Scaffolding in coach-player interactions within video feedback sessions: the development of game reading in youth soccer players

Samuel Adriaan Hangx

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[*s3111113*]
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Department of Psychology
University of Groningen
Examiner/Daily supervisor:
[*Prof. Dr. Ruud den Hartigh*]

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Abstract

Elite level soccer requires players to make quick decisions within a dynamic and unpredictable context. A crucial cognitive skill that supports this ability is game reading: identifying and interpreting patterns within a game. Coaches often use video feedback sessions to improve this skill. Nevertheless, it is unclear what instructional strategies are the most efficient. This study investigates whether scaffolding (adaptation of question level by the coach based on player's response) is related to the development of game reading skills in youth soccer players. Three video-feedback sessions between professional KNVB coaches and under-15 and under-16 national youth players have been analyzed. All verbal utterances from both the coaches and the players were coded using a soccer specific Skill Theory framework. Results show that players consistently operated at a higher complexity level than the coaches. No pattern of game reading development within the players was observed, nor did we find a pattern suggesting scaffolding by the coaches. In some cases, the coaches seemed to have followed the Skill Theory level of the players, instead of guiding them towards higher levels. This may suggest a lack of challenge provided by the coaches. These findings suggest that even experienced soccer coaches may lack instructional and pedagogical skills to effectively support game reading development during video feedback sessions. This highlights the need to train coaches in adaptive questioning techniques, to support the ongoing development of young athletes.

Keywords: Scaffolding, Skill Theory, coach-player interaction, game reading development, youth soccer players, Complex Dynamic Systems

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Soccer is a fast, dynamic game full of unpredictable events, which relies on split-second decision making. Players face a lot of challenges, like having the ball on their feet, knowing opponents are closing in on them. How do players make the best decision when there is limited time to decide? To do that, players need information about where their teammates are and how opponents are pressing. Ideally this information is already present in players' heads before they receive the ball, which enables efficient decision making. This knowledge of on-field factors is an example of a very important skill in soccer: game reading. Coaches may use video-feedback to develop game reading in soccer players. In this thesis I aim to explore if the amount of scaffolding (the ability of adjusting the complexity levels of questions to the players' descriptions of soccer game plays) used by the coaches is related to the development of game reading skills in youth soccer players during video feedback sessions.

Game reading

Game-reading is considered an important skill for athletes, especially in open-play sports such as soccer (Ali, 2011; Den Hartigh et al., 2014, 2018; Reilly et al., 2000; Williams, 2000). Game-reading is often used to describe a players' ability to interpret the dynamic information unfolding on the field. This includes for instance the trajectory of the ball, the positions of other players, and the unfolding actions of the game (Den Hartigh et al., 2014; Williams, 2000). This cognitive process is fundamentally real-time in nature, that is, it takes place in the here-and-now (Den Hartigh et al., 2014).

Soccer players, particularly those of elite caliber, exhibit a remarkable ability to selectively attend to important cues amidst the dynamics of the game (Den Hartigh et al., 2018). They have a heightened ability to discern game-related information, such as the spatial

orientations of fellow players on the field. This selective attention enables them to quickly recognize familiar patterns of play, like a teammate's preferred movement or an opponent's tactical approach. Through years of experience and training, these players develop an intuitive sense of where to direct their attention and how to filter out distractions, supporting their capacity for rapid pattern recognition. The development of game reading and skilled perception is crucial for soccer players for good in-game decision-making, split-second anticipation and excellent performance (Abernethy, Thomas & Thomas, 1993; Ali, 2011; Williams, 2000).

Coach-player interaction – Complex dynamic systems perspective

To foster the development of game reading, coaches can use video feedback analysis. On regular basis coaches sit down with players to support their learning and developmental process by showing them clips of the envisioned style of play or to analyze their own play. However, there remains a lack of knowledge of what pedagogical approaches coaches should use during these video-feedback sessions (Groom et al., 2011; 2012). Therefore, this study adopts a complex dynamic systems (CDS) perspective to increase our understanding of how certain interactions between coaches and players contribute to developmental outcomes (e.g., Meindertsma et al., 2014; Van Der Steen et al., 2019). A complex system holds multiple interacting elements, of which the sum commonly is more than the sum of its parts (Van Geert, 2008; 2011), where a dynamic system can be defined as a developmental system that describes how one state changes into another (Weisstein, 1999; van Geert & Steenbeek, 2013). The complex dynamic system develops over time, as an effect of interacting components and skills emerge from this interaction. This could lead to learning a new skill or, in this case, developing game reading. Within this research, the system consists of the coach, player and the game reading task.

CDS emphasizes that development is a nonlinear process and a result of a dynamic interaction between multiple actors. Within the development of game reading the coaches role is crucial, while offering the right amount of support at the right time. The coach asks questions to challenge the players' knowledge based on the complexity of their previous answers, by sequencing these questions logically to improve learning in the most optimal way (Van Geert & Steenbeek, 2005). The focus of this study is on this dynamic interaction, which is called scaffolding.

Scaffolding

Scaffolding is a widely used concept in developmental psychology and is a process, in which an adult temporarily provides encouragement and assists in the child's learning, while working on a task (Van Der Steen et al., 2012). Scaffolding originates from Vygotsky's social learning theory (1962). Vygotsky claimed that there is a gap between what children can achieve when they act individually versus what the same individual can achieve with the help of another more competent individual. This range between the actual developmental level and the potential developmental level is called the "Zone of Proximal Development (ZPD)" (Van Geert, 2000). Central to scaffolding is that the actual current level on which the individual performs determines the type of help that is given (Chang, Sung, & Chen, 2002). The more competent individual shapes the given help to the needs of the child, which supports the child to achieve a result that is more than what he would achieve individually. Parts of the specific help are being integrated into the child's inherent abilities, elevating its actual level into a higher potential developmental level. It is important that the help provided during scaffolding is just a little beyond the actual level of what the individual could achieve alone (Olson & Pratt, 2000). By doing this, the more competent individual creates little steps in which the child is able to develop.

One important condition of scaffolding is that the scaffolds are temporary (Van Der Stuyf, 2002). As the child's abilities increase, the provided scaffolds should be removed. The goal of the educator must be to teach the child how to perform individually, create self-regulation and to increase learning competencies. Van der Steen et al. (2014) indicated that a teacher's adaptive support can help gradually shift a child's understanding upward during the performance of a school task. Within the context of their study, Skill Theory (Fischer, 1980) provides a developmental scale that serves as a coding framework to analyze the complexity and variability of children's skills and cognitive abilities. Recent studies have applied the Skill Theory framework within the domain of sports, specifically to examine the concept of game reading in soccer.

Skill Theory in soccer

The development of game reading is a process of growth in skill levels, which can be measured with Skill Theory, originally developed by Fischer (1980). Skill Theory offers us a way to assess cognitive complexity of how individuals organize their actions and reasoning, while considering the ongoing interaction between person and context (Fischer & Bidell, 2006). This theory serves to quantify skills in a range of different domains.

The Theory divides levels in three tiers. The first is sensorimotor skills, which are simple relations between actions, objects or individuals. The second tier explains representations, in which we refer to knowledge that contain not directly observable structures. The third tier explains abstractions. These abstractions consist of general understanding of the phenomenon including interactions between actions and game features. These three tiers are all divided in single actions, mappings (combinations of actions) and systems (relations between mappings) (Den Hartigh et al., 2014, see Table 1 for soccer-specific examples).

Den Hartigh and colleagues (2014) developed a soccer-specific coding system based on Skill Theory which enables us to quantify soccer related utterances of game play representations. These utterances can be placed on a hierarchical scale from 0 to 7, where a higher Skill Theory level represents a more complex utterance of interactions between elements of the game play, in other words game reading (see Table 1). In a recent study, for instance, Den Hartigh et al. (2018) applied this coding system to compare the game reading skills of selected and non-selected under-12 soccer players. Participants watched short video clips of match situations and were asked to verbalize what they observed. These verbalizations were then coded using the Skill Theory framework to determine their level of complexity. Results showed that selected players consistently showed higher levels of complexity in their game-reading utterances compared to their non-selected peers. They more frequently described game elements such as the player, teammate, and field using higher-order representations, indicating a deeper and more structured understanding of the game. This study highlights the potential of soccer-specific Skill Theory as a reliable tool to assess game reading skills in youth players and provides valuable insights for talent identification and development in soccer (Den Hartigh et al., 2018).

TABLE 1
Illustration of Skill Theory complexity levels in soccer

Complexity level	*Description*
1: Single sensorimotor characteristics	Understanding of single observable characteristics of game features or actions that are not related to any other game feature or action (the player runs).
2: Sensorimotor mappings	Understanding of observable relations between game features or actions (the player kicks the ball).
3: Sensorimotor systems	Understanding of observable causal relations between game features or actions (the player passes the ball to his team member).
4: Single representations	Understanding of not directly observable characteristics of game features or actions (the player gives a cross pass).
5: Representational mappings	Understanding of relations between not directly observable characteristics of game features or actions (The player gives a cross pass to the left wingback).
6: Representational systems	Understanding of relations between three or more not directly observable characteristics of game features or actions (the left wingback gives a cross pass to the striker).
7: Abstractions	General (non-concrete) understanding holistically inferred from the interactions between the actions and game features during the game play (they play kick and rush soccer).
0: Error	Wrong understanding of game features or actions in the game play (the striker shoots, while it was the left forward that placed the shot).

Video analysis in soccer

A tool that contributes to the development of game reading is video analysis, where coaches present short video clips to a player alongside some verbal instructions (Mason et al., 2020; Otte et al., 2020; Potrac et al., 2000). These video clips can be footage from the players own performance during training and matches and can be used for direct feedback and reflection on his own performance. The footage could also be more general, for illustrating the way a coach wants their players to perform and show examples of specific situations.

In the light of recent technological improvements in sports, the utilization of video analysis in soccer has widely grown (Cuevas et al., 2020). The use of video analysis enables coaches to incorporate visualizations of game play in their instructions and feedback towards players. In this context, game-reading refers to a players' ability to discern dynamic elements such as the movement of the ball, positioning of teammates, and actions of opponents (Den Hartigh et al., 2014).

The soccer-specific adaptation of Skill Theory provides an excellent framework for coding game reading. However, prior research has primarily focused on testing the applicability of Skill Theory within the domain of sports. In the studies by Den Hartigh et al. (2014; 2018), soccer players were only shown videos without the presence of a coach. This study represents the first attempt to examine the development of game reading in an environment involving interaction between a coach and a player, while utilizing soccer-specific Skill Theory.

The present study

In this study we aim to explore if the amount of scaffolding used by the coaches is related to the development of game reading skills. We use a complex dynamic system perspective on the development of game reading within youth soccer players. More specifically, we study coach-player interactions during video-feedback sessions, where we

focus on the utterances by both the coach and the player while using the soccer specific Skill Theory based scale (Den Hartigh et al., 2014; 2018). With regard to the coach-player interaction, we are interested in the abilities of professional soccer coaches when it comes to scaffolding, and if the amount of scaffolding used is related to the development of game reading skills in youth soccer players. A setting was created in which professional coaches had individual video-feedback sessions with soccer players. Visual plots of the conversations' Skill Theory-levels made it possible to determine if there were signs of scaffolding patterns during the sessions and to examine how this could be related to the development of game reading skills in youth soccer players. It is expected to see a higher level of development in sessions where coaches were able to use a bigger amount of scaffolding.

Methods

Participants

For this study, 30 talented Dutch youth soccer players aged 14-16 were recruited. These players were nominated to play in the national under-age soccer team and are generally considered the most talented soccer players from their specific age group. The participants were part of the national youth teams of the KNVB (Royal Dutch Football Association). This concerns the under-15 and under-16s. Both the participants and their parents had to give permission for participation. In our sample we only include outfield players (i.e., no goalkeepers given their specific role within a soccer team). In the course of a typical soccer season, these teams came together to train, and play (international) matches during so-called "training camps". It is during these training camps that we collected the data.

The participant recruitment took place via the respective head coaches of the under-age teams. They typically act as a gatekeeper for the team, determining the moments when players train, rest or have time-off. They agreed to support the study and to have their coach-player video feedback sessions recorded. These sessions are part of standard procedures

during training camps and as such this study can be easily integrated into the programme, requiring only minimal effort or modifications. Given that this already is an existing process of the training procedure, no compensation is provided for participation.

The present study involves the analysis of three conversations conducted by three different coaches and players. These were selected randomly from the dataset. This study serves as a pilot for a larger study by the KNVB, which will include the analysis of all 30 recorded conversations.

Procedure

Prior to the data collection, the Ethical Committee of Psychology (ECP) of the University of Groningen granted approval for the start of the current study.
The players of the under-15 team received an invitation to our study with the usual invitation from the KNVB. The online invitation contains a link to Qualtrics where the players and parents could give consent for participation. The players of the under-16 team were approached during a meeting on campus and received a physical letter. In our study, we recorded these video-feedback sessions between player and coach.

The recording of the under-16's took place during a training camp in Portugal, where we setup a hotel room for the coach and player to sit down at a desk with a laptop. We created a similar environment for the under-15's in a small conference room, during their camp in the Netherlands. During the sessions, participants were equipped with a microphone, and a camera was placed behind them in a position that provided a clear view of both the participants and the laptop screen. While the recording sessions were initially designed to last approximately 12 to 15 minutes, most sessions ultimately had a duration closer to 20 minutes.

The recordings were then transcribed and transferred to an Excel sheet where all coach and player utterances were coded according to the "Skill Theory coding book". Each utterance could contain multiple individual actions, each associated with its own distinct Skill

Theory rating. For each utterance, the highest individual rating was selected, enabling the construction of a visual representation of single, sequential values. By only selecting the highest score, the highest level achieved within the utterance is prioritized, without diminishing its value by considering accompanying statements.

Materials

In the video-feedback sessions the coach discusses 6 short videoclips with the player. These videoclips are between the 16 and 35 seconds each and contain footage from international senior soccer matches of the Dutch national team and are selected based on their representativeness of how the coach wants to play. The type of soccer actions within video clips is evenly distributed across the four game phases (attacking, defending, transition from attack to defense, and transitioning from defense to attack) and are retrieved from an open-access database that includes all international senior soccer matches. I used a Sony FDR-AX43A camera and Røde wireless microphones for the recording of the sessions. For transcribing the recordings, I used Whisper, which is an application that can transcribe video and audio recordings to text.

For coding the transcribed texts, according to Skill Theory, I used the "Codeerboek voor het Meten van Cognitieve Vaardigheden van Voetballers" (De Meij, M., Van Der Steen, S., & Den Hartigh, R. J. R., 2012).

Results

The analysis consists of three separate conversations, each involving a different coach and player. These interactions are described individually per conversation below.

In the first conversation the players' mean Skill Theory Level is 3.74 (SD=1.40; min=1; max=6), where the coach's mean lies .84 lower (M=2.90; SD=1.40; min=1; max=5). A t-test revealed a statistically significant difference between the two participants' Skill Theory-levels (p=.034).

I further examined the following possibilities: that the player leads the conversation over the coach (r=-.016) and that the coach guides the interaction (r=.098). These results indicate only weak correlations for both directions, suggesting that while there may be slight tendencies, such as the coach responding to the players' Skill Theory level, these are not strong enough to provide strong support for a consistent pattern.

As figure 1 shows, in only six instances does the coach ask a question that is of a higher level than the players' preceding answer. In these cases, there does not seem to be a clear relationship between the level of the players' response and the level of the coach's question. In all other instances, the coach asks a question at the same or even a lower level compared to the players' previous expression. No pattern that indicates scaffolding can be observed, where one would expect the coach to gradually raise the level, resulting in visible growth in the players' Skill Theory level.

No clear pattern emerged from the data indicating development in game reading during the first conversation. The observed variations appear to be random, rather than indicative of any systematic growth. It should be noted that the players' initial level is already quite high.

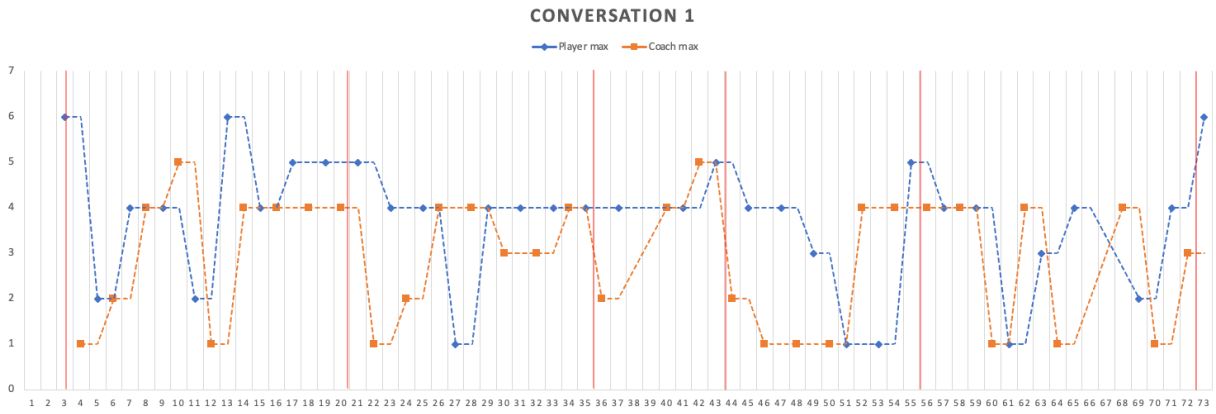

Figure 1. Conversation between coach 1 and player 1. The vertical red lines indicate the start of a new videoclip.

The second conversation shows similar tendencies as those identified in the first session. The players mean Skill Theory-level is 3.22 (SD=1.65; min=1; max=6), with the coach's mean .64 behind (M=2.58; SD=1.23; min=1; max=5). The coach frequently appears to ask questions at a lower Skill Theory-level than the level at which the player responds. The players' average level is considerably higher here, and there is also notable variability in the level of the players' responses. This difference in Skill Theory-levels does not appear to be significant (p=.081).

There seems to be neither evidence for the assumption that the player leads the conversation (r=.082), nor for the assumption that the coach takes the lead (r=.175). The correlations for both ways are very weak.

Compared to the first conversation, there seems to be even less evidence here of a relationship that would indicate any degree of scaffolding (figure 2). The player reaches higher Skill Theory levels regularly, while the coach stays behind.

Analysis of the second session showed no pattern indicating progress in the players' game reading abilities. Observed changes in level from both the player and the coach appeared to occur randomly, lacking signs of structured development.

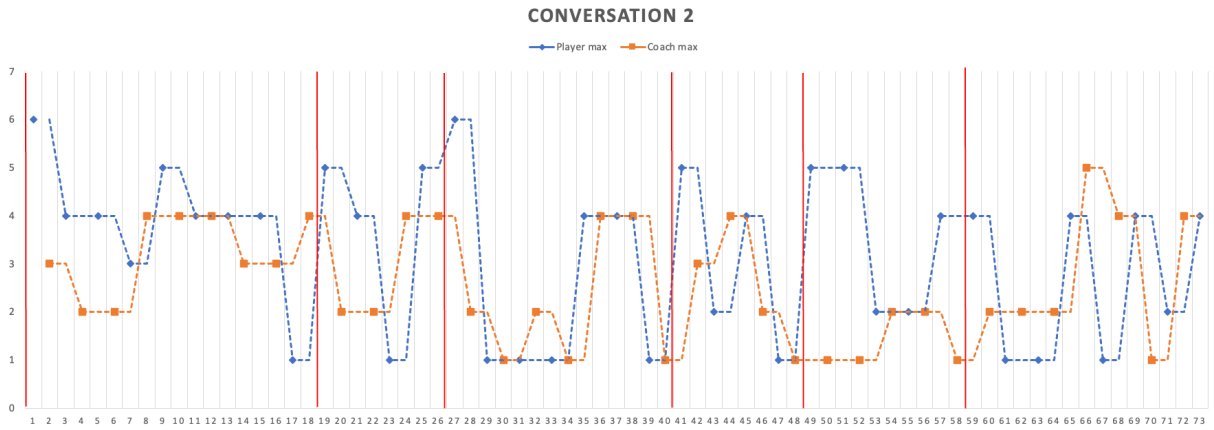

Figure 2. Conversation between coach 2 and player 2. The vertical red lines indicate the start of a new videoclip.

In the third conversation, the difference in mean Skill Theory-level between the player and the coach is even more evident. The player demonstrates a higher average level (M = 3.65; SD = 1.50; min = 1; max = 6) compared to the coach (M = 2.43; SD = 1.30; min = 1; max = 5), resulting in a gap of 1.22 points. There appears to be a significant difference in Skill Theory-levels (p=.002) between the two participants. Figure 3 shows that the player more frequently responds at Skill Theory-levels 5 and 6, whereas the coach asks a level 5 question only once. Most of the coach's questions are at levels 1 and 2. It seems like the player is hardly challenged by the coach to improve their level of game reading.

Similar to the other conversations, there is no support for the assumption that the coach follows the players' lead (r = .013). No evidence was found to support the possibility that the coach guides the player during the conversation (r = -.178). This demonstrates only weak relations.

There is no evidence to support the idea that the coach used scaffolding techniques in the interaction.

Moreover, no signs of development in the players' game reading emerged during the conversation. The variation in Skill Theory-levels from both participants appears to be random, rather than the result of a structured approach or growth.

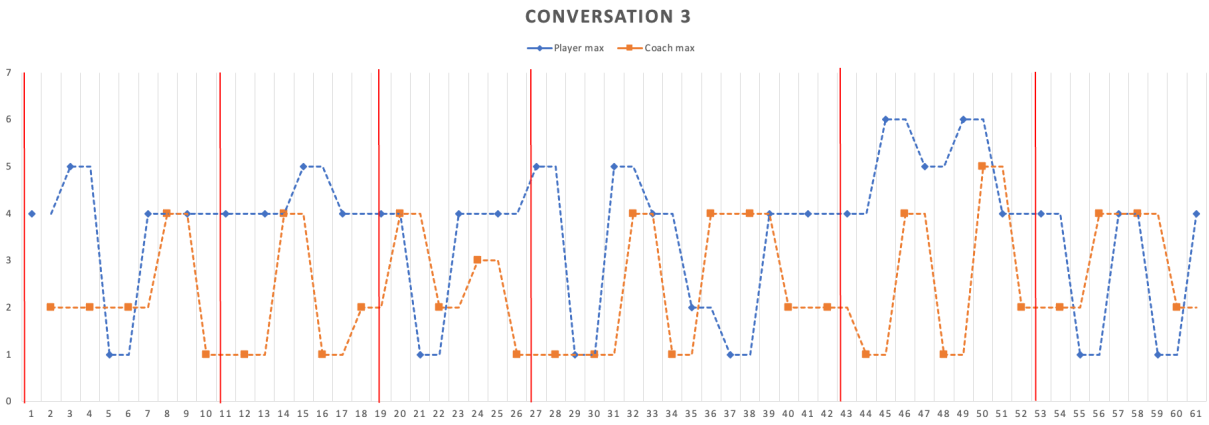

Figure 3. Conversation between coach 3 and player 3. The vertical red lines indicate the start of a new videoclip.

Conclusion

The players show significant higher Skill Theory-levels in two out of the three conversations. The varying levels of questions and answers seem random and suggest that the coaches interact without a clear plan. There is no significant evidence for a relation between the Skill Theory-level of the questions of the coach and the players' answers, in either direction.

Across all three conversations, there is no observable pattern that would indicate scaffolding by any of the three coaches. Likewise, there appears to be no pattern of growth in the players' game reading levels. It should be noted that the players' game reading levels were already quite high at the beginning of the conversations. Nonetheless, the maximum level (7) was never achieved.

Discussion

This study aimed to investigate whether the amount of scaffolding used by professional soccer coaches during video-feedback sessions is related to the development of game reading skills in talented youth players. Based on Skill Theory (Fischer, 1980; Den Hartigh et al., 2014) and a Complex Dynamic Systems (CDS) perspective, it was expected that coaches who adaptively increase the complexity of their questions, in response to the players' answers, would stimulate growth in players' cognitive representations of game play. However, the findings across three analyzed sessions do not support this hypothesis.

Across three conversations, no pattern was found suggesting development in the Skill Theory levels within the players' utterances, nor a pattern that would suggest any form of scaffolding by the coaches. The results suggest that neither the coaches took the lead in the conversation to challenge the players, nor that the coaches have followed the level of the players. In two of the three conversations, the coaches' questions were of a significant lower

level than the players' prior response, indicating missed opportunities for game reading development.

From a CDS perspective, learning is the result of dynamic interactions between actors (coach and player) and context (game reading task). Contrary to the expectations, the results did not show evidence for development within these interactions. The observed variations in Skill Theory levels were more random than structured and lacked the sequential pattern that characterizes scaffolding (Van Geert & Steenbeek, 2005).

It is important to take into consideration that the game reading level of two of the participating players is already quite high, with average Skill Theory scores of 3.65 and 3.74 and a maximum up to level 6 (out of 7). In comparison to previous research by Den Hartigh et al. (2018); selected youth players had an average score of 3.46, while non-selected players had an average of 3.34. The high scores in this study could be explained by the fact that we used data of selected players from the KNVB national team under-15 and under-16. They are expected to be the best players in the country of their respective age category. The difference in level of game reading might not be as high as expected because they are already at a very high level. The high level of game reading combined with lack of challenge provided by the coach may have reduced the room for visible growth within the limited time span of a single session. This might be different for non-selected Dutch Premier League players and non-professional players. Nevertheless, Skill Theory-level 7 was never achieved in any of the conversations, suggesting there was still developmental potential that remained untouched.

Theoretical and practical implications

These findings suggest that scaffolding, as conceptualized in developmental psychology, may not automatically be used in interactions in sports, even when coaches are experienced professionals and players are highly talented. This implies a gap between pedagogical theory and the coaching practice in high performance settings. It may be possible

that in this setting the focus is more shifted towards task performance than cognitive development.

Furthermore, Skill Theory provides a powerful tool to analyze complexity levels in soccer related utterances, however its application in coaching interactions is relatively new. Prior studies using Skill Theory in sports contexts have examined individual responses to videoclips without coach involvement (Den Hartigh et al., 2014; 2018). This study extends that work by using the soccer specific Skill Theory framework in a dynamic, interactional setting.

Thirdly, the lack of scaffolding may be due to contextual parts of the study, such as time pressure or performance expectations. Scaffolding may be better observed in a setting with clear (scaffolding) instructions and developmental goals (Van Geert & Steenbeek, 2005).

From a practical coaching perspective, the findings offer important insights. The absence of scaffolding suggests that the KNVB coaching education may benefit from paying attention to cognitive development skills, such as pedagogical skills, adaptive questioning (Van der Steen et al., 2014), and learning how to bridge a players' "zone of proximal development" (Vygotsky, 1962). Scaffolding is an important developmental skill, which appears to be underutilized in the current video-feedback task. While coaches often possess tactical knowledge and game insight, they may lack sufficient pedagogical skills and understanding to effectively stimulate cognitive development in players.

Moreover, the data suggests that talented youth players have high level game reading skills, but their potential has not been challenged within the analyzed sessions. Coaches may have unintentionally limited the learning potential by asking questions of lower Skill Theory-levels and lacking challenge in their approach. Coaches may benefit from learning scaffolding tactics, for instance recognizing the players level of reasoning, formulating questions that are just beyond this level and guiding the player through gradual increases in complexity. This

training can be developed through both Skill Theory and Complex Dynamic Systems approaches, which together could help coaches in stimulating more advanced game reading in youth soccer players.

Lastly, this study serves as a reminder that talented players still require challenge. High game reading levels should not be a reason to reduce the challenge placed on the young athletes. They have a strong foundation upon which more understanding can be built. Without challenge young soccer players may hit a cognitive platform and may not reach their full potential.

Limitations and future directions

Although the approach of the design was large, the sample size used for this study (three conversations) was small, as this study functions as a pilot for a larger ongoing project. This limits the generalizability.

Secondly, while the soccer specific coding system is well-validated, the focus on the highest level per utterance may have limited the value of the entire utterance. Within a player utterance that includes both a high-level insight and a low-level description, only the single highest score was counted, which may change the visible patterns. Future research could further analyze this by for instance using an average of utterance complexity or other metrics.

Thirdly, the video-feedback task was conducted in a naturalistic environment during an actual training camp. While this supports the ecological validity, it also means that the sessions were not controlled for scaffolding. Future research could manipulate the extent of scaffolding by informing coaches about scaffolding strategies or scripting questions of different Skill Theory-levels.

Lastly, future research could study longitudinal effects through repeated sessions with scaffolding to examine the progress of game reading over a period of time.

References

Abernethy, B., Thomas, K. T., & Thomas, J. T. (1993). Strategies for improving understanding of motor expertise [or mistakes we have made and things we have learned!!]. In J. L. Starkes & F. Allard (Eds.), *Advances in psychology* (Vol. 102, pp. 317–356). Elsevier. https://doi.org/10.1016/S0166-4115(08)61478-8

Ali, A. (2011). Measuring soccer skill performance: A review. *Scandinavian Journal of Medicine & Science in Sports, 21*(2), 170–183. https://doi.org/10.1111/j.1600-0838.2010.01256.x

Chang, H.-Y., Sung, Y.-T., & Chen, I.-D. (2002). The effect of concept mapping to enhance text comprehension and summarization. *Journal of Experimental Education*, *71*(1), 5–23.

Cuevas, C., Quilón, D., & García, N. (2020). Techniques and applications for soccer video analysis: A survey. Multimedia Tools and Applications, 79(39–40), 29685–29721. https://doi.org/10.1007/s11042-020-09409-0

De Meij, M., Van Der Steen, S., & Den Hartigh, R. J. R. (2012). *Codeerboek voor het meten van cognitieve vaardigheden van voetballers* [Coding book to measure cognitive skills of soccer players]. University of Groningen, Department of Psychology.

Den Hartigh, R. J. R., Van der Steen, S., De Meij, M., Van Yperen, N. W., Gernigon, C., & Van Geert, P. L. C. (2014). Characterising expert representations during real time action: A Skill Theory application to soccer. *Journal of Cognitive Psychology, 26*(7), 754–767. https://doi.org/10/1080/20445911.2014.955530

Den Hartigh, R. J. R., Van Der Steen, S., Hakvoort, B., Frencken, W. G. P., & Lemmink, K. A. P. M. (2018). Differences in game reading between selected and non-selected youth soccer players. *Journal of Sports Sciences, 36*(4), 422–428. https://doi.org/10.1080/02640414.2017.1313442

Fischer, K. W. (1980). A theory of cognitive development: The control and construction of hierarchies of skills. *Psychological Review, 87*(6), 477–531.

Fischer, K. W., & Bidell, T. R. (2006). Dynamic development of action and thought. In R. M. Lerner (Ed.), *Theoretical models of human development. Volume 1 of Handbook of child psychology* (6th ed., pp. 313–399). Wiley.

Groom, R., Cushion, C., & Nelson, L. (2011). The delivery of video-based performance analysis by England youth soccer coaches: Towards a grounded theory. *Journal of Applied Sport Psychology, 23*(1), 16–32. Https://doi.org/10.1080/10413200.2010.511422

Groom, R., Cushion, C., & Nelson, L. (2012). Analysing coach-athlete 'talk' in elite sport: Towards a conceptual framework. *Sports Coaching Review, 1*(2), 120–134. Https://doi.org/10.1080/2159676X.2012.693525

Mason, R. J., Farrow, D., & Hattie, J. A. (2020). An analysis of in-game feedback provided by coaches in an Australian Football League competition. *Physical Education and Sport Pedagogy*, *25*(5), 464–477. https://doi.org/10.1080/17408989.2020.1734555.

Meindertsma, H., & Van Geert, P. (2014). Predictions and explanations: short-term processes of scientific understanding in young children [Dissertation]. Rijksuniversiteit Groningen

Olson, J. and Platt, J. (2000). The Instructional Cycle. Teaching Children and Adolescents with Special Needs (pp. 170-197). Upper Saddle River, NJ: Prentice-Hall, Inc.

Otte, F. W., Davids, K., Millar, S., & Klatt, S. (2020). When and how to Provide Feedback and Instructions to Athletes? How Sport Psychology and pedagogy Insights can improve coaching interventions to Enhance Self-Regulation in Training. Frontiers in Psychology, 11. https://doi.org/10.3389/fpsyg.2020.01444

Potrac, P., Brewer, C., Jones, R., Armour, K., & Hoff, J. (2000). Toward an holistic understanding of the coaching process. Quest, 52(2), 186–199. https://doi.org/10.1080/00336297.2000.10491709

Reilly, T., Williams, A. M., Nevill, A., & Franks, A. (2000). A multidisciplinary approach to talent identification in soccer. Journal of Sports Sciences, 18(9), 695–702. https://doi.org/10.1080/02640410050120078

Van Der Steen, S., Steenbeek, H., Van Dijk, M., & Van Geert, P. (2014). A process approach to children's understanding of scientific concepts: A longitudinal case study. *Learning and Individual Differences, 30*, 84–91. https://doi.org/10.1016/j.lindif.2013.12.004

Van Der Steen, S., Steenbeek, H., Wielinski, J., & Van Geert, P. (2012). A Comparison between Young Students with and without Special Needs on Their Understanding of Scientific Concepts. Education Research International, 2012, 1-12. https://doi.org/10.1155/2012/260403

Van Der Steen, S., Steenbeek, H. W., Hartigh, R. J. D., & Van Geert, P. L. (2019). The Link between Microdevelopment and Long-Term Learning Trajectories in Science Learning. Human Development, 63(1), 4–32. https://doi.org/10.1159/000501431

Van Der Stuyf, R. R. (2002). *Scaffolding as a teaching strategy*. Adolescent Learning and Development, Fall 2002.

Van Geert, P. (2000). The dynamics of general developmental mechanisms: From Piaget and Vygotsky to dynamic systems models. *Current Directions in Psychological Science, 9*(2), 64–68. https://doi.org/10.1111/1467-8721.00062

Van Geert, P. (2008). The dynamic systems approach in the study of L1 and L2 acquisition: An introduction. *Modern Language Journal, 92*(2), 179–199.

Van Geert, P. (2011). The contribution of complex dynamic systems to development. *Child Development Perspectives, 5*(4), 273–278. https://doi.org/10.1111/j.1750-8606.2011.00197.x

Van Geert, P., & Steenbeek, H. (2005). The dynamics of scaffolding. *New Ideas in Psychology, 23*(3), 115–128.

Van Geert, P., & Steenbeek, H. (2013). The emergence of learning-teaching trajectories in education: A complex dynamic systems approach. *Nonlinear Dynamics, Psychology, and Life Sciences, 17*(2), 233–267.

Vestberg, T., Jafari, R., Almeida, R., Maurex, L., Ingvar, M., & Petrovic, P. (2020). Level of play and coach-rated game intelligence are related to performance on design fluency in elite soccer players. *Scientific Reports, 10*, 9852. https://doi.org/10.1038/s41598-020-66180-w

Vygotsky, L. S. (1962). *Thought and language*. MIT Press.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes* (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds.). Cambridge, MA: Harvard University Press.

Weisstein, E. W. (1999). *CRC concise encyclopedia of mathematics*. CRC Press.

Williams, A. M. (2000). Perceptual skill in soccer: Implications for talent identification and development. *Journal of Sports Sciences, 18*(9), 737–750.

During the writing of this thesis, I made limited use of AI tools (such as ChatGPT) only to assist in rephrasing sentences and summarizing literature. All content related decisions, interpretations and writing were carried out by me. All sources have been properly verified and cited.

Appendix

Excel: Data Thesis Sem Hangx