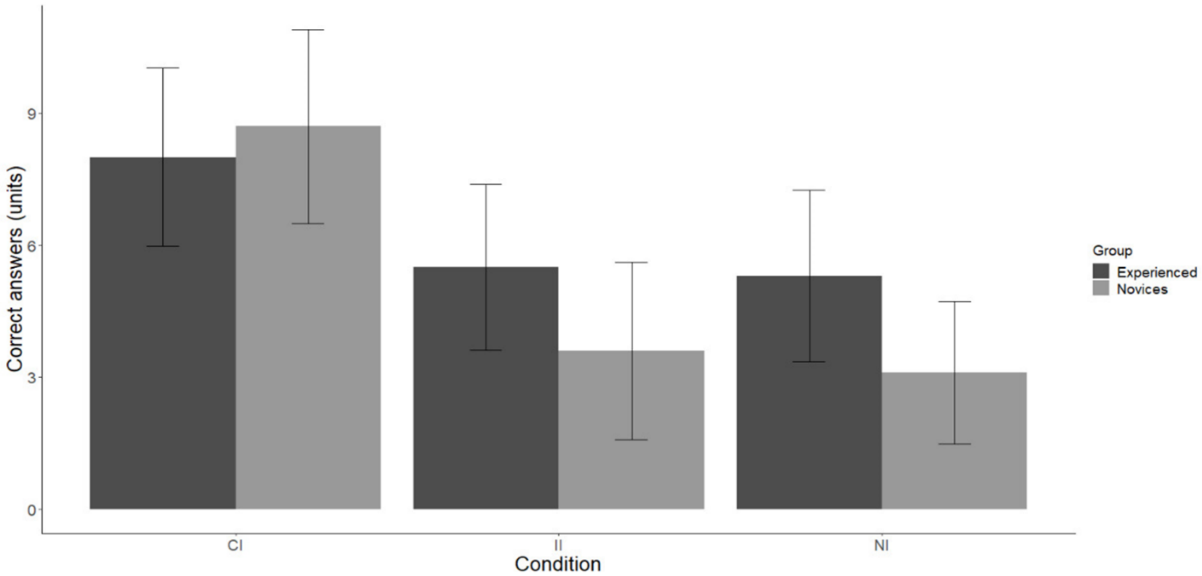


Figure 3: Means (standard deviations) of the correct answers for each group and condition.



Note. CI: congruent information; II: incongruent information; NI: no information. This applies to all figures below

Figure 4: Means (standard deviations) of the number (A) and duration (B) of fixations.

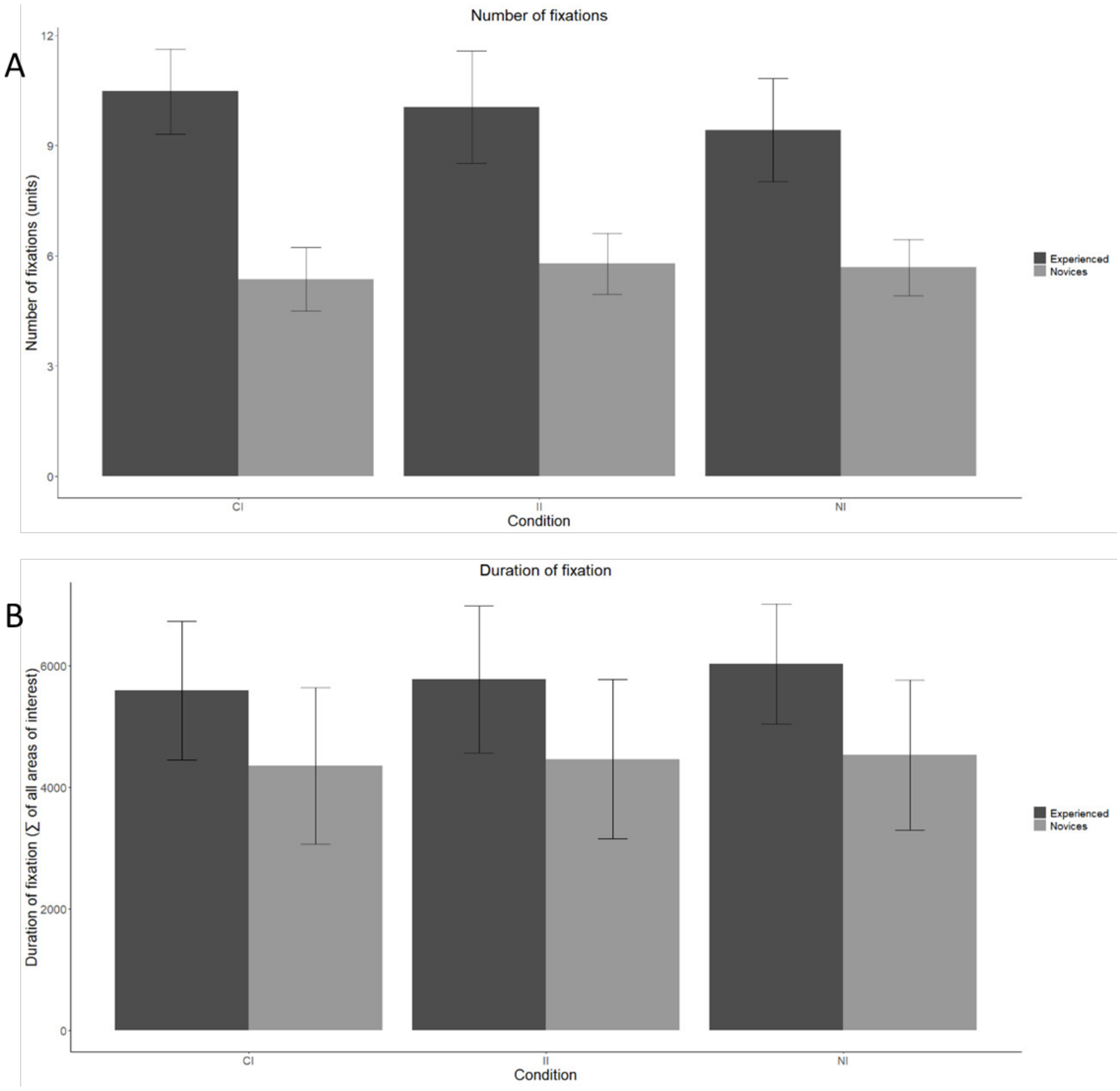


Figure 5: Mean (standard deviation) of the duration of the fixation on the head, trunk, hip, kicking leg, non-kicking leg, and ball.