Computer-based anticipation training in soccer:
Is there a transfer to the field?

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Lokaverkefni til BS-gráðu í sálfræði

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Abstract

In this study an attempt was made to determine if a sport-specific anticipation training program using implicit guidance would improve anticipatory performance on a computer-based soccer penalty kick task, and also if that same program would improve performance in an actual on-field penalty kick situation. Twelve soccer goalkeepers were matched into two groups: an experimental group and a placebo-control group. Prior to the training intervention both groups completed a computer-based penalty kick anticipation test and an actual on-field penalty kick test. During the training intervention, the experimental group viewed temporally occluded videos of penalty kicks combined with implicit guidance, whereas the placebo-control group only completed the pre- and post-tests along with receiving generalized vision training. Results revealed a significant interaction between time and group from pre-test to post-test in anticipating the correct direction (but incorrect height) of the penalty kicks in the computer-based task. However, the improvements observed for the experimental group in the computer-based task did not transfer to the actual on-field penalty kick task.

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It is common to hear coaches and athletes talk about focus, concentration, or attention when evaluating or explaining performance in sports. For example, the Costa Rican international Keylor Navas currently playing for Real Madrid stated “there were moments in the game when we were not concentrated and created chances for the other team” (Collins, 2016) after a narrow 2-1 victory against Las Palmas in the Spanish league. These explanations and many more like them refer to a construct called attention or concentration.

Attention

Despite how commonly attention is used in everyday life, researchers have not yet reached an agreement on how to define attention (Abernethy, 2001; Moran, 2009). Some researchers agree that attention includes at least three components or dimensions (Posner & Boies, 1971; Moran, 2004). Other researchers have attempted to define attention in a perhaps more simple manner. For example, Goldstein (2008) defined attention as a process where an individual concentrates on certain environmental features, thoughts, or activities. Another definition of attention provided by Boutcher (2008) stresses the importance of being able to switch between these sources of information and also how much information can be attended to at any given time. Returning to the multidimensional approach to attention in order to give an overall image of what attention really is. In Posner & Boies’ (1971), three components of attention were identified. These three components were alertness, divided attention (or attention as a limited capacity), and selective attention.

Attention alertness refers to how alertness and arousal affect the breadth of attention (Boutcher, 2008). For example, numerous studies have reported that increased emotional arousal results in a more narrow attentional field (see Easterbrook, 1959 for a review). Similarly, other studies indicate that in stressful situations, performance on a central visual task tends to decrease the ability to respond to stimuli located in the periphery (Bacon, 1974; Hockey, 1970; Landers, Qi, & Courtet, 1985; Land & Tenenbaum, 2012). Attentional alertness can therefore be an extremely important component in sport performance since many sport skills are usually performed under stressful circumstances. For example, overarousal can be prevent a point guard in basketball from detecting the movements of players in the periphery (Boutcher, 2008) and can thus be detrimental to sport performance. A penalty kick in soccer is another example of a sport skill where arousal can influence performance (Wilson, Wood, & Vine, 2009). During a penalty kick in soccer, the penalty-taker has a free kick only 11 meters from the goal with only the goalkeeper standing in his way of scoring (Van der Kamp, 2011). In this highly controlled situation, a remarkably high percentage (i.e., 20-25%) of penalty kicks are unsuccessful (Jordet, Hartman, Visscher, & Lemmink, 2007). The skill of the penalty taker has been assumed an important factor for the outcome of a penalty kick (McGarry & Franks, 2000). However more recent studies report that psychological factors (i.e., anxiety) are in fact the most influential components for the outcome of penalty kicks (Jordet, 2009; Jordet, Elferink-Gemser, Lemmink, Visscher, & Button, 2006; Jordet et al., 2007). It is also important to add that increased arousal can be beneficial to athletic performance up to a certain point, where further increase will lead to a rapid decrease in performance (Janelle, 2002). Many theories have been proposed on the relationship between arousal and performance, but most sport psychologist would agree that arousal can have both positive effects (e.g., prepare the athlete for action) and negative effects (e.g., narrow attentional field) on performance, depending on the individual (Weinberg & Gould, 2015).

Divided attention (or attention as a limited capacity) refers to the fact that only a limited amount of information can be processed at any given moment (Boutcher, 2008). Humans have some serious limitations when it comes to the ability to perform two or more tasks at the same time (Abernethy, 2001). Athletes repeatedly encounter situations during competition where the performance of two concurrent tasks is required (Huang & Mercer, 2001), so being able to perform two or more tasks simultaneously is an important factor of expert performance in sports. However, relatively few researchers have explored the performance of two concurrent skills in the sport setting (Abernethy, 1993). According to Abernethy (2001), when performing two or more concurrent tasks, a person can expect some selective decrements in the performance of either one of the tasks or general decrements in both of the tasks. For example, Parker (1981) made one of the first attempts to study performance of two concurrent skills in the sport setting. In this study, netball players of different skill levels (A, B, and C) were required to complete as many passes to a designated target and return as many passes as possible in 30 seconds (primary task). The netball players were concurrently required to monitor the illumination of lights located in the periphery (secondary task). Results revealed no significant differences between the players in the number of passes and catches made in the primary task. When the players were required to perform the primary and secondary tasks simultaneously, some decrements in performance were apparent for all players. However, the more highly skilled (A) players made fewer detection errors than the lesser-skilled (B and C) players. This indicates that the highly skilled players need less attentional capacity to perform the primary task compared to the lesser-skilled players and can therefore pay more attention to the secondary task. Similar results have been found in soccer as well. In Smith and Chamberlins (1992) soccer players of different skill level were required to perform two concurrent tasks. The primary task involved sprinting through a 15.25m slalom course and the secondary task involved dribbling a soccer ball and identifying geometric shapes projected on a screen located at the end of the slalom course. Results revealed that the when the players performed the primary task in conjunction with the secondary task, decrements in performance were apparent. However, decrements decreased as the skill level of the players increased. Also central to the discussion of attention as a limited capacity is automaticity. Findings suggest that motor task performance becomes more automatic with extensive practice and increased experience (Huang & Mercer, 2001) and thus demands less attentional capacity. Novices, for example, devote so much attentional capacity to skill execution (e.g., dribbling) that they may not afford the attentional resources necessary to perform another secondary task (e.g., monitoring movement around them) simultaneously. Experts, however, are able to perform these skills without using up as much attentional capacity and can, therefore, focus on other aspects of the situation (Beilock & Carr, 2001).

Selective attention refers to the process where certain information, out of all the available, is selected for detailed processing while other information is screened out or ignored (Abernethy, 2001; Boutcher, 2008). The amount of information that an individual gets exposed to every second is colossal and the conscious mind is very limited when it comes to processing all of this information (Wolfe et al., 2015). Probably the best-known real life example of selective attention is listening to a single voice in a room full of people talking at the same time (Pashler, H. E., 1999). Similarly, a soccer defender who deliberately selects to attend to the movements of the opponent he is supposed to mark while there are players moving everywhere around him. In sports there can be numerous distractions or irrelevant information. The ability to identify the most relevant and information-rich areas, focus attention towards those areas and extract meaning from those areas effectively is crucial for successful performance in sports (Williams, Davids, & Williams, 1999). This allows athletes to select appropriate responses and also to use that information to predict events in the nearest future. For example, in Abernethy (1990), differences in advance cue utilization between expert and novice squash players were examined using video simulation. The participants' objective was to predict both the direction and force of the opponent's stroke. Results revealed that experts were superior in predicting the event outcome from the information available. Also, experts were capable of picking up information from the early part of the opponent's actions such as the opponent's arm action. This indicates that experts direct their attention towards information-rich areas and perhaps give this information different meaning than novices and are therefore better at predicting what will happen next based on early information from the preceding situation (Williams, Ward, & Smeeton, 2004).

Attention and concentration are sometimes used interchangeably although they are not the same. According to Moran (2004), concentration can be viewed as another dimension of attention. Concentration refers to the ability to focus on specific elements in the environment and also to switch focus between different elements in a rapidly changing environment. This definition can be broken down into four parts. Focus on relevant environmental cues, maintaining that attentional focus, being aware of the situation (being in the moment), and shifting attention when necessary (Weinberg & Gould, 2015). All these factors are a vital ingredient for a successful athletic performance. Even if only one of these factors is missing during a competitive situation it can mean the difference between success and failure. The first part, focus on relevant environmental cues, has been briefly discussed in regards to selective attention (see Wulf, 2013 for a review). Numerous studies have attempted to identify important advance cues in sports. For example, Abernethy and Russell (1987) examined visual search strategies of expert and novice badminton players in order to assess their use of advance cues. Results revealed that the arm, in addition to the racquet, of the opponent is an important source of information.

Maintaining attentional focus is another part of concentration and refers to the ability to maintain concentration on a specific stimuli or location over time (Schweizer, Zimmermann, & Koch, 2000) such as for the duration of a competitive game of soccer. This part can be extremely hard as so many athletes indicate when evaluating or explaining performance in sports, especially in sports where a competitive match can last up to hours, like in the case of tennis and golf (Weinberg & Gould, 2015). When people perform cognitively demanding tasks for a long time, many will experience mental fatigue which can result in a deteriorated task performance and reduced motivation to continue to work on the task at hand (Faber, Maurits, & Lorist, 2012). In Faber et al. (2012) reaction times and response accuracies were obtained from participants performing an adapted Eriksen flanker task. Results reported that participants' abilities to suppress irrelevant information decreased as the result of mental fatigue. Similarly, physical fatigue can impede athlete's efforts to concentrate on the task at hand (Moran, 2008).

Situational awareness has been recognized across many different domains as being critical to effective decision-making and performance (Endsley, 2015). Endsley (1988; see Di Tore, 2015, p. 501) defined situation awareness as "the perception of elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future". If we transfer this definition into the sport settings and take soccer for example, these elements can be the movement of the players on the pitch (teammates and opponents), the speed and direction (flight) of the ball and so on. It can also be something the player brings to the situation, like his knowledge, experience, and/or the coaches instructions prior to the game or practice (Weinberg & Gould, 2015). Knowing when and where to look is crucial to successful sport performance (Mann, Williams, Ward, & Janelle, 2007) along with other knowledge-based factors that can explain differences between expert and novice athletic performance (Moran, 1996, 2004). Research by Fran Allard and colleagues (Allard & Starkes, 1980; Allard, Graham & Paarsalu, 1980) showed that experts and novices used different visual search strategies during competitive situations. Expert and novice basketball and volleyball players were recorded using eye mark recorders. Researchers found that experts use very different search strategies than novices. First, experts looked at spaces behind the defenders, then the position of the defenders and then at the position of their teammates. In contrast, novices appeared to go the other way round, indicating that this was perhaps the result of knowledge and past experience showing the experts the most information-rich areas.

Shifting attentional focus is also important in the context of sports. In sports like soccer or basketball, where things change rapidly, players' attentional focus must also change rapidly if they are to keep up with the pace of the game and perform well.

According to Nideffer (1976a; see DePalma & Nideffer, 1977) effective deployment of attention is an important variable in many different performance and decision-making situations. Nideffer and colleagues (1976b; see Boutcher, 2008) identified attentional focus along two dimensions: width (broad or narrow) and direction (internal or external). A broad-external focus allows athletes to focus attention on a relatively large area of the external environment, whereas a broad-internal focus allows athletes to focus attention inwards on different strategies and past experience (Boutcher, 2008). A narrow-external focus allows athletes to focus attention towards a solitary (narrow) element in the external environment (Bishop, n. d.). For example, a soccer player focused only on the ball as he prepares to shoot. Finally a narrow-internal focus involves focusing on a specific element of the intended action. For example, visualizing the perfect shot or perform some kind of a pre-shot routine which might involve relaxing and taking a deep breath (Weinberg & Gould, 2015). Being able to shift attentional focus between different attentional styles and adopt the right one as demanded by the situation is crucial for sport performance (Boutcher, 2008). For example, Wulf, Lauterbach and Toole (1999) examined whether external focus of attention would provide learning advantages for a sport skill under field-like conditions, compared to internal focus of attention. Novice golfers were either required to focus on the arm swing (internal focus) or on the club swing (external focus). Researchers found that an external focus of attention was more effective for performance, both during practice and retention.

Attention training

Expert performance in sports requires a combination of both motor and perceptual-cognitive skills (Broadbent, Causer, Williams, & Ford, 2015). Despite this fact, perceptual-cognitive training is often neglected. Coaches and players seem to recognize the importance of these cognitive factors but unfortunately they are rarely systematically trained (Murgia et al., 2014). The emphasis is usually on motor skills and training them repeatedly in order to improve performance. However, during a competitive setting much information processing has to occur prior to performing an action (Singer, 2002) and, thus, underlining the importance of perceptual-cognitive skills in sports. Numerous studies have attempted to determine whether or not these perceptual-cognitive skills can be improved with training, and if so, how. For example, an interesting study on the effects of imagery on attention revealed that attentional focus on a visual search task can in fact be improved using imagery or visualizing searching for a certain target object in a scene. Also, imagery was even more effective in training attention than actually practicing the task itself (Reinhart, McClenahan, & Woodman, 2015). In another study, effectiveness of an imagery training program in improving national softball players' selective attention was examined. In this study, the training intervention consisted of 28 sessions of practicing an audio-taped imagery program. Researchers found that the training program enhanced the ability to focus on task-relative stimuli and integrate external stimuli without them overloading or narrowing attention (Calmels, Berthoumieux, & d'Arripe-Longueville, 2004). Other, relatively simple techniques such as self-talk, simulation in practice, cue words, nonjudgmental thinking, routines, competition plans, and overlearning skills have all been found successful in enhancing concentration of athletes (Weinberg & Gould, 2015). These techniques help athletes focus their attention on task-relevant information and ignore any internal or external distractors that may hinder their performance.

Visual training

There are several sports vision training programs that are commercially available (see Revien & Gabor, 1981; Seiderman & Schneider, 1983; Revien, 1987; Australian Optometric Association, 1987). These programs are direct adaptations of visual training exercises commonly used by optometrists for the enhancement of vision in children, especially those with reading disabilities. According to these programs, sports performance itself will improve by enhancing certain aspects of vision that are important for athletes. However, there is no convincing evidence that support that these programs actually improve performance (Wood & Abernethy, 1997). Abernethy and Wood (2001) assessed the effectiveness of two generalized visual training programmes in enhancing visual and motor performance for racquet sports. Participants were divided into four groups. The first group used Revien and Gabor's (1981) vision training programme which included eye exercises for athletes. The second group used Revien's (1987) videotape-based training programme. Each visual training group completed four 20 min visual training sessions and one 20 min motor practice session each week for four weeks. The third and fourth group served as placebo and control groups for comparison. Visual function and sport-specific motor performance was measured before and after the training intervention (four weeks).

Results showed no evidence that these visual training programmes improved vision or sport-specific motor performance. Further, there is no evidence that these vision training programs benefit soccer-related skills (Cohn & Chaplik, 1991). Another example of a generalized visual training is a concentration grid exercise. The concentration grid contains two-digit numbers ranging from 00 to 99. The objective is to scan the grid and select as many sequential numbers as possible (i.e. 01, 02, 03) within a certain time limit. This exercise is intended to improve attentional focus and the ability to scan the environment for relevant cues (Weinberg & Gould, 2015), and because these abilities are important in sports it is therefore inferred that it also improves actual sports performance. However, as mentioned before, there is lack of research supporting that these programs actually improve performance (see Wood & Abernethy, 1997). Some research has reported correlations between the concentration grid exercise and enhanced performance (Williams, 1986). Ziegler (1994) used the concentration grid exercise in combination with other laboratory and applied exercises and found improvements in the execution of the experimental soccer drills after the intervention. However, because this study included a multistep attentional shift training program (i.e., video-based training, soccer drills, instructions), further research is needed to determine the precise effects of each of the components involved, including the concentration grid.

Early researchers studying perceptual-cognitive skills believed that experts had superior visual abilities compared to novices such as visual acuity, depth perception or broad peripheral vision (Starkes & Lindley, 1994). Although experts differ from novices on sport-specific measures of attention allocation and gathering of sport-related information, later work suggests that they do not differ in general visual abilities (Mann et al., 2007). According to Memmert, Simons, and Grimme (2009) the difference between experts and novices might be better explained by how differently experts process information they attend to, where factors such as knowledge and experience are influential. For example, Memmert (2006) found that basketball players were more likely to notice an unexpected gorilla in the visual scene when performing a basketball pass counting task (from Simons & Chabris, 1999), indicating that their expertise and familiarity with similar dynamic situations (catch and pass) allows expert basketball players to direct their attention towards other areas.

Anticipation

In team sports such as soccer, athletes must be able to often make decisions and anticipate future events under demanding constraints such as time. Anticipation refers to the ability to select the most important cues in order to determine an opponent's likely intention (Williams, Ward, Herron, & Smeeton, 2005) or in other words, being able to determine effectively what is going to happen before it actually happens (McMorris, 2004). Being able to perceive intentions based on someone's movements and hence anticipate the outcome of his actions is crucial for optimal performance in sports (Smeeton, Huys, & Jacobs, 2013). Research focused on identifying the perceptual-cognitive characteristics of experts have revealed that experts have the ability to pick up advance cues from the movement or posture of their opponents and are therefore better at predicting their intentions. On top of that, experts might also have more effective search strategies, because of their experience and knowledge, when it comes to analyzing the movement of the opponent that allows them to fixate on information-rich areas of the display, and while doing so saving time and effort by not fixating on irrelevant areas (Ryu, Kim, Abernethy, & Mann, 2013). For example, using the location of a ball toss in a tennis serve or the wrist angle of a bowling arm in cricket to predict the direction of the ball and respond accordingly and as quickly as possible (Müller & Abernethy, 2012).

Penalty kick anticipation

According to Kuhn (1988) around three-quarters of penalty takers use a so called keeper-dependent (or open loop) strategy which involves monitoring the movements of the goalkeeper until the last moment and, based on those observations, deciding where to shoot the ball. By anticipating the goalkeeper's intentions the penalty taker aims to shoot the ball in the direction to which the goalkeeper is not moving towards or, in other words, shoot the ball wherever the goalkeeper is not. This particular approach seems to be particularly useful when confronted with a goalkeeper who commits early to a certain direction (Morya, Ranvaud, & Pinheiro, 2003). According to Morya et al. (2003), penalty kickers who employ the keeper-dependent strategy only appear successful in redirecting their penalty kicks based on advance information from the goalkeeper's movements if the goalkeeper commits himself to a certain direction more than 400ms prior to foot-ball impact, whereas chance performance is apparent when the goalkeeper moves less than 150ms prior to foot-ball impact. More recently, a study conducted by Van der Kamp (2006) revealed almost twice as long critical time periods for redirecting penalty kicks using the keeper-dependent strategy. Indicating that this strategy might not be an efficient one but rather degrade penalty kick performance. However, these results also emphasize the importance for goalkeepers to wait longer until initiating their dive (at least for the three-quarters of players who employ this strategy).

Ball flight following a kick is the most accurate source of information regarding the direction of the ball. However, ball flight information in penalties becomes available so late in the process that using that as an advance cue for anticipating kick directions greatly reduces the odds of the goalkeeper saving penalties because it leaves hardly any time to dive in the direction the ball is heading. Because of this, differences in goalkeepers' penalty saving skills (anticipation) are usually found in how the goalkeepers pick up and utilize information that becomes available prior to ball flight (Navia, Van Der Kamp, & Ruiz, 2013).

Researchers have attempted to determine the important sources of information (available prior to foot-ball impact or ball flight) expert soccer goalkeepers use in penalty kick situations. The findings, however, reveal conflicting outcomes. Some evidence suggests that it is the movement of the hips, kicking leg and trunk of the opponent just prior to or during the moment of impact with the ball that is most important (Tyldesley, Bootsma, & Bomhoff, 1982; Williams and Burwitz, 1993; Savelsbergh, Williams, Van der Kamp, & Ward, 2002). Franks and Harvey (1997) attempted to identify what sources of information (available prior to foot-ball impact) goalkeepers can reliably use to increase their chances of saving penalty kicks. They concluded that the placement of the non-kicking leg was the earliest reliable advance cue for penalty kick direction, occuring around 200 – 250ms prior to foot-ball impact. This time interval correlates well with biomechanical studies that have reported the duration of the instep drive commonly used in penalty kicks (Grant, Reilly, Williams, & Borrie, 1998) to be around 250ms (see Lees & Nolan, 1998; Levanon & Dapena, 1998; Nunome, Asai, Ikegami, & Sakurai, 2002). According to Franks and Harvey (1997), focusing on the orientation of the non-kicking leg during his placement just prior to foot-ball impact appears reliable in 80% of penalty kicks (see Savelsbergh, van der Kamp, Williams, & Ward, 2005).

Graham-Smith, Lees, and Richardson (1999) found that it took goalkeepers 1.03 sec on average to reach the farthest parts of the goal (e.g., top left corner) and .61

sec to reach the closest parts (e.g., areas close to the goalkeeper) during a penalty kick. However, these durations are usually not short enough for the goalkeeper to intercept the ball (save the penalty). Researchers have found the average ball flight time to be between .344 sec (Morya, Bigatão, Lees, & Ranvaud, 2005) and .648 sec (Savelsbergh et al., 2002). Based on these movement and ball flight duration measures it would therefore be advantageous for goalkeepers to use these reliable advance cues because it gives them more time to respond without causing decrements in performance. If goalkeepers where to respond only at foot-ball impact or during early ball flight, they would most likely not be able to save the penalty kick.

As mentioned earlier, research evidence has revealed somewhat contradictory results on what advance cues from the opponent's kinematics are most reliable for goalkeepers when anticipating the direction of a penalty kick. In addition, there might be more than one kinematic indicator of the opponent's intentions. Is it possible to track multiple kinematic information at once?

According to Goldstein (2011) it is possible to pay attention to more than one thing at a time through divided attention. Laboratory tracking tasks have demonstrated that individuals have the ability to track four or more objects simultaneously (Cavanagh & Alvarez, 2005). Numerous researchers have shown that peripheral vision is useful in natural scene perception, both for recognition of features and scene gist (To, Gilchrist, Troscianko, & Tolhurst, 2011). Researchers have attempted to answer the question how different fields of view (i.e., central vs. peripheral) contribute to scene gist contribution. Results indicate that even though central vision has a higher visual resolution than peripheral vision, the latter is more useful for attaining maximal gist recognition. For example, Hüttermann, Memmert, Simons, & Bock (2013) examined the impact of different gaze strategies on performance on a visual task. In one condition expert and novice athletes were required to report the properties of a two separate stimuli (i.e., circle or triangle) that appeared equidistant from and on opposite sides of a fixation point located on the center of a projected screen. In the other condition (control), experts and novices were required to report the properties of a single stimulus that appeared at various distances from the fixation point. Results revealed that participants who fixated between the objects and, thus, attended to both in the periphery, were better at reporting their properties than participants who fixated on one object and attended to the other in the periphery. Whether this has any practical value (e.g., during actual competitive situation) is still to be determined. However, this indicates that if goalkeepers must attend to more than one advance cue (e.g., the movement of the hips and orientation of the non-kicking leg) during a penalty kick in soccer, they might benefit from fixating between them. It is important to add that central vision is of course extremely important for object recognition (Larson & Loschky, 2009).

Research paradigm

There has been some debate regarding how to carry out studies investigating which areas of the visual display provides the most information for predicting opponent's intentions and also, which method provides the most reliable results. Research on perceptual anticipation began with Jones and Miles (1978) when they used temporal occlusion to examine the ability of amateur tennis players and experienced coaches to predict which direction the opponent's serves would go (see McMorris, 2004).

Temporal occlusion involves presenting participants with video clips that have been selectively edited to stop at different times. Their objective is to anticipate the end result based only the information available (Williams, Davids, & Williams, 1999). For example, Jones and Miles (1978) showed players and coaches video clips of a tennis player's serve. The video clips were occluded (hence the name) at different time periods, either 42ms before racquet-ball contact, 126ms after contact, or 336ms after contact. The participants were then required to report their predictions by indicating were the ball would land on a diagrammatic representation of the tennis court. The limitation with this approach is that it does not reveal the nature of the anticipatory cues the subjects use to predict future events. It only provides the time of extraction of important visual cues (Williams, Davids, & Williams, 1999).

By combining temporal occlusion with spatial or event occlusion procedures, researchers are able to reveal the nature of the advance cues athletes use in the anticipation process (McMorris, 2004). Spatial occlusion is very similar to temporal occlusion except that certain sections of the display are hidden from view instead of the whole display. In a badminton anticipation study (Abernethy & Russell, 1987) using both temporal and spatial occlusion, expert and novice badminton players viewed video clips of a badminton player executing series of strokes into the receiver's court. The video clips were either edited to occlude at different times or certain body parts of the badminton player hidden from view (masked). The occlusion periods were: 4 frames (167ms) prior to racquet-shuttle contact, 2 frames (83ms) prior to racquet-shuttle contact, at contact, 2 frames (83ms) after racquet-shuttle contact, or the full shuttle flight was available (no occlusion). The body parts that were masked were the player's racquet and arm holding the racquet, only the racquet, face and head, lower body, and irrelevant background features. Experts were found to be able to pick up earlier advance cues than novices and this appeared to be related to their reliance on the arm along with the racquet of the opponent.

The argument behind this approach is that the accessibility of an advance cue and the time that cue becomes available influences the anticipation performance of the athlete (Williams, Davids, & Williams, 1999). In other words, if anticipation performance changes substantially depending on whether or not a certain advance cue is masked (hidden from view), that cue is likely to be important when anticipating the opponent's likely intentions (McMorris, 2004). However, the limitation with this approach is that it requires the researcher to determine what areas of the display are important and what areas are not. Most research on visual search behavior in sports have used the customary approach of comparing differences across skill levels in order to identify consistent skill-based differences in visual search strategies or anticipation.

Computer-based training

Although these occlusion methods mentioned above have their limitations they have established significant differences between experts and novices regarding sport-specific measures of perceptual skills in which experts have consistently demonstrated superior athletic performance over novices (Abernethy & Russell, 1987; Abernethy, 1990; Williams & Burwitz 1993, Abernethy, Gill, Parks, & Packer, 2001). Studies examining expert-novice differences have shown that experts recognize patterns from within their sport-specific domains more quickly and accurately than novices and they are also able to anticipate their opponents intended actions earlier based on limited amount of information and often under severe time constraints (Abernethy, Wood, & Parks, 1999). In other words, it is not only the physical abilities (e.g., speed, strength, technique) that separate expert performers from novices, but also perceptual-cognitive skills.

Most of the research focused on identifying consistent differences between experts and novices when it comes to the acquisition of advance information has been conducted within laboratories using computer simulation programs. However, despite the extensive amount of literature on expert-novice differences, there is relatively little known about how the perceptual skills that separate them are developed and even less known about whether these skills can be improved with training. Williams and Burtwitz (1993) used video simulations that recreated the goalkeepers' customary view of the action (i.e., penalty kick) and directed them to focus on the most informative cues. Their results indicated a significant improvement in the anticipatory performance for soccer penalty kicks. Several other researchers using video simulation tasks have found improvements in anticipatory skills in various sports such as tennis (Scott, Scott, & Howe, 1998), soccer (Savelsbergh, Van Gastel, & Van Kampen, 2010; Ryu et al., 2013), field hockey (Williams, Ward, & Chapman, 2003), softball (Gabbett, Rubinoff, Thorburn, & Farrow, 2007), cricket (Mann, Abernethy, & Farrow, 2010), and basketball (Starkes & Lindley, 1994).

McMorris and Hauxwell (1997) examined whether using a video simulation would improve the ability of novice goalkeepers to anticipate the direction of penalty kicks. Participants watched series of penalties at pre-test that were either occluded two frames before foot-ball contact, at contact, two frames after contact, and after the ball had reached the goal (full flight). Their objective was to indicate where the ball would cross the line. Participants were then arbitrarily divided into three groups of ten: a control group and two experimental groups. The first experimental group watched a video of 250 full flight (no occlusion) penalties, whereas the second experimental group watched a video of 500 full flight penalties. Both groups were given written instructions regarding important advance cues (i.e., angle of run up, and/or kicker's trunk). Results revealed that both experimental groups improved significantly at all occlusion periods except full flight. Observing 500 penalties did not produce significantly more learning than observing 250. In another study, Ryu et al. (2013) compared guided perceptual training to unguided training in improving response accuracy for anticipating the direction of soccer penalty kicks. In the guided condition the participants viewed video clips of penalties where critical kinematic information was highlighted. Color cueing was also used to highlight the visual search strategies used by expert goalkeepers. In the unguided condition the participants viewed video clips without supplementary guidance (mere exposure). They found that both the guided perceptual-training group and unguided perceptual-training group were more accurate than a control group that had no form of training, but the guided perceptual-training group was more accurate than the other two. These results indicate that it is more effective to view video clips with supplementary guidance than without it.

Studies have shown that novices can learn to use perceptual anticipation (McMorris, 2004). Identifying expert-novice differences and then being able to improve them with training, therefore, has practical value. If the perceptual skills that characterize experts were not possible to train (learn), the research focused on identifying these differences would have no practical value. One might argue that because expert performers were not born with their expert perceptual skills, extensive training and learning must have taken place, further supporting the notion that these skills can be trained.

Implicit vs. explicit learning

Computer-based training programs usually simulate the athlete's customary view of the action (e.g. defending a penalty kick; see Savelsbergh et al., 2002; Savelsbergh et al., 2005). Also, these programs usually include filmed sequences that are presented to the observer/learner and paired with instructions on where to focus their attention. Subsequently the observer must predict the opponents' intended action and lastly he receives feedback about the correct response. This form of training is presumed to promote perceptual skill learning by directing attentional focus towards important perceptual features and away from irrelevant features (Williams, Ward, Knowles, & Smeeton, 2002).

An important question regarding the instructions that are usually paired with the film sequences is whether participants need to be told explicitly what advance cues to direct their focus towards, or can the meaning of the information be learned equally well (or better) without these explicit (i.e., verbal) instructions (Farrow & Abernethy, 2002). According to Masters (1992), motor skills can be acquired implicitly.

Implicit motor learning involves acquiring a new skill without receiving any explicit (i.e. verbal) instructions on how to perform that particular skill (Maxwell, Masters, & Eves, 2000). In contrast, explicit learning involves acquiring a new skill through the use of such specific instructions (i.e., verbal).

Farrow and Abernethy (2002) examined whether or not anticipatory skills could be learned through implicit video-based perceptual learning. Junior tennis players were divided into four groups: an explicit learning group, implicit learning group, placebo group, and a control group. During training, the explicit and implicit learning groups watched identical video-based temporal occlusion footage of tennis serves. Athletes in the explicit learning group received explicit instructions about important advance cues (i.e., location of a ball toss and angle of the racquet head) that indicate service direction, whereas the athletes in the implicit learning group were not given any explicit instructions. Instead, they were supposed to estimate the speed of each occluded serve. Results revealed that the implicit training group significantly improved performance from pre-test to post-test whereas the explicit learning group did not.

Issues of transfer

Numerous studies using video simulation or other computer-based training programs have failed to stress the importance of external validity. That is, they neglect to measure whether improvements observed in a video simulation task (due to training) actually transfer to improvements in a real-world setting, such as physically defending a penalty kick during competition or training. If performance only improves in the video simulation task inside a laboratory, but not during actual real-life tasks, then these studies would have very limited applicability since the ultimate goal is obviously to improve the performance of athletes in a competitive (real-world) setting. A study conducted by Savelsbergh et al. (2010) is an example of a study where the focus is on measuring improvements inside the laboratory (in the computer) as opposed to measuring whether the computer-based training improves actual on-field performance. In this study, researchers attempted to teach 30 novices how to anticipate ball direction during penalty kicks. Participants began watching 30 video clips of penalties (pre-intervention test) and were required to indicate the direction of the ball by moving a joystick. After that, participants were divided into three groups: perceptual training group, training group and control group. The perceptual training group watched video clips of penalties where certain areas of the display were highlighted to guide attention. The training group also watched the video clips but without any highlighted areas. The control group did not receive any training. Results revealed that perceptual training led to an adjustment in search behavior and also that the perceptual training group was more successful than the other two in saving penalties in the computer. However, this study (and others like it) does mention that the next step would be to test how effective this training intervention is in improving actual on-field penalty saving performance of goalkeepers.

There has been some debate regarding how practical it is having athletes sit in front of a computer screen pressing a button, whereas in real life they are “on their toes” and ready for action and actually have to make a physical response (e.g. dive to the right or left) in order to defend the penalty kick. According to Starkes and Lindley (1994) a transfer will result to the extent that the simulator elicits the same cognitive processes required when performing the actual on-field task. An interesting study was conducted by Williams et al. (2003) where they used a novel method in training anticipation in field hockey. In their study, participants were required to wear all the necessary protective gear and instructed to respond to the video clips by moving as if to intercept the ball before it crossed the goal line. The results showed significant improvements in anticipatory performance of the participants who underwent perceptual training.

Study purpose

The purpose of this study was to address the issue of transfer. That is, do sport-specific (soccer) computer-based vision or anticipation training programs only improve performance on computer-based tasks or does improved performance on a video simulation task actually transfer to improved performance in a real-life task? An attempt will be made to measure the transfer from a computer-based task to an actual on-field task, an issue mostly overlooked by researchers. The task used in this study was a penalty kicking task were goalkeepers were required to both defend actual on-field penalty kicks and computer-based (video simulated) penalty kicks before and after a training intervention. As in Jones and Miles (1978) the temporal occlusion paradigm was also used in the present study. Also, given the intriguing findings of Farrow and Abernethy (2002) regarding the effects of implicit learning on improving the anticipatory skills of junior tennis players in predicting the direction of an opponent’s serve we decided to implement that method in the present study.

It was hypothesized that the sport-specific computer-based training program would improve anticipatory performance of goalkeepers in the computer-based penalty kicking task, resulting in more penalty kicks correctly anticipated by the goalkeepers. Also, it was hypothesized that the improved performance in the computer-based penalty kick task would transfer to improved performance in the actual on-field penalty kicks in the form of more penalties saved.

Method

Participants

Twelve Icelandic male soccer goalkeepers were recruited using convenience sampling. Two of the participants were playing in the premier division (the top division) in Iceland, four were playing in the first division (second best division) while the other six are currently playing at the youth level in Iceland. The mean age (M) for the participants was 18.8 (SD=2.6). The participants were matched into groups based on their performance on penalty kick anticipation tasks, both a computer-based task and an actual penalty kick task. The groups were then randomly assigned to either a placebo-control condition or a visual attention training condition. Informed consent from all the participants was obtained prior to commencing this study.

Apparatus

A digital video camera was used to record multiple penalty kicks. The computer used in the pre- and post-intervention tests was a MacBook Pro laptop with a 13.3-inch (1280 x 800) screen. The same computer was also used for the training intervention. A modified external keyboard was used in both the pre- and post-intervention tests and also the training intervention. The programs used to run the video clips in the computer and present them to the participants were Matlab and Psychtoolbox. The program used to process the data was the Statistical Package for the Social Science (SPSS, version 21). A 10 by 10 concentration grid was also used in the training intervention.

Procedure

Pre-intervention tests

Prior to the pre-intervention computer test (described later), the participants were required to physically defend a total of 60 penalty kicks in a real life situation. The goalkeepers (participants) were required to wear all the appropriate protective gear associated with their role (i.e. shin guards and gloves) to try to best simulate their competitive environment. The penalty kickers were usually two to three outfield players that played for the same club as the participants, and thus of the same ability level as the goalkeepers. The penalty kickers were instructed to shoot the ball at five predetermined targets just as they would in a normal competitive setting and were required to do so successfully in order for the penalty kick to count. The penalty kicks were equally distributed between the five targets in a random order. The goalkeepers were simply instructed to try to save as many penalty kicks as possible. The researcher logged every successful penalty kick and the number of times the goalkeeper was successful in defending them versus not successful in defending them. Data regarding whether or not the goalkeeper made a save, went in the correct direction, and height was also collected. Note that if the penalty taker was unable to hit one of the five targets (e.g., over the crossbar or past the goal) that penalty kick was excluded from the data. This process was then repeated for every single participant and data collected. The field test usually took place at the end of the participants' normal training session at their usual training facilities (on an actual soccer field).

Computer-based measures

In the pre-intervention computer-based test, five male soccer players in the Icelandic U19 national team (18-19 years of age) were recorded taking series of penalty kicks. The video clips were recorded from the goalkeepers' customary perspective (i.e., the middle of the goal) using a digital video camera. The camera was positioned at 177 cm from the ground (as in Savelsbergh et al., 2002) using a tripod to best simulate the goalkeepers' customary perspective since they tend to slightly bend their knees when preparing to defend a penalty kick. Five targets were marked on the goal (bottom-left corner, top-left corner, bottom-right corner, top-right corner, and the center of the goal) and were positioned about 0.5 m from the posts. The players were instructed to shoot the ball at a specific target each time. Each player was required to successfully shoot the ball five times at all of the predetermined targets. Video clips of unsuccessful shots were deleted. The video clips were then selectively edited to either occlude at the moment where the foot of the penalty kicker made contact with the ball, or when the penalty kicker placed his non-kicking leg next to the ball.

In total there were 125 useful penalty kicks recorded on film (25 clips for each target). These video clips were then randomly placed into multiple sequences, distributed evenly across all five targets, and used in the anticipation test in order to evaluate their baseline performances.

The participants' objective was to anticipate as many penalty kicks as they could with only limited amount of information available indicating the direction of the penalty kick by pressing one of five keys on a computer keyboard. The keyboard was modified, leaving only five keys available for pressing. On top of that the five keys resembled the layout of the five targets of the goal (bottom-left corner, top-left corner and so forth) in order to make the pressing easier for the participants and to prevent them from accidentally pressing other irrelevant keys on the keyboard. The participants were instructed to respond as quickly and as accurately as possible to the penalty kicks.

First participants viewed ten penalty kicks that were occluded at foot-ball impact and were given the same instructions to respond as quickly and accurately as possible. These videos were used as a training round and had the sole purpose of familiarizing them with the modified keyboard and making them more comfortable with the whole setup. Next participants viewed 30 video clips that were also occluded at foot-ball impact and were given the same instructions to respond as quickly and accurately as possible but ultimately just try to anticipate as many penalty kicks as possible. After viewing 30 penalty kicks that were occluded at foot-ball impact, the participants then viewed another 30 video clips. The latter 30 were occluded earlier, more specifically at the moment when the penalty taker places his non-kicking leg next to the ball as he prepares to shoot the ball towards the goal.

Also, in the computer-based pre-intervention test there was a time limit for how long the participants had to respond to each penalty kick. The time limit was set at 0.2 seconds after foot-ball impact. If the participants took longer than that to respond, instructions would appear on the screen informing the participants that an earlier response was necessary in order to successfully save the penalty kick, otherwise the ball would have already reached the goal. However, if the participants responded earlier than foot-ball impact, the video clip would still continue to the point of occlusion (foot-ball impact). Note that the time limit was also present in the ten penalty kicks the participants viewed in the training round.

Training intervention

For the training intervention a new sequence of penalty kicks were recorded. Five different male soccer players of the same age and comparable skill level as the ones in the pre- and post-intervention tests were recorded taking series of penalty kicks. The penalty takers received exactly the same instructions as the ones mentioned earlier and were also required to successfully shoot the ball five times at each of the five targets located in the goal. The use of different penalty takers was conducted to prevent the participants from becoming familiar with the previously viewed penalty kicks or perhaps detecting some kinematic pattern associated with each player.

The training intervention included ten sessions (approximately 15 minutes each) in ten consecutive days. The training intervention for the experimental group involved three conditions. The first one was identical to the one in the pre- and post-intervention tests where the participants watched a video clip sequence of 20 penalty kicks (in each training session) that were occluded at the moment of foot – ball impact. The participants were instructed to respond as quickly and accurately as possible but ultimately try to anticipate the penalty kicks.

The second condition also involved participants watching series of penalty kicks (20 each training session) that were occluded at the moment of impact, but in this condition implicit instructions or guidance were provided (see Farrow & Abernethy, 2002). The supplementary guidance involved a static red circle located next to the ball in which the opponent's non-kicking leg would eventually go into (see Franks & Harvey, 1997; Savelsbergh, 2005). The red circle was either located to the left or right side of the ball depending on whether the penalty taker was left- or right-footed. The red circle implicitly indicated where the participants should focus their attention and which areas of the display provide them with the richest information in order to increase their likelihood of defending penalty kicks.

The third condition included 20 video clips that were occluded earlier, that is when the penalty taker placed his non-kicking leg next to the ball in order to force the goalkeepers to respond earlier. In all three conditions of the training intervention the participants also received feedback regarding whether or not they were successful in anticipating the penalty kicks. If the participants were unsuccessful in anticipating the penalty kicks, a feedback regarding the correct response was provided. The feedback informed the participants of whether they anticipated the correct direction but wrong height, or simply anticipated the wrong direction.

In total the participants viewed 600 video clips of penalty kicks over the course of the training intervention.

The placebo-control group also went through a vision training program, but of a different kind. Participants in the placebo-control group received training in a response time task. In the response time task, a red square on a black background appeared on the computer screen and the participants were supposed to press one out of five keys on a keyboard corresponding to the squares location. As soon as the participants pressed a key indicating the squares location, the square immediately disappeared and reappeared at another location and the process repeats itself 25 times. The locations of the square were the same as the five targets on the goal (bottom-left corner, top-left corner, etc.). Note that the square moved to another location (of the possible five) in a random order to prevent the participant from detecting some kind of pattern in the squares movements. In the training intervention the participants in the placebo-control group went through this program three times each training session. The placebo-control group was also required to solve a concentration grid exercise. The concentration grid contains two-digit numbers ranging from 00 to 99. Their objective was to scan the grid and select as many sequential numbers as possible (i.e., 01, 02, 03) within 60 seconds. The placebo-control group repeated this exercise (the concentration grid) three times each training session (as in Ziegler, 1994).

Post-intervention tests

After the ten sessions of the training intervention were completed, the baseline measures described earlier were repeated.

Results

Data from the pre- and post-intervention tests regarding numbers of saved (correctly anticipated) penalty kicks and correct directions was collected for all 12 participants in both the computer-based and actual on-field tasks.

Computer-based results for the anticipatory performance can be found in table 1. As table 1 demonstrates, the participants in the experimental group appeared to perform better at post-test than the participants in the control group. On closer inspection, participants in the experimental group appeared to improve their performance (i.e., save more penalties) from pre-test to post-test in the computer-based task. In contrast, the participants in the control group appeared to decrease their performance (i.e., save fewer penalties) from pre-test to post-test. Also, participants in the experimental group appeared to perform better at post-test in anticipating the correct direction of the penalty kicks (PostDirectionComputer) compared to participants in the control group who appeared to decrease their accuracy in predicting the correct direction of the penalty kicks.

Table 1. Descriptive statistics (in percentages) for the two groups' pre- and post-intervention performance on the computer-based tasks

Group		PreSaved Computer	PostSaved Computer	PreDirection Computer	PostDirection Computer
Experimental group	Mean	21,11	23,61	40,28	46,11
	Std. Deviation	7,43	7,56	6,53	8,08
Control group	Mean	21,67	19,72	43,06	38,33
	Std. Deviation	3,65	6,62	3,23	2,36

A 2 X 2 (group by time) repeated measures ANOVA was carried out to analyze the computer-based results for saved penalty kicks. There was neither a significant difference for time, $F(1, 10) = .018$, $p = .895$, nor was there a significant difference between the groups, $F(1, 10) = .281$, $p = .608$. Also, there was no significant interaction between time and group, $F(1, 10) = 1.170$, $p = .305$.

A 2 X 2 (group by time) repeated measures of ANOVA was also carried out to analyze the computer-based results for correct direction anticipation. There was neither a significant difference for time, $F(1, 10) = .069$, $p = .798$ nor was there a significant difference between the groups, $F(1, 10) = 1.064$, $p = .327$. However, as demonstrated in figure 1, results revealed a significant interaction between time and group, F(1, 10) = 6.256, p = .031.

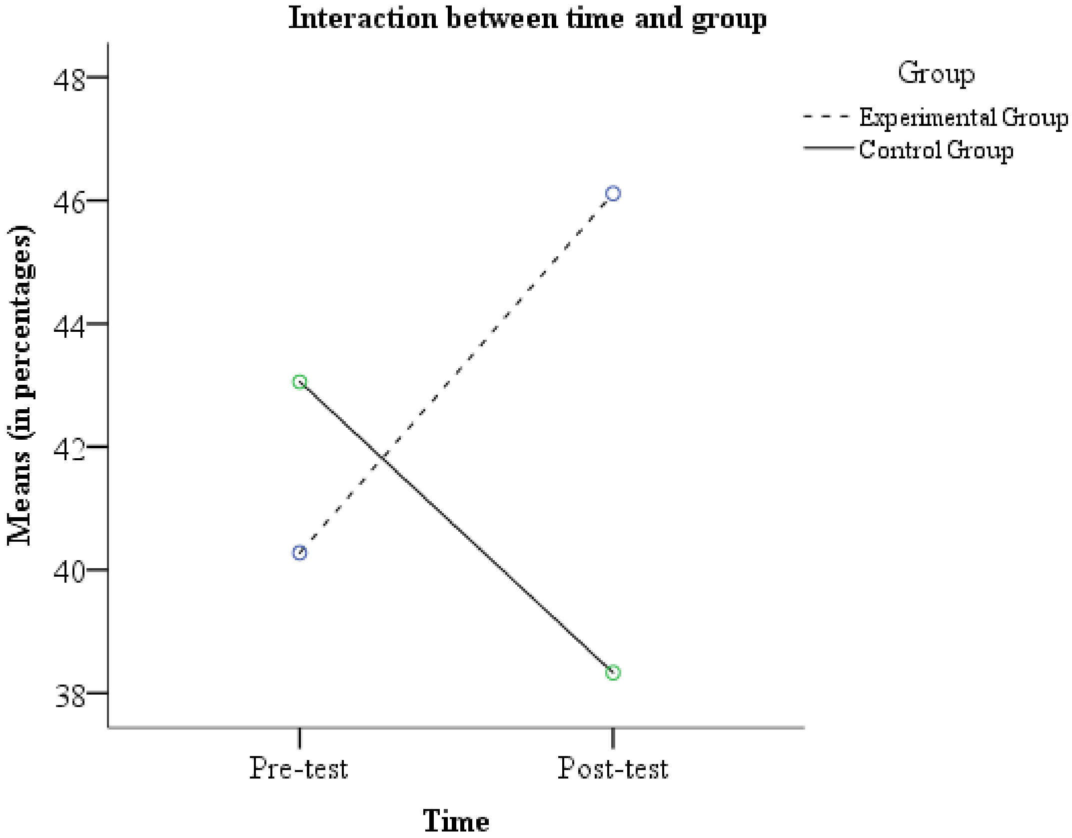

Figure 1 . Interaction (in percentages) between time and group in the computer-based task when anticipating the correct direction

On-field results for the anticipatory performance can be found in table 2 which includes the descriptive statistics for the actual on-field penalty kicks. Both before and after the training intervention, the participants in the control group appeared to save the most on-field penalties. However, the experimental group appeared to predict the correct direction of the on-field penalties more often than the control group both before and after the training intervention.

Table 2. Descriptive statistics (in percentages) for the two groups' pre- and post-intervention performance in the actual on-field penalty kicks

Group		PreSaved ActualPK	PostSaved ActualPK	PreDirection ActualPK	PostDirection ActualPK
Experimental group	Mean	17,22	21,39	53,33	54,44
	Std. Deviation	5,34	3,71	5,37	8,54
Control group	Mean	19,72	25,56	45,56	49,72
	Std. Deviation	4,64	7,12	5,93	6,36

Another 2 X 2 (group by time) repeated measures ANOVA was carried out to analyze the actual on-field results for saved penalty kicks. In the actual on-field penalty kick performance, there was a significant difference for time, F(1, 10) = 13.333, *p* = 0.004. However, there were no significant differences between groups, F(1, 10) = 1.447, *p* = .257 nor was there a significant interaction between time and group, F(1, 10) = .370, *p* = .556. In figure 2, the main effects of time on actual on-field performance can be found.

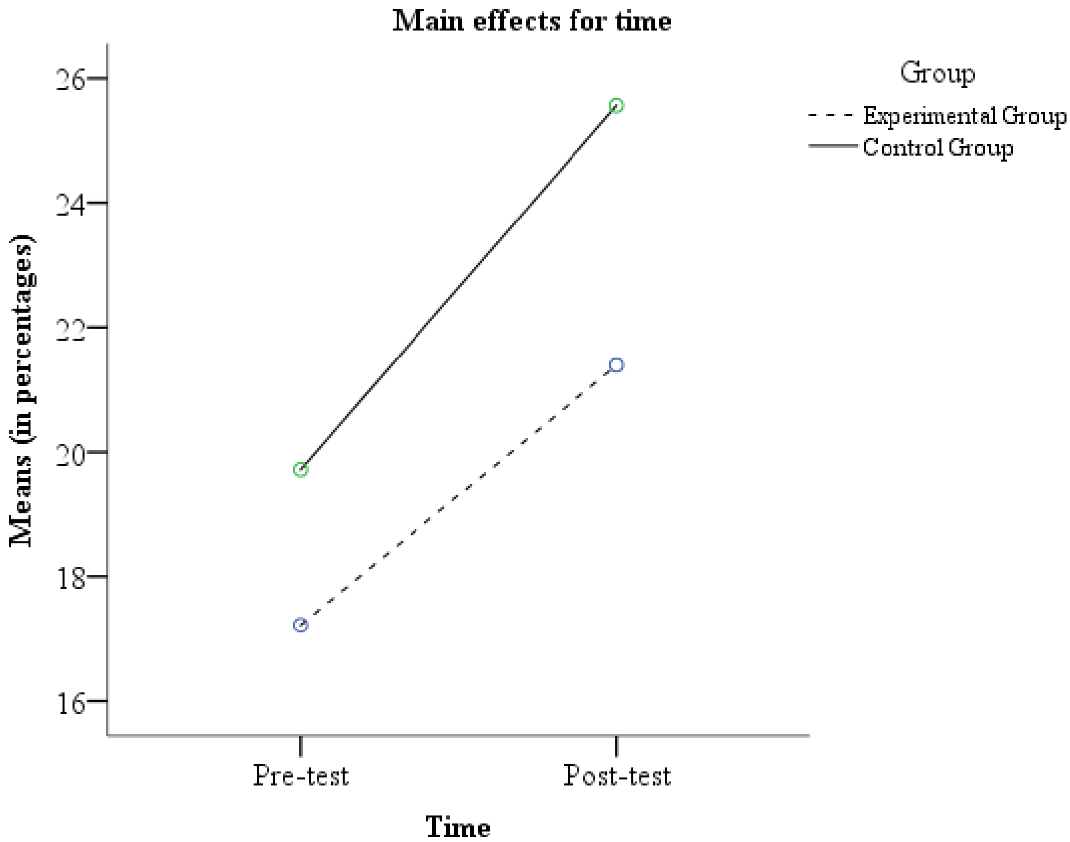

Figure 2. Main effect (in percentages) of time for the two groups' pre- and post-intervention performance (saving penalty kicks) in the actual on-field penalty task

As apparent in figure 2, the experimental group increased the mean from pre-test to post-test by more than 4% and similarly the control group increased the mean by almost 6%.

A fourth and final 2 X 2 (group by time) repeated measures ANOVA was carried out to analyze the actual on-field results for correct direction anticipation. There was neither a significant difference for time, F(1, 10) = .926, *p* =.359, nor was there a significant interaction between time and group, F(1,10) = .310, *p* = .590. However, there was a significant difference between groups, F(1, 10) = 5.371, *p* = .043, in favor of the control group.

Discussion

In this study, an attempt was made to evaluate if improvements observed in a sport-specific computer-based anticipatory task actually transfer into improved performance in a real-life competitive situation. The issue of transfer is an important one, but relatively few studies have addressed this matter and even fewer (if any) in relation to soccer or soccer goalkeeping. Unlike previous studies on the development of anticipatory skills, this study only included experienced goalkeepers of comparable skill level, whereas expert-novice comparison has been the most common approach thus far (see Savelsbergh et al., 2005).

Computer-based performance

We predicted that for the experimental group, the computer-based anticipation training program would produce significant improvements in both anticipating penalty kicks correctly (i.e., save more penalties) and anticipating the direction of the penalty kicks (i.e., dive more often in the correct direction) in the computer-based task, whereas no such improvements would be apparent for the placebo-control group.

The results of this experiment provide some support that anticipatory skills can be enhanced with practice using video simulation (see Abernethy, Wood & Parks, 1999; see also Lidor, Ziv, & Gershon, 2012 for a review). After 10 sessions of the vision training program (training intervention) no significant improvements in saving penalty kicks were apparent for the experimental group from pre-test to post-test. On closer inspection, results revealed that participants in the experimental group did not save significantly more penalty kicks (anticipating the correct direction and height) during post-test compared to the placebo-control group. However, the results did reveal a significant interaction between time and group for anticipating the correct direction of penalty kicks (correct direction but incorrect height). Participants in the experimental group improved significantly in predicting the correct direction of the penalty kicks following the training intervention. This is an important finding because in order to successfully save a penalty kick, a goalkeeper must dive to the correct direction. In fact, previous research (McMorris et al., 1993) has found that it is somewhat easier to predict the horizontal (post to post) direction of the ball than the vertical (ground to crossbar). Indicating that most errors are associated with incorrect height predictions. According to Müller and Abernethy (2012) there is generally sufficient time in striking sports (i.e., tennis, baseball) to make minor adjustments in racquet or bat movement during ball flight, but not to select a different swing pattern (e.g., switch from forehand to backhand). Similarly, if a goalkeeper anticipates the correct direction (but incorrect height) of a penalty kick and dives accordingly he might be able to make some minor adjustments during ball flight, such as stretching his arm or leg upwards or downwards depending on the height of the penalty kick, but he will not be able to switch to a different direction (i.e., from left to right or vice versa).

It is interesting to note that the difference between the experimental group and the placebo-control group in the computer-based post-intervention test was both due to improved prediction accuracy for the experimental group and a decline in prediction accuracy for the placebo-control group. Following the training intervention the experimental group improved his direction prediction accuracy by almost 6%, whereas the placebo-control group decreased his direction prediction accuracy by almost 5%. We predict that the superior anticipatory performance of the experimental group is most likely due to a genuine improvement in performance (see Ryu et al., 2013; Savelsbergh et al., 2010). However, it is possible that the improved anticipatory performance of participants in the experimental group was a reflection of a change in response time.

The participants in the experimental group might have identified the implicit advance cue (the orientation of the non-kicking leg), highlighted with the red circle, and used it to their advantage to better anticipate the direction of the penalty kick and hence save more penalties. However, it is also possible that the improvements might be explained with changes in response time, familiarity, or experience. McMorris and Hauxwell (1997) hold that because experience is thought to aid anticipation, then observing countless videos of penalty kicks from the goalkeepers' perspective would provide more experience and thus result in an improved anticipatory performance. In other words, the mere exposure to numerous penalty kicks on a computer screen might improve performance. This might further explain why the experimental group, who watched 600 penalties (plus the 60 in the pre-intervention test) in the training intervention, improved anticipatory performance in the post-intervention computer-based test as opposed to the placebo-control group, who only watched the 60 penalty kicks in the pre-intervention test.

More recent research holds that repetitive encounters with an on-field event (e.g., penalty kicks) can provide athletes with situational information which enables them to be more accurate when anticipating the direction of a ball than exclusively using certain advance cues or body information (Crognier & Féry, 2005; Gray, 2002; McRobert, Ward, Eccles & Williams, 2011). Furthermore, Ryu et al., (2013) found that guided perceptual training was even more effective in improving direction accuracy for anticipating the direction of soccer penalty kicks. This might further explain why participants in the experimental group, who received supplementary (implicit) guidance, significantly improved their performance in anticipating the correct direction of penalty kicks in the post-intervention computer-based test compared to the control group.

On-field performance

There is a pressing concern within the literature of anticipation and that is the lack of clarity on the applicability of data from a video-based simulation task to actual on-field performance where perception and action combine to influence performance (Dicks, Button, & Davids, 2010). Majority of research on the anticipation of soccer goalkeepers has either focused on identifying important advance cues (kinematic information) expert goalkeepers utilize when predicting the opponent's likely intentions, or whether or not anticipation as a skill can be learned (often by novices) (see Navia, Van Der Kamp, & Ruiz, 2013; Ryu et al., 2013). Transfer to actual on-field situations has mostly been overlooked.

Following the training intervention, some improvements in saving penalties on the field were apparent for participants in both groups. Therefore, the results of this experiment indicate that the degree to which the vision training program was successful in improving actual performance on a penalty kick task is very little, if any. Because, although the participants in the experimental group seemed to improve their on-field performances in the post-test compared to the pre-test, so did the control group, which did not receive any penalty-specific vision training. Also, there was neither a significant difference for time nor a significant interaction between time and group when analyzing the actual on-field results for correct direction (but incorrect height) anticipation. Indicating that the improvements observed in the computer-based direction anticipation (correct direction but incorrect height) post-intervention test did not transfer to improved direction anticipation in the actual on-field post-intervention test. However, there was a significant difference between groups in anticipating correct penalty kick direction (but incorrect height) during the actual on-field post-test, in favor of the control group. On closer inspection there appear to be differences between the groups in both the pre-intervention on-field test and the post-intervention on-field test where the control group scores higher on both occasions (see figure 2). Because there was no significant interaction between time and group, it is not possible to attribute the cause for the difference to the placebo intervention (i.e., response time task and the concentration grid exercise).

Limitations

These results question whether or not these perceptual training programs actually improve on-field performance. Of course when evaluating performance on the field compared to in a computer there are other factors that contribute to overall performance. On the field an athlete has to connect perception to action whereas sitting in front of a computer and pressing a key on a keyboard involves virtually no action. According to Navia et al. (2013) goalkeepers who are more agile and/or explosive have a certain advantage compared with goalkeepers who lack those qualities. Goalkeepers armed with those qualities are perhaps more capable of waiting longer before diving because they are able to reach the necessary position to intercept the ball in less time than their counterparts and therefore able to pick up important advance cues that do not present themselves until late in the penalty kick process (e.g., the placement of the non-kicking leg). This indicates that physical abilities contribute to saving penalty kicks and that there might be individual differences between members of either group regarding those particular abilities that contribute to overall performance.

Diving too early (perhaps guessing) will usually result in goalkeepers missing important advance cues that become available late in the penalty kick process and can reveal the opponents' likely intentions and, by doing so, decrease their probability of successfully saving penalties. As mentioned before, some penalty takers use a so called keeper-dependent strategy during a penalty kick (Kuhn, 1988). However, in this study the directions the penalty takers shot the ball towards were predetermined (both in the computer-based and the on-field task). This is also known as a keeper-independent strategy (see Kuhn, 1988) where the penalty taker decides in advance where to shoot the ball and ignores any movement the goalkeeper may or may not make. Using this method in this study is not without it's flaws. Firstly, the goalkeepers might benefit from guessing and ignoring important kinesthetic cues (i.e., the non-kicking leg), therefore, reinforcing that particular behavior. Secondly, this method prevents the penalty takers from using what might be their preferred strategy, and might, therefore, influence their penalty kicks. Also, it prohibits the penalty takers from changing direction the very last moment based on the movements of the goalkeepers. So even if the penalty takers observed the goalkeepers initiating their dive way too early to the corner they were supposed to shoot towards, they were not allowed to redirect their shot to the opposite corner (as they might do during real competition) of where the goalkeeper was moving. Another point is that goalkeepers can use strategies that can implicitly influence penalty takers (see Savelsbergh, Versloot, Masters, & van der Kamp, 2010). For example, goalkeepers can stand slightly off-center in the goal, which can influence the penalty taker to direct the penalty kicks more often to the side that has more space (Masters, Van der Kamp, & Jackson, 2007). Also, goalkeepers can appear smaller by keeping their arms down and, by doing so, more penalty kicks will be directed closer to their body (Van der Kamp, & Masters, 2008). In the present study, these strategies do not influence the penalty takers because of the predetermined targets.

However, this method ensures that there are no discrepancies between where the penalty takers intended to shoot the ball and were they actually shot the ball. As mentioned before, if the penalty takers were unsuccessful in shooting the ball at the predetermined target, that penalty kick was excluded from the data.

Earlier research has often neglected to mention the middle of the goal as a potential target for a penalty kick direction (see Ryu et al., 2013; Savelsbergh et al., 2002; Savelsbergh et al., 2005).

Perhaps it would be more effective to highlight a different area than the non-kicking leg, or perhaps highlight the non-kicking leg in combination with some other reported advance cues (see Tyldesley et al., 1982; Williams & Burwitz, 1993).

It is important to note that there is a fine line between diving too early and diving too late, and perfecting such a skill requires extensive amount of practice. Perhaps, having ten perceptual training sessions in ten consecutive days was not enough to produce a visible difference, indicating that maybe additional sessions were needed in order to observe a difference in on-field (motor) performance. Ryu et al. (2013) found that only seven days were enough to produce significant improvements in anticipating the direction of penalty kicks in a computer-based task. So there may be less than ten sessions needed to produce significant improvements in anticipatory skills in a computer-based task, but according to the results of the present study, there might be more than ten sessions required to produce significant improvements in the actual on-field penalty kicking task. Perhaps it would be better to distribute these 10 sessions over the course of several weeks including 2-3 sessions each week. Each of the three conditions in the training interventions consisted of 20 video clips of penalty kicks. Implicit guidance was only available in the second condition in order to prevent the participants from becoming too reliant on the guidance (see Ryu et al., 2013). Perhaps additional video clips including implicit guidance are necessary to improve on-field performance. Further research is needed.

Future directions

Perceptual-cognitive skills training could be a valuable method for training athletes on important sport-specific skills (i.e., anticipation) that are required for optimal performance (Broadbent et al., 2015). However, further research is needed on whether or not training these perceptual-cognitive skills via computer-based training programs using simulations that mimic the actual on field situation actually work to improve actual performance on the field. We propose that a future research should attempt to use explicit guidance during the training intervention. Also it would be ideal (but perhaps difficult) to divide experienced goalkeepers into five different groups where one group receives penalty-specific vision training, one that receives motor training (on-field), and another one that receives a combination of both penalty-specific vision training and motor training. The fourth group would receive a placebo intervention (generalized vision training) and finally the fifth group would not receive any training at all (control). Also, since imagery training programs have showed some promising results (see Reinhart et al., 2015; Calmels et al., 2004), it would also be interesting to examine whether using imagery training program would enhance anticipatory performance both on a computer-based penalty kick task and also on an actual on-field penalty kick task.

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