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Differences in game reading between selected and non-selected youth soccer players

Ruud J. R. Den Hartigh[a], Steffie Van Der Steen[b], Bas Hakvoort[c], Wouter G. P. Frencken[c,d] and Koen A. P. M. Lemmink[c]

[a]Department of Psychology, University of Groningen, Groningen, The Netherlands; [b]Department of Special Needs Education and Youth Care, University of Groningen, Groningen, The Netherlands; [c]Center for Human Movement Sciences, University of Groningen and University Medical Center Groningen, Groningen, The Netherlands; [d]Football Club Groningen, Groningen, The Netherlands

ABSTRACT

Applying an established theory of cognitive development—Skill Theory—the current study compares the game-reading skills of youth players selected for a soccer school of a professional soccer club ($n = 49$) and their non-selected peers ($n = 38$). Participants described the actions taking place in videos of soccer game plays, and their verbalisations were coded using Skill Theory. Compared to the non-selected players, the selected players generally demonstrated higher levels of complexity in their game-reading, and structured the information of game elements—primarily the player, teammate and field—at higher complexity levels. These results demonstrate how Skill Theory can be used to assess, and distinguish game-reading of youth players with different expertise, a skill important for soccer, but also for other sports.

Game-reading is one of the key skills athletes need to master in various sports, such as soccer (Ali, 2011; Den Hartigh et al., 2014; Reilly, Williams, Nevill, & Franks, 2000; Williams, 2000). In soccer, game reading can be defined as the player's ability to notice and integrate the moving information on the field, including the ball, the team members, the opponents, as well as the actions they perform (e.g., Den Hartigh et al., 2014; Williams, 2000). By definition, game-reading is a process that unfolds in real time (Den Hartigh et al., 2014), and it is assumed to underlie the anticipation and decision-making skills of soccer players (e.g., Ali, 2011; Williams, 2000). Researchers have attempted to increase their understanding of perceptual-cognitive skills, such as game reading, for decades. Based on the results of recall and recognition tasks (e.g., Williams, Hodges, North, & Barton, 2006), visual search tasks (e.g., North, Williams, Hodges, Ward, & Ericsson, 2009), and verbal report methods (e.g., Roca, Ford, McRobert, & Williams, 2011), researchers concluded that soccer players with higher expertise can better identify relevant game information, for instance the positions of other players on the field. More specifically, these research methods have provided insights into what kind of information experts pay attention to, as well as how players evaluate situations on the field based on retrospective reports. What has been lacking, however, is a theory-based method to examine how players with different expertise *structure* the relevant information *in real time*, that is, during game plays. In other words, how do players actually "read" the ongoing flow of information?

In the current study, we demonstrate how a theory of cognitive development, Skill Theory (e.g., Fischer, 1980, 2008; Fischer & Bidell, 2006; Schwartz & Fischer, 2004; Van Geert &

Fischer, 2009), can (a) be used to gain insights into the game-reading skills of youth soccer players, and (b) yields a method to reveal differences in expertise between youth players, more specifically between those selected for a soccer school of a professional soccer club and their non-selected peers.

Skill theory

According to Skill Theory (Fischer, 1980; Fischer & Bidell, 2006), skills can generally be defined as thinking structures, tied to a particular domain. Skill Theory offers a framework to study, and test, these domain-specific cognitive skills across different achievement contexts, such as education, business, and sports (e.g., Dawson & Heikkinen, 2009; Den Hartigh et al., 2014; Van Der Steen, Steenbeek, Van Dijk, & Van Geert, 2014). Two central characteristics of Skill theory that are particularly interesting in light of the concept of game reading are as follows: (a) Skills are constructed in real time, for example, during an activity, and (b) skill levels are defined in terms of their complexity, which reflect the level of (cognitive) structuring. Higher levels indicate that the person combines more elements or higher-order conceptualisations of these elements (Fischer & Bidell, 2006; Van Der Steen et al., 2014; for soccer-related examples, see below).

Skills can be measured along a hierarchical scale of increasing complexity. The Skill Theory scale consists of ten levels, organised into three tiers, which we shall briefly illustrate using soccer-related examples (see Table 1). The first tier refers to sensorimotor skills: Connecting actions to observable effects (e.g., a soccer player notices that "the player shoots"). The second tier refers to representations, reflecting

CONTACT Ruud J. R. Den Hartigh ✉ j.r.den.hartigh@rug.nl 🖃 Department of Psychology, University of Groningen, Grote Kruisstraat 2/1, 9712 TS, Groningen, The Netherlands

Table 1. Skill Theory complexity levels including illustrations from soccer.

Complexity level	Description
1: Single sensorimotor characteristics	Single observable characteristics of game elements or actions that are not related to any other game element or action (the player runs).
2: Sensorimotor mappings	Observable relations between game elements or actions (the player kicks the ball).
3: Sensorimotor systems	Observable causal relations between game elements or actions (the player passes the ball to his teammate).
4: Single representations	Not directly observable characteristics of game elements or actions (the player plays a through pass).
5: Representational mappings	Relations between two not directly observable characteristics of game elements or actions (The player plays a through pass to the left wingback).
6: Representational systems	Relations between three or more not directly observable characteristics of game elements or actions (the left wingback plays a through pass to the striker).
7: Abstractions	General (non-concrete) rules or concepts, holistically inferred from the interactions between the actions and game elements during the game play (they play kick and rush soccer).
0: Error	Wrong conception of game features or actions in the game play (the striker shoots, while it was the left forward that placed the shot).

Complexity levels 8–10 (abstract mappings, abstract systems, and single principles) were not included, because these levels go beyond single abstractions, which is virtually impossible with regard to the game of soccer.
Adapted from Den Hartigh et al. (2014) with permission of Taylor and Francis Ltd, www.tandfonline.com.

components that are more independent of specific observable actions. For example, when a soccer player mentions that a player "plays a through pass", this is not *directly* observable, but inferred from the players' specific movements and their positions in relation to each other. The third tier refers to abstractions, which represent general non-concrete concepts, such as "they apply a zonal defence strategy" or "they play kick-and-rush soccer". These are general terms for a game strategy that can be holistically inferred from the movements of the players relative to one another, or the speed and the way the ball is passed to other players.

Within each tier, a similar structure of three levels of increasing complexity exists. The first level corresponds to single sets, that is, single sensorimotor actions, representations, or abstractions. An example of a single sensorimotor action would be "the player runs". At the second level, these single sets are coordinated so that they form relations between these sets, called mappings, such as "the *player* kicks the *ball*" for the sensorimotor tier. At the third level, these mappings are connected to form systems. For the sensorimotor tier, this means that an action is connected to its observable effect, such as "the *player* kicks the *ball* to his *teammate*". When systems are combined, they form a system of systems, the first level of the next tier (see also Den Hartigh et al., 2014; Van Der Steen et al., 2014). In total, the scale thus consists of three tiers, each containing three levels (see Table 1).

A skill theory application to game-reading in soccer

Based on the framework of Skill Theory, game-reading skills can be defined along the hierarchical scale, where higher levels are indicative for a more complex reading of the interactions between the game elements and actions that unfold during the game play. By higher levels, we mean that the game reading contains more elements, or higher-order conceptualisations of these elements (e.g., correctly identifying the player as "the left forward"). In a recent study, Den Hartigh et al. (2014) used a Skill Theory coding system to capture the game-reading skills of adult soccer players. Three groups of players—professionals, high amateurs, and low amateurs—were exposed to videos of brief game plays and asked to describe the actions taking place, while they were watching. Players with higher levels of expertise could integrate the events and elements of the game plays at higher complexity levels of the Skill Theory scale. To date, this study is the only attempt to test whether differences in soccer expertise can be understood and measured using the Skill Theory scale. To further test its merits for the game of soccer (and sports in general), the following two steps are yet to be undertaken. First, it should be examined whether the Skill Theory approach can be applied across the life span of expertise development (i.e., also to youth players). Second, we should not only be able to distinguish between expertise levels of adult soccer players (Den Hartigh et al., 2014), but also of youth players of the same age-category with different levels of expertise.

The current study

In this study, we applied Skill Theory to test whether youth soccer players with relatively high expertise (under-12 soccer players selected for the soccer school of a professional club) could be distinguished from players with less expertise (their teammates who were not selected). In line with Den Hartigh et al. (2014), our hypothesis was that the selected youth players demonstrated higher game-reading complexity levels. This study also explored additional differences between these groups, for instance whether selected players described particular actions (e.g., scoring actions) or game elements (e.g., players on the field) at higher complexity levels.

Method

Participants

Our sample consisted of 88 youth male soccer-players recruited from regional amateur clubs. In August/September 2015, 49 of these players (M_{age} = 10.91, SD = .30) were selected by scouts of a professional soccer club and invited to practice at one of the five regional soccer schools (the one nearest to the player's home address). These soccer schools are organised the professional soccer club in collaboration with five amateur clubs. Training sessions of the soccer schools were executed by coaches of the amateur clubs, but supervised by a coach of the professional club. Eventually, players of these soccer schools are drafted into the under-12 team of the professional club's youth academy (they then leave their amateur club). The remaining 39 participants were peers of the selected players, who were playing for one of the five amateur clubs, but who were not selected for the soccer school (M_{age} = 10.55, SD = .43). Both the players and

their parents provided active consent before the start of the study. Participation was voluntary, and participants were assured that their contributions would be treated confidentially.

Procedure

The protocol of this study was approved by the ethical committee of the Department of Psychology, University of Groningen. A researcher made appointments with the participants at their club. After filling out their demographic information, the researcher asked participants to stand on a marker on the floor, in front of a 27″ HD screen at 1.15 m. Next to the screen, and in a 90° angle from the participant, an HD video camera was placed to record participants' verbal reports.

Participants were instructed to watch soccer game plays and to simultaneously verbalise aloud the actions taking place on the field. After two practice videos, three soccer game plays were presented with a 30 s interval between the videos. At the end of the session, the researcher transcribed the descriptions.

Materials

The three selected videos were offensive game plays with a clear starting-point (a kick-off, goal-kick, or throw-in) and end-point (a goal or goal attempt), retrieved from a database with matches of the under-12 team of the professional soccer club. These HD-quality videos lasted 25 s, 30 s, and 19 s and were filmed from an elevated position next to the midline (TV perspective).

The coding system

A soccer-specific Skill Theory coding system was used to code the descriptions. This coding system was originally developed by a focus group consisting of a soccer player (and graduate student), a Skill Theory expert, and a sport scientist (De Meij, Van Der Steen, & Den Hartigh, 2012). The soccer player familiarised himself with Skill Theory literature and related coding systems to assess the complexity of thinking structures in real time. He translated the hierarchical Skill Theory scale to soccer, based on (a) course material for (future) coaches and (b) discussions with players and coaches on the kinds of elements and actions involved in the game of soccer. Through the regular meetings between the members of the focus group, the theoretical base of the coding system could be preserved, as well as the link between Skill Theory, the sport science literature, and football practice. The coding system was pilot-tested with soccer players of different levels and then used for a study described elsewhere (Den Hartigh et al., 2014).

The coding system is based on the fact that the game of soccer includes game elements, which combine to form specific actions, which in turn combine to form game plays. For example, the player, the ball, and a teammate (game elements) can be combined to represent a player who passes the ball to his teammate (an action), which can be combined with other passes (actions) to form an attacking game play. When the interactions between the game elements and actions during the game play are integrated at higher

Table 2. Illustration of how the final game-reading complexity level is constructed according to a participant's real-time verbalisations.

Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8
He runs forward with the ball	B	SBV	1	1	3	1	3
A 1–2	P	SBM	1	4	3	1	4
He crosses the ball in front of the goal	P	SBMD	1	1	4	1	4
Heads it to the striker	P	SBM	1	1	3	4	4
And he scores the goal	S	SBD	1	1	3	1	3
							3.60

The first three steps can be characterised as coding preparation. Step 1 = separating actions; step 2 = labelling actions; step 3 = labelling game elements; step 4 = number of (coupled) actions; step 5 = Skill Theory level assigned to the action; step 6 = number of game elements within the action; step 7 = Skill Theory level of game elements; step 8 = final complexity level of entire game play description.
Description: He runs forward with the ball, a 1–2, he crosses the ball in front of the goal, heads it back to the midfielder and he scores the goal.

complexity levels, a higher score on the scale is attained (Den Hartigh et al., 2014).

The verbalisations of the participants were coded in a sequence of eight steps. In Table 2, we provide a concrete illustration of the coding procedure based on real-time verbalisations during a game play. In the first step, the verbalised *actions*, representing a specific act (e.g., shooting, kicking, or passing), or state (e.g., standing, having) were separated. In the second step, the separated actions were given one of the following labels to make identification easier: action of a single player with the ball (B); passing action (P); action involving a player who outplays his opponent (U); scoring action (S); defending action (V); and action of the player without the ball (e.g., walking, standing, or running, L). In the third step, the different *elements* involved in the described actions were labelled to make it easier to identify them: the player who performs the action (S); the ball (B); the teammate of the player (M); the opponent (T); the space or field (V); and the goal (D).

In the next two steps (steps 4–5), different scores based on the complexity scale were given to each *action* distinguished in the previous steps. In the fourth step, a score was given for the number of actions that were coupled in the action description. When two actions are coupled, this reflects a more comprehensive (i.e., complex) game reading. This is the case when a relation is made between actions that follow each other in time (e.g., "The striker *moves* in front of the defender, so that he can *score*") or when they take place at the same time (e.g., "The player *heads* back to the *incoming* striker"). Note that, the example in Table 2 does not include a coupling between actions. In the fifth step, a score was given for the complexity level of each action description. Actions can be described in a relatively simple, directly observable way (i.e., sensorimotor level), but can also be described as a particular kind of action that is inferred from the positions or kinds of movements of the players on the field (i.e., representational level). In Table 2, the verbalisation that a player "heads it to" corresponds to a directly observable passing action (i.e., level 1 – sensorimotor), whereas "A 1–2" is not directly observable, but is *inferred* from the way in which a player combines with a team member in that passing action (i.e., level 4 – representation).

In the next two steps (steps 6–7), different scores based on the complexity scale were given to each *element* distinguished in step 3. In the sixth step, the number of elements included in the action descriptions was scored. In Table 2, "heads it to the striker" contains the player (who heads), the ball, and the team member (striker), and therefore three elements. In the seventh step, a score was given to the complexity level of the different elements (player, teammate, opponent, field, goal, and the ball). Higher complexity levels are scored when, in contrast to directly observable characteristics, elements are described with a representation (level 4). Representations are reflected by descriptions including a not directly observable characteristic. In the example, "the striker" corresponds to a representation, because the fact that he is the striker is not directly observable, but is inferred from information about that player's position on the field in relation to other players' positions.

In the final step (8), a score for the overall complexity level was given for each action. This score is based on the preceding four skill scores, together reflecting the game reading of each action and the elements in that action. Finally, the coding procedure ended by calculating the total game-reading complexity score of the entire game play, which is the mean of the action descriptions (3.60 in Table 2). This number, reflecting the way in which all the actions and game elements were integrated during the game play, served as the main unit of analysis for this study.

Reliability of the coding system

When the first set of verbalisations were transcribed, 15 transcriptions were randomly selected and sent to the first author of the coding system (De Meij et al., 2012). The researcher in charge of the data collection and the first author of the coding system coded the transcriptions independently, and the reliability was assessed using a percentage of agreement [(number of same findings) /(number of same findings + number of divergent findings)]. The agreement rate was very high: 95% for the types of described actions (step 2); 97% for the types of elements in the actions (step 3); 100% for the couplings of the actions (step 4); 100% for the complexity levels of the actions (step 5); 98% for the number of described elements (step 6); 99% for the complexity of the elements (step 7); and 97% for the overall complexity levels of the action descriptions (step 8).

Data analysis

To test our hypothesis, the two groups (selected and non-selected players) were compared on their average (overall) Skill Theory complexity level. Because the ANOVA assumption of normality was not met, we applied a Monte Carlo permutation analysis, which has more power than nonparametric alternatives (Adams & Anthony, 1996; Todman & Dugard, 2001). The Monte Carlo permutation test determines the probability that an observed result is caused by chance. The scores of all participants in the two groups were reshuffled to obtain a redistributed set of scores; this was repeated 10,000 times. Then, the probability was determined that the randomly reshuffled scores showed differences between the two groups

that were equal to, or bigger than, the actually observed differences. In addition to the *P*-value, we calculated effect sizes (Cohen's *d*) to determine the meaningfulness of the results. An effect size below .3 is considered as small; between .3 and .5 as small-to-moderate; between .5 and .8 as moderate-to-large; and above .8 as large (Cohen, 1988).

Besides the comparison in terms of the overall complexity level, we also explored differences with regard to the actions and game elements separately, meaning across the steps 4–8. Again, significance testing was conducted using the Monte Carlo permutation procedure, and effect sizes were reported in case of significant differences ($P < .05$).

Results

Despite the use of practice videos and the instruction to describe the game plays while they were watching, some participants provided retrospective descriptions. One participant in the non-selected group, who did this for all videos, was therefore excluded from the analysis. Five other participants provided one or two retrospective descriptions. These retrospective descriptions were excluded, but we did include the participants' real-time descriptions of the other videos. Ultimately, out of the 87 participants we included for the analysis, seven retrospective evaluations were excluded and 254 transcribed videos of the real-time (game-reading) verbalisations could be taken into account.

Skill theory complexity levels

In accordance with our hypothesis, the Monte Carlo permutation test revealed higher complexity levels of game-reading for the selected players (M = 3.46, SD = .22) than for non-selected players (M = 3.34, SD = .23, P = .01), with a moderate effect size (d = .51). Differences in terms of complexity levels of actions and game elements were further explored. We decided to first compare the average number of actions combined (step 4), complexity levels of actions (step 5), number of game elements (step 6), and complexity levels of game elements (step 7), and to investigate in more detail those steps revealing a significant difference (P < .05) between the two groups. For step 7—complexity level of game elements—we found a significant difference. The selected players had a higher average complexity score for the game elements (including player, teammate, opponent, ball, field, and goal, M = 1.53, SD = .46) than the non-selected players (M = 1.27, SD = .36, P = .002). The effect size was moderate to large (d = .63).

To further examine this difference, we investigated whether the number of game-element descriptions at a *representational level* was higher for the selected players. Indeed, selected players more often used representations to describe game elements (M = 1.23, SD = 1.22) than the non-selected players (M = .54, SD = .72, P < .001, d = .69). This means that the selected players more often described the elements at a level that goes beyond a simple observation. For instance, instead of noticing that "*the player* scores", a participant could say "*the striker* scores", inferring this from the player's (changing) position on the field in relation to the positions of
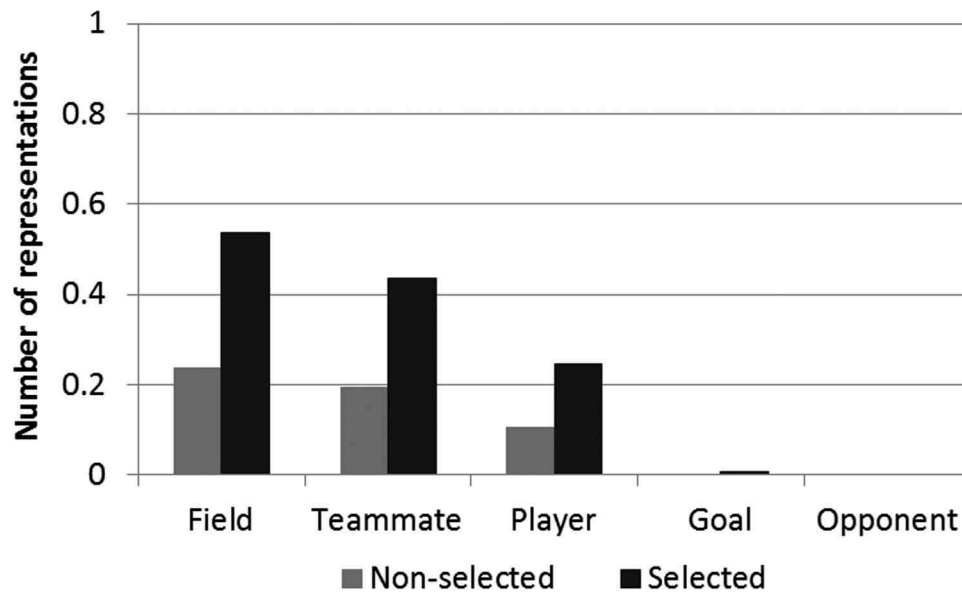
Figure 1. Average number of representations per game play. Note that the ball is not included as a separate category, because the ball can only be described at a directly observable sensorimotor level (i.e., often just as "the ball").

the other players. Figure 1 shows that, for both groups, representations were primarily found in descriptions of the field, teammate, and player. For each of these elements, the selected players had a higher score than the non-selected players (field, $P < .001$; teammate, $P = .03$; and player, $P = .06$).

Discussion

The aim of this study was to examine whether the game-reading skills of youth soccer players who were selected for a soccer school of a professional club could be distinguished from those of the non-selected players. The results indicate that the selected youth players structured the information from the game plays they viewed at higher levels of cognitive complexity. In line with the study of Den Hartigh et al. (2014) among adult soccer players, we can conclude that the Skill Theory complexity scale provides an accurate measure of game-reading skills that can distinguish between youth players of the same age category with relatively subtle differences in presumed expertise-levels.

Theories specifically focused on cognitive expertise have proposed that experts possess a larger databank of domain-specific situations that may happen, which are stored in long-term memory, and can be accessed rapidly (Ericsson & Kintsch, 1995). This is typically mentioned in studies using recall and recognition tests (e.g., Chase & Simon, 1973; Williams et al., 2006) and retrospective verbal reports (e.g., North, Ward, Ericsson, & Williams, 2011; Roca et al., 2011), in which athletes recognise or report on previously viewed or played game situations. Although it is possible that performance in these retrospective tasks activates structures of long-term memory, it remains a question whether this can explain cognitive expertise expressed *in real time*, such as game-reading, given that athletes need to perceive and respond to a constantly changing, context-specific flow of information. In order to

account for the ongoing, real-time reading of the continuously changing game situation, a theory that proceeds from a faster, dynamic and in-situ process, such as Skill Theory (Fischer, 1980), may be more applicable (for other approaches proceeding from an in-situ process, see Araújo, Davids, & Hristovski, 2006; Den Hartigh, Cox, & Van Geert, 2017; Fajen, Riley, & Turvey, 2009).

Differences in level of actions and game elements

In addition to a general difference in complexity level, we found significant differences between the selected and non-selected players in terms of the game *elements* they described. The mean complexity level of the described game elements was higher for the selected players, who also used more representations, primarily when describing the field, teammate, and player. Attaining higher complexity levels for these elements may be particularly valuable in soccer. As an illustration, compared to a simple observation, such as "a player moves forward and shoots to another player", the description "the left wingback moves to the free space and passes the ball to the striker" shows a more comprehensive integration of the relationships between various game elements. According to Williams and colleagues, especially this ability to integrate *relational* information between players on the field is an important characteristic of expert performance in soccer (e.g., North et al., 2009; Williams, 2000; Williams et al., 2006).

Although we did not find significant differences between the groups in complexity levels of separate *actions*, such differences were found among adult soccer players (Den Hartigh et al., 2014). Professional adult soccer players relatively more often use high complexity levels to describe actions without the player with the ball, that is, off-the-ball movements and defending actions such as "choosing position" or "defending the zone". A possible explanation could be that soccer players

typically start to master, and therefore "read", such strategic movements at a later stage, or are able to verbalise them at a later stage. In our sample, we indeed detected only six representations for off-the-ball movements, all provided by the selected players.

Implications

The current study demonstrates expertise-related differences in cognitive skills between soccer players of the same age category. Taking the current study and the one of Den Hartigh et al. (2014) together, Skill Theory seems a useful framework to capture game-reading skills, across the age range from youth to adult players. A major advantage of the Skill Theory coding system is that it is accessible and can be reliably used (percentages of agreement > 90%). Alternative methods, such as eye tracking, are often more time-consuming and costly to use. In addition, although examining gaze behaviours of soccer players reveals what information players look at in real time, these methods do not address how players integrate what they see in real time (e.g., does the participant see that a player "chooses position"?). Skill Theory thus provides a reliable instrument to measure game-reading, which is called for in soccer for talent detection and development purposes (Hoare & Warr, 2000).

Limitations and future directions

The aim of this study was to gain insights into the game-reading skills of youth soccer players, which we captured through coding their verbalisations based on Skill Theory. The game-reading skills of soccer players are assumed to underlie successful decision-making behaviour (cf. Roca et al., 2011; Williams, 2000; Williams et al., 2006), yet we have not focused on this decision-making process, and so more research is needed to confirm this hypothesis. Structuring information during game plays at higher complexity levels could go hand in hand with successful soccer actions and decisions. For instance, noticing that "the striker moves to the free space" might afford the action to chase the player during a match, whereas perceiving that same action as "a player sprints to the right" may not afford that action. An interesting next step would be to examine players' decision-making in direct relation to complexity levels of game-reading.

Furthermore, in the current study, we showed the players game plays from a TV perspective. This allowed us to assess players' reading of the entire game as it unfolded, from a perspective that was equal for all players, which resulted in a controlled research design. However, in a natural situation, players have their own perspective that depends on the position they have on the field, their walking direction, and gaze direction. An important avenue for future research is therefore to test game reading skills from a player's perspective at different playing positions. Although this is difficult to accomplish in real time on the actual field, much progress is currently made in video analysis software (e.g., Frencken, Lemmink, & Delleman, 2010), as well as virtual- and augmented reality. By making use of these developments, it may become possible to present game plays from the viewing perspective of the player and for real-time reading of the game.

Furthermore, future research may examine the *development* of game-reading skills in soccer. According to the Skill Theory literature (e.g., Fischer, 2008; Fischer & Van Geert, 2014), different children may demonstrate different developmental trajectories with regard to their cognitive skills, which are formed out of the repeated interactions between person and context. Notably, in the domain of soccer, the dimensions of the field and number of players on the field increase from a small-sided to a full-sided game around the age of 11–12, and changes in the size of the field lead to the emergence of different patterns of play (e.g., Folgado, Lemmink, Frencken, & Sampaio, 2014; Frencken, Van Der Plaats, Visscher, & Lemmink, 2013). This can be a typical period in which players' abilities to structure the relevant information on the field reorganise and develop differently for different players.

Conclusion

In this article, we introduced Skill Theory to identify and investigate a crucial skill in soccer: game-reading. Using a homogeneous sample of under-12 soccer players, our study shows with moderate to large effect sizes that (a) youth soccer players who were selected for a soccer school of professional club had higher scores on the Skill Theory complexity scale than their peers who were not selected, and that (b) at a more detailed level, selected players structured the information of the game elements—primarily the player, teammate and the field—at higher complexity levels. Skill Theory is thus a promising approach to studying expert performance in soccer. Given that game reading skills are considered to be essential for different sports, such as soccer, field hockey, and volleyball (cf. Smeeton, Ward, & Williams, 2004), the Skill theory complexity scale may have widespread applications.

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Disclosure statement

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