focusing on the effectiveness and risks of the keeper independent and keeper dependent strategies in both laboratory and competitive settings (i.e., FIFA World Cup and UEFA European Championships). Second, Chapters 4 to 6 analyzed (un-)conscious influences on the penalty takers’ decision-making. It does so by modifying the off-center paradigm to more realistic performance environments that include the penalty taker’s use of different strategies and interacting goalkeepers. To shed further light on the origin of the off-center effect and test the mediating role of attention, I adopted/modified line bisection and landmark discrimination tasks, which are typically used in cognitive neuroscience to investigate discrepancies between conscious and unconscious perception. Finally, Chapter 7 also analyzed the extent to which the off-center effect could also arise in different and more complex sports environments (i.e. the beach volleyball serves).

In what follows I will first summarize – separately for penalty kick strategy and the off-center effect – the main findings, and subsequently discuss briefly the pertinent issues that need to be addressed in future research on penalty kicking, or more generally, research on strategic factors that potentially influence performance in highly competitive (sports) environments.

8.1. Penalty kick strategy

The first part of the thesis addressed the effectiveness and risks of the two most common penalty kick strategies (Kuhn, 1988; van der Kamp, 2006). Penalty takers have two options to approach a penalty kick. They either anticipate and/or wait for the goalkeeper to jump to one side and kick the ball to the opposite side (i.e., keeper dependent strategy) or they decide on a kick direction before the run-up and stick to that plan regardless of the goalkeeper’s actions (i.e., keeper independent strategy). Previous research had indicated that the keeper independent strategy may be the best choice, because penalty takers who use a
keeper dependent strategy risk to have insufficient time available to respond to the
goalkeeper’s action when these occur late during the run-up (van der Kamp, 2006).
Particularly against the better goalkeepers (who routinely move late, Savelsbergh et al., 2005),
penalty takers often end up in a situation in which they do not have enough time to initiate
and execute an accurate and powerful kicking movement. Chapter 2 assessed the degree to
which the characteristics of the penalty takers’ gaze behavior before and during the run-up
affects the effectiveness of the two strategies. It additionally aimed to do so for low- and high-
pressure situations. Unfortunately, we did not succeed in systematically increasing the
participants’ anxiety, but the findings in Chapter 2 do show a clear relationship between
patterns of gaze and the effectivity of the two strategies (see also Noël & van der Kamp,
2012). That is, participants were equipped with a mobile eye tracker and instructed to kick
penalty kicks while adopting their preferred penalty kick strategy. Besides gaze patterns,
success and accuracy of the penalty kick, which was defined as the distance from the nearest
body part of the goalkeeper the ball passed the goal line, were assessed. Gaze patterns in the
keeper dependent strategy were suboptimal and decreased kicking accuracy compared to the
keeper independent strategy. That is, in the preparatory phase before the run-up participants
who used a keeper independent strategy spent the most time looking at the (target) areas in the
goal to the left and right of the goalkeeper, whereas penalty takers using keeper dependent
strategy focused predominantly on the goalkeeper. Once the run-up had started gaze shifted
more and more towards the ball for both strategies, but only the penalty takers who adopted a
keeper independent strategy attended almost exclusively to the ball briefly before contact. By
contrast, penalty takers using a keeper dependent strategy kept looking at the goalkeeper,
because they still needed to identify (or confirm) the direction of the goalkeeper’s dive. The
later gaze pattern seems unfavorable or perhaps even disruptive for accurate (visual) control
of the kicking movement and contact with the ball (see also van der Kamp, 2011). In fact,
evidence from other interceptive aiming tasks as golf putting or cricket demonstrates a similar
necessity for gazing at the ball to guarantee accurate aiming (e.g., Vickers, 1996; Croft, Button & Dicks, 2010). Accordingly, a positive relation between kick accuracy and time spent looking at the ball and target area, and a negative relation between kick accuracy and time spent looking at the goalkeeper were found. In sum, compared to the keeper independent strategy, using a keeper dependent strategy induces a less optimal gaze pattern for controlling the accuracy of the kicking movement and hence increases the risk that the penalty kick is unsuccessful.

It is important, however, to recognize that the (dis-)advantages of the two strategies observed in the experimental setting used in Chapter 2 and other previous work cannot automatically be generalized to competitive matches. The high standards of experimental control in previous studies (even when conducted on the field) may have gone at the expense of the external validity of the study. To make sure, Chapter 3 investigated the frequency of occurrence and the effectivity of the two strategies by professional soccer players in real competition more directly. To this end, an observational tool was developed that allowed us to reliably identify penalty kick strategy. Observers rated various characteristics of pre-recorded penalty kicks by penalty takers who either used keeper independent or keeper dependent strategies. Based on these ratings, a logistic regression model was created that identified the penalty kick strategy correctly in over 90% of the penalty kicks. The model included three predictors: attention to the goalkeeper, run-up fluency and kicking technique. Penalty takers using the keeper dependent strategy spent more time looking at the goalkeeper (Chapter 2; Noël & van der Kamp, 2012), use a less fluent run-up (van der Kamp, 2006) and kick with the inside of their foot (Lees & Owens, 2011). Next, we used the model to analyze penalty kick strategies from penalty shoot-outs during FIFA World Cups (1986 - 2010) and UEFA European Football Championships (1984 - 2012). It turned out that the keeper independent strategy was the more frequent strategy: approximately 80% of all penalty kicks. This predominance was irrespective of the importance of the penalty kick and the experience of
the penalty taker. In addition, unlike previous experimental studies (e.g. van der Kamp, 2006), no indications were found that one of the penalty kick strategies is more effective, that is, success rates for the two strategies were comparable.

To sum up, although experimental studies provide clear explanations for the superiority of the keeper independent relative to the keeper dependent strategy, associated with both perceptual and action aspects, a more direct assessment of the effectiveness of the two strategies during competitive matches revealed that they were equally successful. Possibly, kicking accuracy as the main dependent variable is insufficiently appropriate as predictor of penalty kick performance (especially in keeper dependent strategy), but the different findings in experimental and observational studies may also reflect that research in strictly controlled experimental settings does not always represent behavior in its habitual environment. Nevertheless, keeper independent strategy is clearly the more frequent strategy, perhaps suggesting that the majority of penalty takers try to avoid the risks that – according to experimental studies – are associated with keeper dependent strategy.

8.2. The off-center effect

The Chapters on penalty kick strategy focused on penalty takers’ deliberately planning of the penalty kick. Nonetheless, research shows that penalty takers can also be influenced by factors that they are not aware of, such as the postures a goalkeeper assumes (van der Kamp & Masters, 2008) or his or her positioning on the goal line (Masters et al., 2007). With respect to the latter, the off-center effect shows that a goalkeeper position on the goal line can have an influence on penalty takers’ goal side selection. That is, when the goalkeeper stands marginally off-center, then penalty takers are more likely to kick to the greater goal side, even though they are not aware that the goalkeeper does not stand in the goal’s center (i.e., they consciously perceive the two sides to be of equal size).
Yet, as with research on penalty kick strategy and in order to ensure a high level of experimental control, the off-center effect has only been investigated in relatively artificial experimental set-ups (Masters et al., 2007; Weigelt et al., 2012). Hence, doubts remain regarding the occurrence of the off-center effect in the more interactive and dynamic situation on the pitch and/or in competition. Masters et al. (2007) only showed that professional players in competitive matches kicked more often to the bigger goal side, but their video-observations do not allow any conclusions whether or not the penalty takers were aware that goalkeepers stood (marginally) off-center. Chapter 4, therefore, scrutinized the occurrence of the off-center effect in a more representative task design, in which a goalkeeper actively tries to save the participants’ penalty kicks. The goalkeepers were instructed to either commit to one side early or to wait until the penalty takers contacted the ball (see Kuhn, 1988), while penalty takers were instructed to either employ a keeper independent or keeper dependent strategy. In addition, the penalty takers also indicated the location on the goal line they (consciously) perceived as the exact center of the goal, and goalkeepers positioned themselves at this perceived center. This ascertained that penalty takers consciously perceived the goalkeeper to stand in the center of the goal. Typically, however, the perceived center did not correspond to actual center of the goal, allowing us to verify that kicks were directed more often to side of the goal that – unbeknownst to the penalty taker – is larger. Results showed that the off-center effect was retained on the pitch with dynamic interactions between goalkeepers and penalty takers. In other words, even with many additional and potentially interfering consciously accessible factors available the effect emerged reliably. This was always true when the penalty taker used a keeper independent strategy. Yet, when the penalty taker adopted keeper dependent strategy and – at the same time – the goalkeeper dived early, then penalty takers directed the ball more often to the empty side of the goal rather than to the side that was marginally bigger at the beginning of the run-up. In deciding where to kick, only the salient information about the goalkeeper’s (early) dive appears to overrule the unnoticed information
about the goalkeeper’s initial position on the line. In other combinations of penalty kick and goalkeeper strategies, the soccer players kicked the ball to the goal side with more space in over 60% of the kicks. This shows the pervasiveness of unconscious perception on decision-making, and underlines its potential for goalkeepers to exploit.

Not only does the off-center effect seem very pervasive, it also provides a unique opportunity to explore interactions between conscious and unconscious perception and its impact on decision-making in more dynamic real life situations than typically used in experimental studies. Accordingly, Chapters 5 to 7 tried to deepen the explanations for the occurrence of the off-center effect and to test the validity of theories of conscious and unconscious perception for real life tasks. In particular, we examined predictions from Dehaene’s taxonomy (Dehaene et al., 2006) that holds that conscious and unconscious perception emerges from different degrees of stimulus strength and top-down attention. To this end, Chapters 5 and 6 employed two different paradigms from cognitive science to assess the role of conscious and unconscious perception in the off-center effect, namely the line bisection (Bowers & Heilman, 1980) and landmark discrimination (Milner et al., 1992) task.

Following typical procedures for line bisection tasks, the participants in Chapter 5 were asked to first place the goalkeeper in the exact center of the goal, and then immediately afterwards carry out a penalty kick. The first task (i.e., placing the goalkeeper) required conscious attention to the goal’s center, whereas in the second task (i.e., choosing where to kick) conscious attention is unlikely being directed toward the goalkeeper position (or finding the side that is bigger), because penalty takers had just positioned the goalkeepers in the consciously perceived center. In line with results on bisection of distant lines (Halligan & Marshall, 1991), participants were inclined to err to the right side in placing the goalkeeper. Yet, they still kicked to the bigger side more often, while they believed the goalkeeper stood in the true center. This indicates that conscious but not unconscious perception is systematically biased. Put differently, it underlines that the off-center effect emerges from
discrepancies between conscious and unconscious perception. It also demonstrates that misbisections are induced when participants are urged to consciously attend to a line’s center.

Chapter 6 provided another demonstration that the off-center effect emerges from a discrepancy in accuracy of conscious and unconscious perception. In it, we adopted a variation of the line-bisection paradigm, the landmark discrimination task (Milner et al., 1992). Participants were presented with pictures of a goalkeeper who was (marginally) displaced to either the left or right side of true center, and were advised to only carry out a penalty kick if they were sure that the goalkeeper was placed in the center of the goal. In addition, they were told to start scanning the scene from either the left or right goal post or the middle of the goal, where the goalkeeper would appear. In the landmark discrimination task scan direction (see Varnava et al., 2002) has been shown to affect conscious perception of a line’s center such that the perceived midpoint shifts away from the end of the line from which the observer starts scanning. Similarly, the results of Chapter 6 revealed that the participants’ decision to kick or not to kick (i.e., reflecting their conscious judgment whether or not the goalkeeper stood in the middle) was affected by their initial scanning direction. However, scan direction did not affect the subsequent decision to which side to kick: the magnitude of the off-center effect remained the same irrespective of scan direction. Hence, scan direction only influenced conscious perception, not unconscious perception. This underlines once more that the off-center effect emerges from the discrepancy of conscious and unconscious perception of the goalkeeper’s position relative to the goal’s center, with only the former being susceptible to attentional asymmetries.

Finally, Chapter 7 scrutinized to what degree deliberate attention to the stimulus of interest (i.e., in penalty kicking the goalkeeper displacement and/or the relative size of both goal sides) is critical for the off-center to occur. This has obvious practical value (if athletes are aware of its existence, does this mitigate the off-center effect?), but it also allowed us to test prediction from Dehaene et al’s (2006) taxonomy for conscious and unconscious
perception in representative scenario’s. According to this taxonomy, different combinations of stimulus strength and top-down attention should result in different sized off-center effects. To test this, we examined aiming in beach volleyball serves, which also allowed us to assess whether the off-center effect can occur in more complex environments than the penalty kick. Chapter 7 showed in two experiments that serve direction of beach volleyball players was indeed influenced by the relative size of three different areas on the court (i.e., the two opponent players divide the court in three areas), even though they declared not to be aware of a difference in the size of these areas. In other words, the off-center effect was replicated in a beach volleyball scenario, suggesting that it is a general phenomenon that is likely influencing decision-making and behaviors in other (sports) situations as well. The two experiments differed in the degree to which attention was directed to the size of the court areas. The off-center effect emerged for stronger stimuli (i.e., larger differences in court area size) in the case that attention was not directed at the stimulus of interest (i.e., when participants were required to only serve if they were sure that the two receiving players divided the opponent’s court in three areas of equal size) than when attention was purposely directed at the stimulus of interest (i.e., when participants were instructed to choose the biggest target area).

8.3. Future directions

There are many theoretical and practical issues that seem pertinent for addressing in future research, both regarding penalty kick strategies and the off-center effect. I will briefly discuss a few. With regard to penalty kick strategy, it would be most interesting to scrutinize the degree to which a penalty taker can learn or improve to employ either the keeper independent or keeper dependent strategy more successfully. For instance, with respect to keeper independent strategy, future research should uncover whether it is possible to minimize the time a kicker needs to plan and/or modify the intended kicking movement, perhaps by also
optimizing gaze patterns. An important issue here would be to develop implicit learning strategies for this, since there is increasing evidence that performance after implicit learning is more robust against stress than performance that is acquired explicitly (e.g., Masters, 1992). Given the impact of stress on penalty success rate (see Jordet et al., 2007), it is perhaps surprising that implicit interventions for penalty kicking have not been investigated in penalty kick research thus far.

Furthermore, considering that both penalty kick strategies seem to be as effective it is important to address why the keeper independent strategy is used much more often than the keeper dependent strategy. Would it be the case that there is an advantage in terms of coping strategy, for instance, is it more suitable for implementing problem-focused strategies? In addition, it has not been examined thus far if penalty kick strategies and goalkeeper strategies (i.e., with respect to diving early or late) can be described in terms of game theory, as has been done successfully for decision about the side towards to kick (e.g. Palacios-Huerta, 2003). This may also clarify if and when penalty takers should stick with one strategy or whether they should alternate so to make their approach unpredictable for the goalkeeper. Finally, it is worth analyzing personal or situational factors that make the use of one of the strategies more preferable than the other. Except for coping strategies (see above), it may be possible that the keeper dependent strategy requires a higher expertise than keeper independent strategy, and consequently that recommendations for amateur players and professional athletes need to be differentiated.

A second theme for future research would be to further scrutinize the applicability of the taxonomy of Dehaene and colleagues (2006) to the penalty kick and (far-)aiming tasks in others sport situations. For example, more direct comparisons are needed to reveal whether the implicit effects of the goalkeeper or opponent’s position do indeed arise on a preconscious and/or subliminal level of perception, and if instructions or other manipulations are possible that allow the two types of unconscious perception to be more clearly distinguished. That is,
the current instructions (see Chapters 5 through 7) were not specifically directed to
distinguish subliminal, preconscious and conscious perception from each other, but were
predominantly developed based on prior observations with the off-center paradigm. It may be
cumbersome however to create instructions and manipulations that fully direct attention to or
away from the area of the two sides of the goal (i.e., presumably the stimulus of interest), also
because participants may, in principle, gain equivalent information by focusing on the
goalkeeper’s position instead of making a direct comparison between the goal sides directly.
In fact, it is still unclear what specific information participants need and use to select kicking
direction and whether this would differ for subliminal and preconscious perception, and
hence, it is not completely transparent where penalty takers should and do direct their
attention toward. Possibly, a more detailed spatio-temporal analysis of gaze may help
interpretation in this respect.

A final theme for research would be to find out in which other situations the off-center
effect may occur. In principle – if the off-center effect is caused by differences in the
accuracy of conscious and unconscious perception – there should be a variety of situations in
which perception of the position of another person (or other task-relevant environmental
properties) can affect an observer’s decision and behavior without getting access to conscious
awareness. That is, though the current thesis mainly concerns penalty kicking in soccer – and
a little bit of beach volleyball – the findings are possibly relevant for a myriad of other
(sports-) situations that people commonly encounter.

9. References

Araújo, D., Davids, K., & Passos, P. (2007). Ecological validity, representative design, and
correspondence between experimental task constraints and behavioral setting: