Chapter 1

1.1. General Introduction

The penalty kick in soccer often constitutes a moment that decides between winning or losing a game, between qualifying for the next round or elimination from competition, and thus between joy and tearfulness. That is, the biggest and most important soccer tournaments and competitions use penalty shoot-outs to determine a winner in the case that the match is drawn after regular playing plus extension time. As such, since 1970 when the penalty shoot-out was adopted by the International Football Association Board, approximately 20 percent of matches in the knock-out phase of the FIFA World Cup, including the World Cup finals in 1994 and 2006, and 30 percent of the knock-out matches in the UEFA European Championships were decided on penalty kicks. Add to this that the penalty kicks taken during normal play, which are awarded after a foul against an attacker inside the defending team’s penalty area, can also be decisive (e.g., during the World Cup final in 1990), and it is not surprising that not only players, coaches and sports media, but also scientists show a keen interest in penalty kicks. Accordingly, in recent years research on soccer penalty kicks has addressed areas as diverse as biomechanics, sport science, (applied) experimental psychology and economics (for recent overviews see, Kibele, 2013; Lees, Asai, Andersen, Nunome, & Sterzing, 2010; Lopes, Araujo, Peres, Davids, & Barreiros, 2008; Memmert, Hüttermann, Hagemann, Loffing, & Strauss, 2013; van der Kamp & Savelsbergh, 2014; Wood, Jordet, & Wilson, 2015).

Yet, researchers investigating the penalty kick are not merely interested in improving the penalty taker’s and goalkeeper’s performances on the pitch, but often also exploit the penalty kick to test scientific theories in a realistic but still relatively controlled performance environments (cf. Noël et al., 2014). That is, as a set piece the penalty kicking offers the
opportunity to test human behaviors in a standardized performance environment with limited degrees of freedom. For example, by analyzing anxiety-induced changes in the gaze patterns of penalty takers (Wilson, Wood, & Vine, 2009) researchers have been able to test if predictions of attentional control theory also hold in conditions that are more representative for real-life situations than the artificial laboratory tasks typically used in experimental psychology. Similarly, the penalty kick has been used to investigate how people behave in so-called zero-sum situations (e.g., Palacios-Huerta, 2003), the differential contributions of dorsal and ventral visual systems (Milner & Goodale, 1995, 2008) in virtual and real (penalty kick) environments (e.g., Dicks, Button, & Davids, 2010b), and the role of local and global informational invariants in action prediction or anticipation from biological motion (e.g., Diaz, Fajen, & Phillips, 2012).

The large majority of penalty kick studies focuses on perception and action factors, such as the anticipation of penalty taker’s kicks by goalkeepers (e.g., Savelsbergh, Williams, van der Kamp, & Ward, 2002), gaze behavior of penalty takers (Wilson et al., 2009), the mental factors in penalty kick performance (e.g., Jordet, Hartman, Visscher, & Lemmink, 2007), or tactical factors, such as evaluating strategies available for penalty takers (e.g., Kuhn, 1988). The present thesis predominantly deals with the latter, focusing on strategic aspects of a penalty taker’s performance, but in doing so also elaborates on perception, action and mental aspect of penalty kick performance. It does so by expanding (and combining) two separate strands of penalty kick research: the manner in which a penalty taker approaches a penalty kick strategically (i.e., penalty kick strategy, Kuhn, 1988) and the way a goalkeeper’s behavior (un)consciously affects a penalty taker’s decisions (i.e., the off-center effect, Masters, van der Kamp & Jackson, 2007).

First, the penalty kick strategy refers to how penalty takers approach the penalty kick. They have the option to either ignore the goalkeeper in deciding where to kick the ball (i.e., the keeper independent strategy) or to let kick direction be dependent on the goalkeeper’s
actions (i.e., keeper dependent strategy) (Kuhn, 1998, van der Kamp, 2006). That is, among professional soccer players there are penalty kick specialists that are presumed to prefer to use a keeper independent strategy and decide penalty kick direction beforehand, like the former English international Matt Le Tissier (nicknamed “Le God”), whereas others like Mario Balotelli and Thomas Müller routinely use a keeper dependent strategy and wait for the goalkeeper to dive left or right (see Van der Kamp & Savelsbergh, 2014). Yet, other than verbal reports in the media, there is currently no method (though Kuhn [1988] reasoned that strategies could be distinguished based on ball speed) for reliable establishing or verifying what strategy these and other penalty takers actually employ. As a result, it is unknown how often the goalkeeper independent or dependent strategies are adopted and which of two strategies leads to the highest success rate (which is obviously of high interest for players and coaches). Laboratory experiments have suggested that adopting a keeper independent strategy bears less risks (van der Kamp, 2006; for a more detailed description see below). However, this work failed to take crucial factors like anxiety into account, which unmistakably affect performance in competitive penalty kicking (Jordet et al., 2007). Therefore, Chapter 3 aims to develop a method that allows the identification of penalty kick strategies in competition in order to delineate their frequency and success rate. Furthermore, Chapter 2 addresses how differences in success rate between the two strategies, if any, can be explained. Specifically, it aims to assess whether employment of one or the other strategy increases resistance against the adverse effects of anxiety by examining to what degree the associated action and perception patterns, such as patterns of gaze, become less optimal in pressure situations.

Most studies and thinking on penalty kick strategies presume that penalty takers deliberately plan how they will carry out a penalty kick. In all probability, however, there will also be factors that unconsciously affect a penalty taker’s decisions and performance. Accordingly, the second strand of research addressed in the current thesis is how a goalkeeper’s behavior can influence the penalty taker’s performance without the latter being
aware of this. Specifically, it further scrutinizes the off-center effect, first demonstrated by Masters et al. (2007). The off-center effect is the phenomenon that a marginal displacement of the goalkeeper relative to the goal’s center, of which the penalty taker is not mindful, can affect a penalty taker’s selection of the goal side to which to kick the ball. However, although the off-center effect has been replicated in other laboratories (Weigelt & Memmert, 2012), these unconscious influences in penalty kicking have only been shown in laboratory experiments in which participants responded to pictures of stationary goalkeepers. Consequently, it remains to be unveiled if the off-center effect also emerges in more representative penalty kick situations where penalty taker and goalkeeper dynamically interact. Contrary to previous laboratory research on the off-center effect, there are other – explicit – influences on a penalty taker’s goal side selection that may or may not override the off-center effect. For instance, a kicker’s preference to kick to the left or right side (Navia, van der Kamp, & Ruiz, 2013) or knowledge regarding the preferred side of the goalkeeper (Misirlisoy & Haggard, 2014) may have a much stronger impact on goal side selection than the marginal displacement of the goalkeeper from the goal’s center which the kicker is unaware. Furthermore, it is important (both practically and theoretically) to further scrutinize if penalty takers can avoid the implicit influences on their behavior, for instance, by attending more closely to the goalkeeper’s position. This also relates to the penalty kick strategy that the penalty taker adopts; that is, with a keeper dependent strategy the penalty taker may become more mindful of the goalkeeper’s position on the goal line reducing the off-center effect, and if, in addition, the goalkeeper also commits to one side of the goal early any impact may be overridden. Finally, if the off-center effect is an instantiation of more general phenomenon of unconscious influences on decision-making, then it should be observable in other (sport) situations than soccer penalty kicks situations as well. All these issues will be addressed in Chapters 4 through 7.
In sum, the current thesis considers both practical and theoretical issues in two predominantly separate strands of penalty kick research. The first part addresses a penalty takers’ (conscious) strategies (i.e., Chapters 2, 3), while the second part (Chapter 5, 6, & 7) consider the unconscious influences associated with the off-center effect. These themes come together in Chapter 4, where the off-center effect is examined in a representative task design in which penalty takers are asked to use keeper dependent or independent strategies and a goalkeeper is asked to actively attempt to save the ball. However, before turning to this experimental work in the next Chapters, I will – in the remainder of this Chapter – first review the issues surrounding penalty kick strategies and the off-center effect in much more detail.

1.2. Penalty kick strategy

Penalty takers can typically use one of two (hybrid) strategies to approach a penalty kick (Kuhn, 1988; van der Kamp, 2006). They can either try to wait for the goalkeeper to commit to one side and/or anticipate the goalkeeper’s dive based on preparatory movements to then kick the ball to the opposite (empty) side of the goal (i.e., goalkeeper dependent strategy), or they can choose the side to which to kick to prior to the run-up or even the game and then stick to their plan regardless of what the goalkeeper does (i.e., keeper independent strategy). Both strategies are thought to have benefits and pitfalls but based on empirical studies, it is commonly assumed that use of keeper independent strategy is more effective and carries less risk than use of keeper dependent strategy (e.g., Van der Kamp, 2006). However, the main findings supporting this claim are that kickers tend to kick less accurately (i.e., more centrally) when adopting a keeper dependent strategy, and increasingly risk to kick to the same side as the goalkeeper moves, the longer the goalkeeper waits (which in fact is what better goalkeepers do, see Savelsbergh, van der Kamp, Williams, & Ward, 2005). That is, studies showed that penalty takers who use a keeper dependent strategy risk running out of
time for accurately modifying the direction of the kick if the goalkeeper initiates the final dive very late during the run-up, since it takes about 500 ms to adjust a movement in response to a (visual) event, in particular if the adjustment is made deliberately (Navarro, van der Kamp, Ranvaud, & Savelsbergh, 2013). For example, Morya, Ranvaud, & Pinheiro (2003) used a computer-based set-up in which participants watched schematic images of penalty kickers approaching the ball and the goalkeeper moving to either the left or right side at different times before the penalty taker contacts the ball. Participants had to move a joystick in the direction they would kick to. They were instructed to always choose the goal side that is undefended by the goalkeeper (i.e., to adopt a keeper dependent strategy) by moving the joystick before the penalty taker reached the ball. Participants were capable of doing this almost perfectly if they had at least 400 ms to choose a side (i.e., if the goalkeeper dived more than 400 ms before the kicker reached the ball). However, if they had less than 150 ms their performance dropped to chance level. That is, they chose the correct goal side in only 50% of these cases.

Van der Kamp (2006) confirmed these results in a more representative task that more closely resembled a real penalty-kicking task. Participants were asked to kick a penalty kick (including run-up) towards a goal but without a goalkeeper. Instead, the goalkeeper was replaced by two light bulbs that indicated toward which of two targets (one left and one right of the center) the kicker had to shoot (i.e., mimicking a diving goalkeeper). That is, if the left light was lit the goalkeeper was assumed to move to the left, resulting in the right side of the goal being undefended (and vice versa). Participants always had to kick to a target square in the undefended side of the goal. With 400 ms or less available to choose to kick to the undefended goal side intermediated skilled participants, who played at an amateur level, did perform at chance level. That is, with no more than 400 ms available they were incapable of adjusting kicking direction in response to the visual signal. In fact, they needed at least 750 ms to perform 100% successful. Furthermore, even if they had more than 400 ms available
kick accuracy suffered as was indicated by participants kicking further away from the center of the relevant target square compared to penalty kicks in which they had to choose before the run-up (i.e., goalkeeper independent strategy). Importantly, the pattern of results was the same as in Morya et al. (2003), with only the critical time interval being different. These differences between the results of Morya et al. (2003) and van der Kamp (2006) are probably due to the differences between tasks and participants’ level of expertise in the two experiments. Yet, considering that penalty takers usually need more than 200 ms to merely carry out the kicking movement, that is without the need to decide where to kick (Lees & Nolan, 1998), it seems reasonable to assume that penalty takers in real penalty kicking need at least around 500 ms to reliably respond to the goalkeepers’ actions and kick to the opposite side of the goalkeeper’s dive (see also Bowtell, King, & Pain, 2009). Taking into account, that the time needed to adjust a movement is likely to increase in pressure situations (Navarro et al., 2012), the 500 ms interval may actually be a conservative estimate, although professional soccer players may possibly need less time to carry out and/or adjust a kicking movement. A limitation of this work is that penalty takers may benefit from anticipation based on the goalkeepers preparatory movements (Sánchez, Sicilia, Guerrero, & Pugnaire, 2005), which is not available when the goalkeeper is replaced by light bulbs. Van der Kamp (2011), however, failed to show that penalty takers were actually able to anticipate, possibly because at the end of the run-up penalty takers attend to the ball (probably to guarantee a decent foot-ball contact, see also Vickers, 1996; Croft, Button & Dicks, 2010), rather than trying to extract information from the goalkeeper’s preparatory movements or dive (Graham-Smith, Lees, & Richardson, 1999). That is, even if they would need less time to adjust their kicking movements to a goalkeeper’s action, kickers may not be able to anticipate the goalkeeper’s dive when it is initiated very late in the run-up, because they are predominantly attending to the ball at that point in the run-up. And even if it would help them anticipating the goalkeeper’s action, adopting a gaze strategy that focuses on the goalkeeper is likely to have additional negative
influence on kick accuracy. That is, penalty takers must also focus on the target they are trying to hit to ensure kick accuracy (Wood & Wilson, 2010a, 2011). Supposedly, penalty takers making use of keeper dependent strategy have more difficulties to satisfy this constraint for optimal gaze behavior during the final phase of their run-up, when they also need to attend to the goalkeeper.

Yet, it is important to realize that these arguments are merely hypotheses: the (optimal) gaze patterns associated with the two penalty kick strategies have not been described in detail. Hence, to verify where penalty takers look at before and during the run-up, the study in Chapter 2 was set up to closely monitor the gaze patterns for both strategies. In addition, the study also aimed to analyze how these gaze patterns are affected by increased anxiety. In this regard, Wilson et al. (2009) reported that time that penalty takers look at the goalkeeper increases, while looking times for the target decrease, when they feel anxious. They explained this – following Attention Control Theory (Eysenck, Derakshan, Santos, & Calvo, 2007) – by presuming that the goalkeeper presents a threat when there is increased pressure to score. However, what remained unclear is the degree to which the goalkeeper can be considered a threat in both penalty kick strategies. For instance, in a keeper independent strategy, penalty takers may actually fear that they will miss the goal completely rather than the shot being saved by the goalkeeper. Hence, Chapter 2 not only aimed to describe gaze patterns in penalty takers employing either keeper independent or dependent strategy, but also to analyze how these gaze patterns change under pressure as a function of penalty kick strategy.

Charting the advantages and disadvantages in terms of perception and action of the keeper dependent and independent strategies in controlled experimental settings, even when carried out on the field as in Chapter 2, are at best indicative for their respective usefulness but do not and cannot provide the definitive answer with respect to the strategy that is most often and most successful used in competitive matches. High experimental control almost
always goes at the expense of external validity. Chapter 3 therefore aimed to develop a tool that allows for identifying the strategy that a penalty taker’s employs using post-match video recordings of penalty kicks. To this end, professional (U-19) players were required to take penalty kicks either using a keeper dependent or a keeper independent strategy. These kicks were judged on a series of factors, which were fed into a model to establish which (combination of) factors best predict penalty kick strategy. Subsequently, the model was used to identify the relative frequency of the strategies and their success rates for penalties taken during international competitions (FIFA World Cups and UEFA European Championships).

1.3. The off-center effect

Using a computer based set-up, Masters et al. (2007) presented participants with (schematic) pictures of a goalkeeper standing on the goal line either displaced to the left or right side of the true goal center. In two experiments they asked participants to choose the bigger side of the goal (either verbally or by kicking a ball toward it), and importantly, they were encouraged to simply guess if they felt unsure about which side was bigger. After their judgment, they provided a rating of how much confidence they had in their judgment. Masters et al. (2007) found that participants’ judgments for the bigger side were above chance level for differences (in area) between the two sides of the goal between 0.5 % and 3 %; yet confidence scores indicated that participants felt they were guessing. Masters et al. (2007) argued that penalty takers distinguish the side with more space, although they consciously perceive the goalkeeper to be standing in the exact center of the goal. That is, if participants show no increased confidence in their judgments compared to conditions in which both goal sides are of the exact same size, then they must have perceived the displacement of the goalkeeper (or the difference in goal areas) without being consciously aware of it. This is called the off-center effect.
Masters et al. (2007) also used a second method to demonstrate that participants can unconsciously perceive the goalkeeper’s displacement on the goal line. They required participants to only carry out a penalty kick, if they perceived the goalkeeper to stand right in the center of the goal. In this way, participants only decide for a side of the goal to direct the ball toward, if the areas of the goal’s sides were consciously perceived to be identical. Consequently, their choice to kick to the right or left would not be consciously influenced by deliberations of which side would be bigger. Furthermore, the experimenters took care that the size of the two goal sides to the left and right of the goalkeeper were never mentioned as a (potential) reason to kick to the left or right. Despite these differences in procedure and instructions, the off-center effect arose for goalkeeper displacements of comparable sizes as in the first two studies: for differences in area between 1.6 % to 3 % the participants choose the side with more space without conscious awareness that the sides differed in size (otherwise they would not have kicked the ball). Notice, that the procedure of these studies resembles – at least to a certain degree – the landmark discrimination task, an often-used neuropsychological test (Milner, Brechman, & Pagliarini, 1992). Participants have to identify which side of a pre-bisected stimulus (typically a horizontal line in the landmark task, but a goal divided in two halves by the goalkeeper in the studies of Masters et al., 2007) is bigger. I will return to this similarity below.

In a replication study, Weigelt, Memmert and Schack (2012) confirmed the basic findings of Masters et al. (2007) using more realistic pictures of a goalkeeper. The authors also aimed to examine the simultaneous influence of conscious and non-conscious processes on penalty takers’ perception and decision-making. Like in the study of Masters et al. (2007), participants were presented with pictures of goalkeepers that either stood in the middle of the goal, or marginally displaced to the left or right from the goal center. Participants performed two tasks: an action task, in which they were instructed to kick the ball to the side with a greater area, and a perception task, in which they were instructed to verbally indicate whether
or not the goalkeeper stood in the middle. For small differences in goal areas, participants in
the action task kicked the ball to the side with greater area, even though in the perception task
they indicated that the goalkeeper stood in the middle. Presumably, they acted above chance
although they were perceptually unaware of a difference in goal side.

Obviously, the off-center effect is intriguing both for practical and theoretical reasons.
However, the studies thus far have all been conducted under relatively artificial laboratory
conditions and with most of the participants being novices in soccer. That is, researchers
chose for high experimental control in an attempt to exclude any influence on goal side
selection other than unconsciously perceived difference in the size of the area of the two goal
sides. However, the drawback is that the research environments and participants were far
from being representative for penalty kicking in competitive situations. It therefore remains
unsure how far the findings can be generalized to real-life environments in which a manifold
of factors can systematically affect a penalty taker’s decisions and performance. These factors
may include knowledge about the immediately foregoing dives of the opponent goalkeeper (in
a shoot-out, see Misirlisoy & Haggard, 2014), or the goalkeeper’s long-term preference to
dive to one or the other side (Palacios-Huerta, 2003), but also the dynamic interactions
between the goalkeeper and penalty kick taker in the current run-up (including deceptive
movements). Clearly, these interactions are strongly influenced by the strategies that
goalkeepers and penalty takers adopt (see above). Masters et al. (2007) did show that the
goalkeeper’s position in the goal does affect a penalty taker’s goal side selection in
competition, but the analysis of video recordings from actual matches does not allow drawing
any conclusions about whether or not the penalty takers were aware or took explicitly into
account that the goalkeeper left more space to one side.

Accordingly, Chapter 4 aims to verify if the off-center effect also occurs in a
representative task design that more closely resembles true penalty kicking, that is, on the
pitch with a proactive goalkeeper that tries to save as many penalty kicks as possible. Penalty
takers were instructed to carry out real penalty kicks employing either a keeper independent or a keeper dependent strategy against goalkeepers who also used different goalkeeping strategies (diving early and late).

Obviously, the results of this study are of interest for goalkeepers and penalty takers (but likely also for athletes in other types of sports, see Chapter 7), because it helps them deciding whether or not to try to exploit the off-center effect in competition. However, also from a more theoretical point of view, it is of interest to examine to what degree outcomes of laboratory studies, involving high experimental control, can be replicated in a more representative environment but with lower levels of control over other potentially pertinent factors (Araújo, Davids, & Passos, 2007).

It was reasoned in previous studies – based on the observation that penalty takers can seemingly unconsciously perceive differences in goal sides or goalkeeper position more accurately than they perceive consciously\(^1\) – that the off-center may have its origin in the discrepancies between the accuracy of conscious and unconscious perception. Theoretically, the distinction between conscious and unconscious perception and decision-making is a complex (and tricky) issue and, arguably, one of the most fiercely debated issues in psychology and cognitive sciences (see e.g. Simons, Hannula, & Warren, & Day, 2007). However, to provide a stronger theoretical background for the off-center effect, I take the recent taxonomy of Dehaene, Changeaux, Naccache, Sackur, and Sergent (2006) as the starting point for clarifying the roles of conscious and unconscious perception in the off-center effect. The taxonomy distinguishes distinct modes of consciousness in perception on basis of the combined influence of two factors; i) the degree of top-down attention and ii) the (bottom-up) stimulus information strength or stimulus saliency (see Fig. 1).

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\(^1\) I will make use of the terms “conscious” and “unconscious” in the introduction and epilog (following Dehaene et al. (2006). The terms “explicit” and “implicit” in chapter 4-7 are used equivalently to the terms “conscious” and “unconscious”.

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Following this taxonomy, conscious perception (i.e., the perceiver is aware of what he or she perceives and can typically verbalize this or deliberately indicate it in another manner) only occurs when the stimulus information is attended to and when it is sufficiently strong or salient. For other combinations of top-down attention and stimulus strength, perception is unconscious (i.e., the perceiver is not aware of what he or she perceives and hence cannot deliberately report on what is perceived, yet perception can influence other behaviors including decision-making) or cannot affect behavior. Furthermore, unconscious perception is labeled as preconscious if a stimulus of sufficient strength is not attended to, while it is denoted subliminal in the case that the stimulus strength or saliency is insufficient.

Hence, only when the stimulus information is attended to and sufficiently strong, perception is conscious, that is, observers are aware and can report what they perceive. With
respect to the off-center paradigm, this indicates that attention to the goalkeeper’s position relative to goal’s center and/or the size of the space of the two goal sides determines whether any unconscious effect on goal side selection should be described as subliminal or preconscious, while stimulus strength additionally determines whether goalkeeper displacement or differences between goal sides can be perceived at all (see Fig.1, also notice that subliminal perception per definition concerns weaker or less salient stimuli than preconscious perception). To make sure, within the off-center paradigm stimulus strength can be considered as the magnitude of the goalkeeper’s displacement from the goal’s center or the differences in area of the two goal side: the larger the displacement or difference, the stronger or more salient the critical stimulus information. It follows from the taxonomy, the off-center effect can only occur for a certain range of combinations of a penalty taker’s allocation of attention to the goalkeeper’s position or goal side differences and certain displacements of the goalkeeper. Accordingly, scrutinizing the stability of the off-center effect under manipulation of the magnitude of goalkeeper displacements from the goal’s center and the penalty taker’s attention to this information is a central aspect of the second part of the current thesis. Such examination not only helps to further validate the Dehaene et al.’s (2006) taxonomy (2006) in more representative tasks than typical used in the cognitive sciences, but may also shed light on the interaction between conscious and unconscious perception.

Chapter 5 assesses the role of stimulus strength (i.e. the goalkeeper’s displacement from the goal’s center) in more detail by adopting the line bisection paradigm, a well-established method from experimental psychology and the cognitive sciences (e.g., Bultitude & Aimola Davies, 2006; McCourt & Olafson, 1997). It specifically analyzes the relation of unconscious and conscious perception in the off-center effect. The line bisection task is developed to assess conscious perception in patients with unilateral spatial neglect, who have problems with consciously perceiving the environment, objects and/or body parts contralateral to the side of brain injury (see Vallar, 1998). Patients (or participants) are asked
to bisect a series of horizontal lines exactly in the center of each line (e.g., marking it using a pencil). The typical observation that patients suffering from unilateral spatial neglect usually err towards the side of the brain lesion (in fact, most often to the right side), makes it a quick marker for identifying neglect (among other tests of course). However, research with healthy control participants has shown that they also systematically err on the line bisection task. This phenomenon is called ‘pseudoneglect’ (Bowers & Heilman, 1980), denoting that healthy humans tend to misbisect lines to the left side of the true center. Yet, the magnitude and direction has been shown to depend on many factors, like distance to the line, scan direction and handedness (for an overview see Jewell & McCourt, 2000).

With respect to the taxonomy of Dehaene and colleagues (2006), the line bisection task requires individuals to provide explicit judgments of the true center of a line. That is, observers intentionally attend to the stimulus of interest (i.e. the line’s center), suggesting that misbisection reflects inaccuracies of conscious perception. Hughes, Bates and Aimola Davies (2004, 2008), however, pointed out that the systematic misbisection might only occur when participants are directly asked to identify the midpoint of a line or an object, in their study a rod. However, when participants were asked to grasp the rod and keep it balanced between the fingertips, no systematic errors occurred. This is in line with the hypothesis that misbisection is a function of the degree to which attention for the midpoint is explicit (cf. Milner & Goodale, 1995, 2008). The off-center paradigm offers the opportunity to further test this hypothesis, but only after a few modifications in the procedures introduced by Masters et al. (2007). Hence, Chapter 5 reports a study in which penalty takers were first asked to place the goalkeeper in the exact center of the goal (as in the line-bisection tasks) and to subsequently carry out a penalty kick and score a goal. The initial positioning task potentially uncovers inaccuracies in conscious perception of the goalkeeper’s displacement from the goal’s center, whereas assessment of the proportion of kicks to the bigger goal side would reflect the (in)accuracies in the unconscious perception of the goalkeeper’s displacement.
That is, given that the penalty taker is first required (and thus attends to) positioning the goalkeeper in the exact center of the goal, any bias in the proportion of kicks toward the goal side with more space must reflect unconscious perception of the goalkeeper position. Put differently, the procedure used in Chapter 5 allows further examining of the claim that the off-center effect reflects a discrepancy between conscious and unconscious perception.

Chapter 6 aims to provide further evidence for the discrepancy in unconscious and conscious perception purportedly underlying the off-center effect in a different, but related version of the line-bisection paradigm, the landmark discrimination task (Milner et al., 1992). In fact, the landmark discrimination task is not unlike the variant of the off-center paradigm originally used by Masters et al. (2007, Experiment 3). In the landmark discrimination task participants indicate whether a pre-set mark bisects a horizontal line at its center or not (i.e., whether the two halves of the line are of equal length). This set up strongly resembles the penalty kick situation: a goalkeeper stands approximately in the middle of the goal, leaving two sides that are (un-)equal in size, which may or may not entice penalty takers to kick towards the bigger goal side. Like in the line bisection task, participants in the landmark tasks indicate that marks somewhat to the left of the true center of the line appear in the middle, i.e., the true center of a line is perceived to its left. Interestingly, this systematic bias in the conscious perception of the midpoint of the line is affected by the way in which the observer scans the horizontal line: the perception of the line’s center shifts away from the (end) point of the line from which the observer starts scanning (Varnava, McCarthy, & Beaumont, 2002). That is, if a line is scanned from left to the right, than the perceived center is shifted toward the right of true center (and vice versa). Yet, it is unknown whether unconscious perception is affected in similar way by scanning direction.

Hence, Chapter 6 not only tried to replicate the third experiment of Masters et al. (2007), but also tried to provide further support for the hypothesis that the off-center effect emerges from a discrepancy between conscious and unconscious perception. Thus,
participants were required to take penalty kicks, but only when they believed that the goalkeeper stood in the exact center of the goal, where they either started each trial by fixating the left or right goalpost or the middle of the goal. Doing so, allowed examining the effects of scan direction on the conscious perception of the goalkeeper position relative to the goal center as well as on the purportedly unconscious decision to which side to kick the ball. We expected initial fixation location to only affect conscious perception of the goalkeeper’s position (i.e., affect the decision to kick or not), but not the (unconscious) subsequent choice to which side to kick. If this turns out to be correct, than this would add further evidence that the off-center effect has its origin in the discrepancy between conscious and unconscious perception.

The taxonomy of Dehaene et al. (2006) does not only predict that stimulus saliency affects whether or not perception is conscious, but also that the degree of deliberate attention for the stimulus should be critical. Unconscious perception of stimuli that are attended is subliminal, but only for stimuli that are too weak to be accessed consciously (i.e., for small goalkeeper displacements). However, unconscious perception is preconscious if the stimulus is not deliberately attended to, but still being sufficiently strong or salient to be consciously noticed. That is, if a penalty taker attends to the goalkeeper’s position, than smaller displacement from the true center will be noticed consciously. That is, the range of displacements for which the off-center effect occurs is likely to be smaller when the penalty taker attends to the goalkeeper. Hence, differences in the degree of top-down attention may explain the differences in the reported range of displacements of the off-center effects (e.g., Masters et al., 2007; Weigelt et al., 2012). That is, in some studies participants are forced to consciously attend to goalkeeper displacements relative to the goal’s center and/or differences in size of the two sides of the goal (e.g., Masters et al., 2007, Experiments 1 and 2; Weigelt et al., 2012), while in other studies they do not need to pay attention to the goalkeeper displacement or goal sides’ size differences, because they have just stated that the goalkeeper
stands in the center of the goal or that there is no difference between the sides (e.g., Masters et al., 2007, Experiments 3). To test this, Chapter 7 investigated the off-center effect in beach volleyball serves, which also allowed establishing its occurrence in another stimulus environment. Like in soccer penalty kicking, the serve in beach volleyball is characterized by placing the ball to the opposite part of the court that is most difficult to defend by the opponent players. In beach volleyball there are two receiving players, who typically position themselves such that the three court areas are more of less of the same size. The off-center effect would occur, if serving players direct the ball more often to largest area, while they believe the areas are of the same size.

In a first experiment, beach volleyball players were asked to only serve the ball if they thought that the areas of the court surrounding the two receiving players were of the same size (analogous to Masters et al., 2007, Experiment 3). I reasoned that once the areas are perceived being of the same size, the server will not deliberately attend to the size of the areas anymore when pondering where to serve; a bias to aim for the largest area points to the size of the area being perceived preconsciously. As a consequence, even relatively large differences in area or displacements of one of the receiving team’s players may still result in unconscious selection. By contrast, in a second experiment, participants were asked to serve to the largest area, even when unsure which of three areas is largest (analogous to Masters et al., 2007, Experiments 1 & 2). They also rated the confidence that their judgment was correct. In this case, participants must deliberately attend to the stimulus of interest (i.e. the sizes of the areas) when choosing the area to serve to. Any biases in choosing the largest area, while players think they are guessing, would point to subliminal perception. Consequently, larger differences in area or larger displacements of one of the two players would result in conscious perception, and hence, the off-center effect should be restricted to a smaller range of differences in areas or displacements of the receiving players.
To sum up, the thesis reports four studies designed to analyze the off-center effect. In Chapter 4 we tried to scrutinize if the off-center effect occurs in a more representative study design with proactive goalkeeping as well as different strategies employed by penalty takers and goalkeepers. In Chapter 5 and 6 I adopted the line bisection respectively the landmark discrimination paradigm to add evidence that the off-center effect has its origin in the discrepancy between conscious and unconscious perception. In Chapter 7 it was analyzed whether instructions that were thought to direct attention to or away from the goalkeeper’s position respectively the goal sides’ sizes affected the extent of the off-center effect in a different (and more complex) stimulus environment.

Chapter 2: Gaze behavior during the soccer penalty kick:

An investigation of the effects of strategy and anxiety²

2.1. Abstract

Gaze behavior of penalty takers who either adopted a keeper independent or keeper dependent strategy was compared for low and high anxiety conditions. Results showed clear performance advantages for the keeper independent strategy as compared to the keeper dependent strategy; balls were shot further away from the goalkeeper and less saves were made. The superior performance of the keeper independent strategy was associated with longer times spent viewing to the target area inside the goal and toward the ball, and shorter looking times at the goalkeeper. The moderate, but significant increase in anxiety, however,