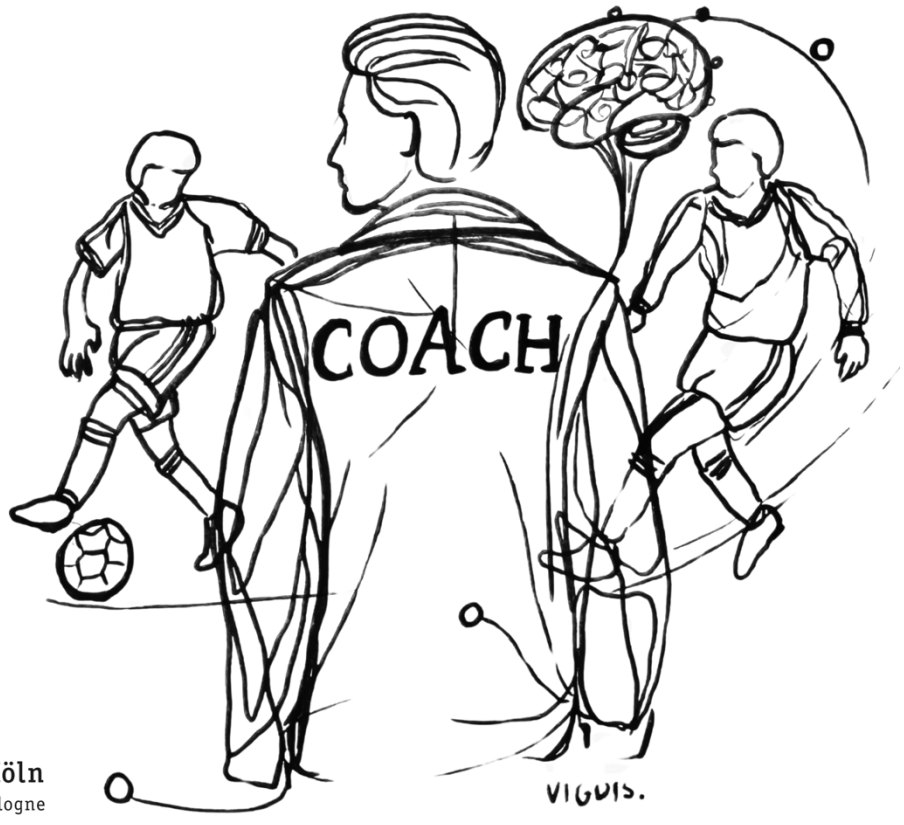
DISSERTATION

A coach's perspective on perceptual-cognitive skills in elite youth soccer

Sinikka Heisler



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Institute of Psychology, Dept. Performance Psychology
German Sport University Cologne
Head of Institute: Prof. Dr. Jens Kleinert

A coach's perspective on perceptual-cognitive skills in elite youth soccer

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Sinikka Marie Heisler
from Hamburg, Germany

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First reviewer:	Prof. Dr. Dr. Markus Raab
Second reviewer:	Prof. Dr. Matthias Weigelt
Chair of the doctoral committee:	Prof. Dr. Mario Thevis
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Affidavits following §7 section 2 No. 4 and 5 of the doctoral regulations from the German Sport University Cologne, February 20th 2013:

Hereby I declare:

The work presented in this thesis is the original work of the author except where acknowledged in the text. This material has not been submitted either in whole or in part for a degree at this or any other institution. Those parts or sentences taken verbatim from other sources, are identified as citations.

I further declare that I complied with the actual “guidelines of qualified scientific work” of the German Sport University Cologne.

Date, Signature

For my family.

Acknowledgements

Defining a metaphor for one's doctoral journey is a tradition at our institute. In my case, I chose a road trip in a VW bus. I made this choice not only because some of my best childhood memories were made traveling through Europe but also because I knew that I would be moving flexibly between various places on my path to completing my doctorate. On this journey—from the soccer field to the institute, between Hamburg and Cologne—many accompanied me part of the way, helping me refuel, pack, or even guiding me along the route. It was a long and rewarding road, marked by the contributions of many, whether on a scientific, applied, or emotional level, all of which I equally value and appreciate.

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Abstract

This dissertation aimed to explore and evaluate the perceptual-cognitive skills (PCSs) of elite youth soccer players from the perspective of experienced coaches and to transfer scientific knowledge into actionable strategies for standardizing subjective assessment procedures in the field. Grounded in a developmental embodied cognition framework, the research project employed a co-productive approach within a mixed-methods study design, fostering collaboration between scientists and practitioners to ensure scientific rigor and practical relevance. Through qualitative video-stimulated interviews, the first study identified 26 soccer-specific PCSs, characterized by behavioral descriptions and grouped into four overarching domains. A heuristic model was presented, highlighting the dynamic and intertwined nature of PCSs involved in each playing situation. A subsequent quantitative evaluation of PCSs revealed that switching, preorientation, and spatial awareness were rated as highly relevant, frequently utilized during play, and readily observable, underscoring their significance for player assessment, talent identification, and development. A gap in the language used by coaches compared to scientific terminology was identified, indicating differences in conceptualizations and a lack of unified PCS-related vocabulary. The empirical findings informed the development of an evaluation form designed to support coaches and scouts in the observational assessment of PCSs during gameplay. This dissertation thereby contributes to an advocated shift from a static to a dynamic consideration of youth players' performance indicators, involving age-specific and context-sensitive evaluation criteria. It provides a robust foundation for improving talent identification and player development strategies, with implications for future scientific and applied directions.

Zuammenfassung

Die vorliegende Dissertation hatte zum Ziel, die perzeptuell-kognitiven Fähigkeiten (PCSs) von Nachwuchsleistungsfußballern aus der Perspektive erfahrener Trainer zu untersuchen und wissenschaftliche Erkenntnisse in umsetzbare Strategien zur Standardisierung subjektiver Bewertungsverfahren in die Praxis zu überführen. Basierend auf einer Entwicklungs-Embodiment-Perspektive wurde ein ko-produktiver Ansatz innerhalb eines Mixed-Methods-Designs verfolgt, um die Zusammenarbeit zwischen Wissenschaftlern und Praktikern zu fördern. Mithilfe qualitativer, video-stimulierter Interviews identifizierte die erste Studie 26 fußballspezifische PCSs, die durch Verhaltensbeschreibungen charakterisiert und in vier übergeordnete Kategorien gruppiert wurden. Ein heuristisches Modell wurde entwickelt, das die dynamische und eng verwobene Natur der PCSs in verschiedenen Spielsituationen verdeutlicht. Eine anschließende quantitative Evaluation der PCSs ergab, dass Fertigkeiten wie Umschalten, Vororientierung und räumliches Bewusstsein als hoch relevant, häufig im Spiel genutzt und leicht beobachtbar bewertet wurden, was ihre Bedeutung für Spielerbewertung, Talentidentifikation und -entwicklung unterstreicht. Ein Unterschied in der Sprachverwendung von Trainern im Vergleich zu wissenschaftlicher Terminologie wurde festgestellt, was auf Unterschiede in den Konzeptualisierungen und einen Mangel an einer einheitlichen PCS-bezogenen Sprache hinweist. Die empirischen Ergebnisse flossen in die Entwicklung eines Bewertungsbogens ein, der Trainer und Scouts bei der Beurteilung von PCSs durch Beobachtung unterstützt. Diese Dissertation leistet einen Beitrag zu einem propagierten Wandel von einer statischen zu einer dynamischen Betrachtung der Leistungsindikatoren von Nachwuchsspielern, indem alters- und kontextspezifische Bewertungskriterien einbezogen werden. Sie stellt bildet eine Grundlage für die Verbesserung von Strategien zur Talentidentifikation und Spielerentwicklung und bietet Implikationen für zukünftige wissenschaftliche und praktische Anwendungen.

List of included articles

This publication-oriented dissertation comprises three manuscripts that have been submitted to peer-reviewed journals in English language[1]. In line with the guidelines of the German Psychological Society (Deutsche Gesellschaft für Psychologie, DGPs), this dissertation adopts a publication-oriented approach, integrating three submitted but yet-to-be-published manuscripts. This structure was deliberately chosen to foster a highly integrated connection among all three papers, enabling multiple rounds of analysis throughout the process. As such, the DGPs explicitly advocate including unpublished manuscripts within doctoral theses to accommodate potential publication delays, thereby ensuring that the dissertation may be solely based on non-published manuscripts if necessary (Deutsch et al., 2016, p. 129).

ARTICLE 1 | Video-based assessment of perceptual-cognitive skills in youth soccer from professional coaches' perspective

Heisler, S. M., Musculus, L., & Lobinger, B. H. (submitted to *International Journal of Sport and Exercise Psychology*)
Date of submission: September 15th, 2024

ARTICLE 2 | Coaches' evaluation of domain-specific perceptual-cognitive skills in youth soccer

Heisler, S. M., Lobinger, B. H., Siebler, M., Raab, M., & Musculus, L. (under review in *Journal of Sports Sciences*)
Date of submission: November 8th, 2024

ARTICLE 3 | Observational assessment of perceptual-cognitive skills in youth soccer players: Empirically informed, theory-based recommendations

Heisler, S. M., Musculus, L., & Lobinger, B. H. (submitted to *Journal of Applied Sport and Exercise Psychology*)
Date of submission: December 9th, 2024

[1] This dissertation has been partially edited using artificial intelligence (AI) tools solely for linguistic and grammatical purposes. No content-related contributions or modifications were made using AI tools.

1. Preface

This work was begun, written, and completed with passion—a passion for soccer and a desire to contribute to the description, explanation, prediction, and optimization of performance - critical goals in sports psychology research and practice (Lobinger & Stoll, 2019). To understand the origins of this work, we need to look back 20 years and return to the tennis clubhouse of TSV Sasel, an unlikely place to serve as the foundation for a dissertation on perceptual-cognitive skills in elite youth soccer. Yet, it was here that I started spending Saturday afternoons with my brother and father, watching HSV (Hamburger Sportverein) players like Mehdi Mahdavikia, Sergej Barbarez, and Daniel Van Buyten creating on-field numerical advantages with outstanding decision-making, executing creative through-balls or intercepting long passes through precise anticipation.

To this day, I cannot pinpoint exactly what inspired me to dedicate my scientific career to studying perceptual-cognitive skills. However, my childhood undeniably played a significant role in shaping this focus, as I began exploring my environment with curiosity from an early age. This curiosity eventually led me to take my first research steps in 2016, centered on this topic. Since 2019, I have expanded my perspective by incorporating an applied approach, gaining valuable experience as a sports psychologist in elite youth soccer. This dual perspective—combining scientific and applied views on psychological phenomena in soccer—is, alongside passion, the foundation of this work. From the beginning, I was motivated to choose a topic that contributes to research and holds practical relevance. I was fortunate to work alongside writing this thesis as a sports psychologist in the HSV and VfL Wolfsburg youth academies, where I observed countless training sessions and matches and witnessed the diverse factors that differentiate players' skills and performance. One aspect that immediately captured my attention was the desire to understand what once seemed like a black box: the perceptual-cognitive skills that drive soccer players' highly dynamic and adaptive performance on the field.

I was fascinated by how young players could often "read" the game without directly focusing on every detail, processing overwhelming stimuli within milliseconds. Their ability to anticipate options before they became apparent ignited my enthusiasm for the fields of perception and cognition. When coaches repeatedly asked me how these skills could be assessed and trained, I realized this was an area I wanted to explore in greater depth. This project is, therefore, strongly driven by the integration of theory and practice, honoring the "two hearts" that beat within my chest.

2. Introduction

"Soccer[2] is a game you play with your brain. You have to be in the right place at the right moment, not too early, not too late."

Johan Cruyff

In the dynamic sport of soccer, a complex interplay of different factors shapes performance. Players must possess excellent technical and athletic skills, adapt rapidly to changing environments, and make advantageous decisions within split seconds (Casanova et al., 2009). To do so, players use perceptual-cognitive skills (PCSs) such as pattern recognition, anticipation, or problem-solving, allowing them to act flexibly in complex game dynamics (Mann et al., 2007). Researchers and practitioners—including coaches, scouts, and club representatives—are deeply interested in uncovering the factors that define expertise and predict performance in soccer (Haugaasen & Jordet, 2012; Williams & Reilly, 2000). Among the diverse criteria used for talent assessment and identification, including physiological, physical, sociological, and psychological dimensions, PCSs have consistently been described as crucial factors (e.g., van Maarseveen et al., 2018; Williams et al., 2020). Nevertheless, there remains uncertainty about unified, soccer-specific conceptualizations of PCSs, which are an essential foundation for many scientific and practical purposes (Kalén et al., 2021). Scientifically, this knowledge is critical for evidence-based model development in expertise and talent identification research (Williams et al., 2020). Further, it is crucial for developing appropriate study designs, informing task and response selection, and optimizing test settings (Kalén et al., 2021). Practically, this knowledge is needed to maximize player assessment, mainly based on unsystematic procedures (e.g., Bergkamp et al., 2022a). Mostly, coaches and

[2] Johan Cruyff originally used the British word *football*, but for language consistency this was adapted to American wording (see e.g., Caso et al., 2023)

scouts observe players from the sidelines, using subjective evaluations of a non-standardized set of criteria to both evaluate current skills and predict future performance (Lawlor et al., 2021; Musculus & Lobinger, 2018; Sarmento et al., 2018). Consequently, there is a need for unified knowledge and language to improve standardized and ecologically valid assessment procedures in the field (Christensen, 2009; Musculus & Lobinger, 2018).

This publication-oriented dissertation (Deutsch et al., 2016) addresses these needs by investigating PCSs in elite youth male soccer players through a coach's perspective. This research program will adopt a developmental embodied cognition perspective (Lux et al., 2021; Musculus et al., 2021). This underlying integrated perspective will investigate PCSs in players aged 13 to 16 in an ecologically valid setting. This includes exploring PCSs in real-life game footage by highly experienced professional coaches to account for embodied cognition assumptions (Wilson, 2002). Embodied cognition posits that PCSs are fundamentally shaped by the dynamic interaction between the player and their environment (Musculus & Raab, 2022). Therefore, to accurately understand these skills, they must be studied within the specific context in which they are applied (Voigt et al., 2023). Professional coaches with extensive experience gained through their playing careers and years of observing high-level games are uniquely equipped to identify and interpret subtle and context-specific information (Raab & Araújo, 2019). A coach's perspective thereby provides access to practice-based knowledge while at the same time fostering the much-needed connection between theory and practice (Musculus & Lobinger, 2018). Investigating PCSs in a youth sample addresses the scientific call to expand research across different age groups, a critical yet often overlooked focus in adult-centered studies (Marasso et al., 2014). This essential perspective facilitates a deeper understanding of the dynamic and non-linear nature of motor-cognitive growth, which is pivotal for developing age-appropriate models and formulating practical, context-specific recommendations on player assessment (Musculus et al., 2021). Importantly, given the general scientific shortcomings in

research on youth soccer players' PCSs (e.g., Scharfen & Memmert, 2019), this dissertation program is framed as usage-inspired basic research (Hassmén et al., 2016). This type of research is a necessary foundation to strengthen and inform future scientific investigations and practical applications. Specifically, this dissertation aims to establish robust methods for investigating age- and soccer-specific PCSs, a critical step in advancing the understanding of motor-cognitive interactions in youth athletes (Musculus & Raab, 2022). Further, from a practical point of view, understanding PCSs in a youth sample allows for age-tailored approaches in player assessment, talent identification, and development (e.g., Heisler et al., 2023).

Building upon these scientific and practical needs, the dissertation's objectives are multifaceted and elaborated on in more detail in Chapter 4.1. The first objective was to explore soccer-specific PSCs' conceptualizations (Article 1), and the language used within the field (Article 2), to evaluate the importance of PSCs for youth soccer performance and assessment (Article 2), and to transfer scientific knowledge to practice by providing evidence-based recommendations for standardized player assessment (Article 3). Guided by the concept of intelligent practice—defined by Glasgow (2013) as the integration of scientific findings into practical, reflective applications—and by usage-inspired basic research, which aims to build fundamental knowledge with practical relevance (Hassmén et al., 2016), this project seeks to produce actionable strategies for assessment procedures and research on expertise, talent identification, and development in the area of soccer-specific PCSs from a coach's perspective.

3. Theoretical background

3.2. Perceptual-cognitive skills

PCSs are defined as the capacity of individuals to locate, identify, and process environmental information and integrate it with existing knowledge to execute an action effectively and readily (Mann et al., 2007; Roca et al., 2013; Tomporowski, 2003). Following Kalén et al. (2021), skills are established through extended practice in a specific domain, such as soccer, and are expressed as observable behaviors (Ericsson, 2003; Ericsson et al., 2014). In soccer, this includes skills such as recognizing familiar patterns, anticipating actions, or solving problems on the field, which enable players to respond swiftly and accurately, even under environmental constraints (Broadbent et al., 2015; Mann et al., 2007). Accordingly, players use PCSs to adapt to a highly dynamic and complex environment that requires fast responses and goal-directed behavior (Travassos et al., 2012; van Maarseveen et al., 2018). Due to these characteristics, skills can be differentiated from perceptual-cognitive functions (PCFs), defined as general mechanisms underlying goal-directed actions in everyday life and are not necessarily directly observable (Diamond, 2013). This distinction inherently introduces another critical scientific differentiation: the contrast between domain-specificity and domain-generality (e.g., Kalén et al., 2021). This conceptual distinction emphasizes whether skills and functions are broadly transferable across various contexts and tasks (domain-general) or adapted explicitly to particular domains (domain-specific), such as specific sports disciplines (Scharfen & Memmert, 2019). Significantly, this distinction extends beyond the contextual level to methodological considerations, encompassing stimuli and response selection. For example, domain-general tasks might involve generic responses such as pressing a button to indicate a decision (e.g., Schumacher et al., 2024), while domain-specific tasks require context-relevant motor executions, such as a soccer player executing a pass (e.g., Musculus et al., 2022). Recent research underscores the pivotal role of domain-

specific PCSs in explaining expertise and predicting future performance (Kalén et al., 2021), which drives the focus of this dissertation toward an in-depth investigation of soccer-specific PCSs.

2.1.1 Perceptual-cognitive skills in talent identification and development

In talent identification and development, which is the systematic process aimed at recognizing and nurturing players with the potential to reach elite performance in the future, PCSs are regarded as fundamental skills (Williams et al., 2020). In soccer, talent identification and development models were pioneered by Williams and Reilly (2000), who outlined critical criteria for talent, integrating PCSs such as attention, anticipation, decision-making, game intelligence, creative thinking, and motor/technical skills. As understanding of these skills evolved, so did the models, leading Williams and colleagues in 2020 to present an updated model highlighting a more refined set of factors, including game intelligence and tactical skills with their visual search, anticipation, and decision-making sub-categories. These models continue to inform theory and practice and are designed to highlight observable skills and characteristics linked to high performance, offering a basis for selecting and developing players (Unnithan et al., 2012). However, despite the increasing sophistication of models, criticisms have raised concerns about the scientific rigor behind these frameworks (e.g., Larkin & Reeves, 2018). For example, the validity of talent predictors has been questioned, noting that these are often derived from cross-sectional expertise studies rather than longitudinal designs, limiting their predictive power (Vaeyens et al., 2008).

Additionally, many studies inform talent identification models through retrospective research, which Hohmann (2005) criticizes for focusing primarily on the characteristics of already successful athletes. This approach assumes that the skills observed in elite players were present and identifiable at an early age, neglecting the dynamic and non-linear nature of talent development (Hohmann, 2005). Accordingly, the broad applicability of these models to diverse

player trajectories and development pathways has been questioned, with researchers emphasizing the need for a sport-specific and developmental focus beyond generalized predictors (Larkin & Reeves, 2018; Musculus & Raab, 2022). In response to these critiques, some experts now argue for the concept of “performance identification” rather than "talent identification," as it reflects a more dynamic and domain-specific approach (Larkin & Reeves, 2018). This perspective suggests that rather than investigating static attributes in players, their performance should be studied more dynamically, including assessments that focus on a player’s observable skills and behaviors in performance contexts (Baker et al., 2019; Unnithan et al., 2012).

To account for this shift, a developmental embodied cognition perspective is an underlying theoretical framework (Lux et al., 2021; Musculus & Raab, 2022). First, empirical support of non-linear perceptual-cognitive growth (Chin et al., 2021; Musculus et al., 2019) questions the applicability of adult-focused research findings to children and youth samples (Marasso et al., 2014). Additionally, this perspective emphasizes that motor development precedes cognitive development (Gottwald et al., 2016; Ridler et al., 2006) and that bodily changes are linked to cognitive changes (Hommel & Kibele, 2016). Consequently, talent models must consider age-specific development, integrating physical and mental growth interplay during critical periods (Musculus et al., 2021). Given the assumed differences between genders in the onset of these critical cognitive periods (e.g., Bramen et al., 2011) it is important to further investigate these differences and consider the development of gender-specific models. By doing so, such models can more accurately capture the evolving nature of PCSs and ensure that assessment and development approaches are appropriately tailored to the developmental stages of youth players. This dissertation focuses on male youth players and outlines future research directions for female players in Chapter 10. Within this research program the age range of 13 to 16 has been chosen because it has been identified as a central age of cognitive

development (e.g., Mata et al., 2011). Additionally, from a practical point of view, this age is crucial as clubs start to ramp up their scouting efforts and invest in long-term commitments to promising players (Larkin & Reeves, 2018). These efforts involve evaluating players' performance based on criteria identified as critical for soccer success, primarily derived from findings in expertise research (Mann et al., 2007).

2.1.2 Perceptual-cognitive skills and expertise

Expertise research aims to identify the key factors and mechanisms that distinguish elite players from their less-skilled counterparts (Mann et al., 2007). Two major theoretical approaches examine expertise in perception and cognition: expert-performance and cognitive component skill approaches. The expert-performance approach (Ericsson, 2003) emphasizes domain-specific expertise, positing that expertise differences are best measured within sport-specific environments and through assessments that closely mirror in-game tasks (Roca et al., 2011). This approach suggests that domain-specific skills, closely linked to environmental demands, play a more direct role in expert performance than domain-general functions (Casanova et al., 2009). On the other hand, the cognitive component skill approach (Nougier et al., 1991) proposes that athletes may demonstrate superior performance in domain-general PCFs, like executive functions, that are not directly tied to the sport but are applicable across various contexts (Voss et al., 2010). A recent meta-analysis by Kalén et al. (2021) highlights the predictive power of PCSs over PCFs. This analysis revealed that skills tailored to the sport, such as anticipation and game intelligence, were more strongly correlated with sports expertise and performance than PCFs, such as executive functions. Consequently, these findings challenge the effectiveness of using domain-general measures alone for assessing sport-specific expertise or talent, suggesting that talent identification and development should focus on PCSs relevant to gameplay (Beavan et al., 2020).

Expertise differences in PCSs in soccer players have been intensively reported (e.g., Mann et al., 2007). For instance, elite soccer players exhibit greater accuracy in decision-making, supported by evidence that their decision-making performance improves significantly with sport-specific training and gameplay experience (Roca et al., 2013). Similarly, anticipation skills are superior among elite players compared to non-elite players (Gonçalves et al., 2015), and they exhibit a higher frequency of visual search behavior (Roca et al., 2018) when compared to players with lower expertise, often honed through extensive, sport-specific experience (e.g., Bennett et al., 2019). While there is still an overrepresentation of adult-focused research, studies on children and youth players also show differences in expertise in PCSs (Marasso et al., 2014). For example, selected elite players outperform non-selected players in decision-making tasks, with better decision-making accuracy attributed to superior perceptual and cognitive processing (Machado et al., 2023). Further, research indicates that scanning behavior—encompassing both the frequency and quality of visual fixations—plays a crucial role in anticipation and decision-making among young elite soccer players (Aksum et al., 2021; Vítor de Assis et al., 2020). Studies have shown that players with higher scanning frequencies tend to make more successful passes and tactical decisions (Aksum et al., 2021) and demonstrate greater tactical efficiency (Vítor de Assis et al., 2020), highlighting the role of advanced PCSs in distinguishing expertise levels. Moreover, these studies underscore the interconnectedness of various PCSs in soccer-specific performance, emphasizing the importance of examining them integratively rather than in isolation (Bergkamp et al., 2019). These exemplary empirical results can inform criteria selection for player assessment and talent identification procedures. Still, a critical question remains whether the skills typically assessed are utilized during real-game play, ensuring ecological validity (van Maarseveen et al., 2018). While methods incorporating soccer-specific stimuli and responses enhance ecological validity, the overall conceptualization of soccer-

specific PCSs remains limited and fragmented (Christensen, 2009; Larkin & O'Connor, 2017; & Larkin et al., 2020). Most studies have focused on a narrow set of PCSs, such as anticipation, decision-making, or visual exploratory behavior (Mann et al., 2007). Nevertheless, PCSs in soccer do not function independently but are dynamically shaped by the player's continuous interactions with their environment (Bennett et al., 2019; Wilson, 2002). This underscores the need for a research approach that systematically explores the breadth of PCSs and their interconnectedness rather than focusing on a selected few, fostering a more comprehensive understanding of their interplay and relevance in real-game scenarios (van Maarseveen et al., 2018). This also includes a focus on observation-based assessment to capture players' PCSs in real-world settings (van Meurs et al., 2022). Generally, this assessment can be differentiated into objective and subjective approaches, with both being implemented in soccer research and practice; however, a stronger emphasis is placed on subjective methods in practice (Höner et al., 2021; Musculus & Lobinger, 2018).

2.1.3 Perceptual-cognitive skill assessment

Objective assessment using standardized, quantifiable metrics to evaluate specific skills or attributes while minimizing the risk of personal bias (Höner et al., 2021). Objective assessments are often considered reliable and valid because they measure defined performance outcomes consistently across players (Dugdale et al., 2020). In soccer, the objective evaluation is dominated by domain-general PCFs (e.g., Beavan, 2021) measured with computerized tests, mainly used for scientific purposes and seldom in applied settings. For instance, test batteries like the Vienna Test System (VTS; Schuhfried, 2013) or other computer-based tests have been used to measure domain-general PCFs such as working memory, inhibitory control, cognitive flexibility, or attention (e.g., Heisler et al., 2023; Huizinga et al., 2006; Scharfen & Memmert, 2019). These instruments typically demonstrate high validity, reliability, and objectivity. However, given both non-sport-specific stimuli and response selection, they lack ecological

validity—a crucial factor for practical applicability in sports (Jordet et al., 2005). To increase ecological validity, another line of research considers soccer-specific stimuli in the selection of test methods, often implemented through video sequences or virtual reality, as exemplified in areas such as decision-making (e.g., Musculus et al., 2019; 2021), anticipation (e.g., Vítor de Assis et al., 2021), and pattern recognition (e.g., Beernaerts et al., 2020). Recently, approaches have been developed and applied to integrate a soccer-specific motor response. Some soccer clubs possess complex tools such as Footbonaut (Saal & Fiedler, 2014), Helix (Kittelberg, 2018), and SoccerBot (Heilmann et al., 2021), which aim to measure PCSs in a standardized setting as close to real-game conditions as possible. Yet, due to limited data availability, it remains uncertain whether these methods can address the limitations of traditional lab-based assessments and increase relevance to the game (Musculus et al., 2022). Further, a meta-analysis indicates that sport-specific stimuli selection was more important than response selection (Kalén et al., 2021).

Additionally, non-computerized methods exist, such as observational tools or questionnaires, to assess PCSs in a standardized and mostly holistic manner, mainly conducted in small-sided games (Klingner et al., 2022; Silva et al., 2014). Within these assessment approaches, PCSs are often one part besides other tactical, physical, or technical criteria (Klingner et al., 2022). The evaluation of PCSs in these procedures is usually based on quantitative analysis of positional data (e.g., Barnabé et al., 2016) or structured observations (e.g., van Maarseveen et al., 2018). These include also the use of established systematic observation instruments, such as the “System of Tactical Assessment” (FUT-SAT), which uses a standardized small-sided game set-up and a structured evaluation based on specific tactical criteria (Costa et al., 2011). More recently, the “Talent Identification Questionnaire in Soccer for Outfield Players” (TIDQ-OP) and “Goalkeepers” (TIDQ-GK) have been developed for the context of talent identification (Lethole et al., 2024a; 2024b). The aim was to support the

systematic procedures in the South African talent identification process of outfield players and goalkeepers, using a standardized list of attributes with respective behavioral descriptions (Lethole et al., 2024a; 2024b). The developed and validated questionnaire includes a wide range of skills and attributes (e.g., technical, tactical, and physical attributes), including PCSs.

The above-presented objective procedures mainly serve scientific purposes and are seldom used in players' assessment in the daily procedures of clubs (Bergkamp et al., 2022a). As such, there remains an underrepresentation of objective assessment methods in the field, which is valid for purposes of performance assessment (Jokuschies et al., 2017), talent identification (Bergkamp et al., 2019), and talent development (Williams & Reilly, 2000). Very few clubs can afford to use advanced technology like expensive systems, such as the Vienna-Test-System (Schuhfried, 2013), Helix (Kittelberg, 2018), or SoccerBot (Heilmann et al., 2021). Even in highly professional and financially well-equipped clubs, player assessment largely relies on subjective evaluations by coaches and scouts, who make decisions primarily based on experience and implicitly ingrained models (Höner et al., 2021; Lawlor et al., 2021). Subjective assessment relies on personal judgments and observations, inherently influenced by the evaluator’s experience and perspective (Bergkamp et al., 2022a; Musculus & Lobinger, 2018). Although this subjective assessment has been shown to hold discriminant validity (Höner et al., 2021) and predictive validity (Schorer et al., 2020), it risks undermining scientific quality criteria, such as objectivity and reliability (Musculus & Lobinger, 2018). This has been demonstrated by studies showing that the subjective assessments of coaches can be influenced by biases, such as confirmation bias and overreliance on observable game outcomes, rather than the player's comprehensive skillset (Larkin et al., 2016; Roca & Ford, 2020).

However, their experiential knowledge is precious, as coaches and scouts can often detect nuanced behaviors that may not be captured by objective metrics alone (Roberts et al., 2021). This practice-based insight allows one to interpret complex game situations, recognize

potential, and assess a player's performance in the dynamics of the actual game (Lath et al., 2021). Unlike the above presented objective measures, which target a specific criterion of interest (e.g., decision-making), the subjective assessment by coaches includes a multidimensional perspective including physical, tactical, technical, and psychological attributes, which are yet mainly assessed in an unstructured and holistic manner (Musculus & Lobinger, 2018). From a developmental embodied cognition perspective, this holistic view of coaches adds significant value by acknowledging the interconnectedness of a player's motor-cognitive skills in the dynamic environment rather than assessing them in isolation (Musculus et al., 2021).

This has led to an increased interest in the subjective assessments made by coaches, which has been explored through a research strand known as the "coach's eye" (Christensen, 2009). These studies investigate how coaches and scouts evaluate players and which criteria they use in their assessments (Roberts et al., 2021; Sieghartsleitner et al., 2019). While there is generally a limited understanding of subjective assessments made by coaches and scouts, this knowledge gap is particularly pronounced for PCSs. To date, there are no publications that specifically explore coaches' knowledge and conceptualizations of PCSs or how coaches and scouts evaluate PCSs through observational assessments (e.g., Larkin & O'Connor, 2017). This dissertation, therefore, aims to address these shortcomings by exploring soccer-specific PCSs through a coach's lens, making use of their experiential knowledge.

3.3. The coach's eye

The subjective assessment by coaches and other recruiters has been investigated and referred to as the "coach's eye" (Christensen, 2009) or the "recruiter's eye" (Larkin et al., 2020). In their review, Lath et al. (2021, p. 2) define the coach's eye as "the process of a coach evaluating or assessing athlete performance," characterized as intuitive, experience-based, subjective, and holistic. It reflects the ability of coaches to observe and assess current

performance and identify athletes with the potential for high performance in the future (Roberts et al., 2021). This concept is deeply rooted in the practical expertise coaches develop through years of involvement in their sport, enabling them to make nuanced judgments about an athlete's current abilities and future potential (Bergkamp et al., 2022b). The value of a coach's experiential knowledge in player assessment has been particularly emphasized in talent identification and development research (Lath et al., 2021), often labeled more precisely as the "coach's eye for talent" (Christensen, 2009). This research framework investigates which criteria coaches use to evaluate performance and predict potential and how these criteria are recognized through observation (Sieghartsleitner et al., 2019). The foundation for this line of inquiry was laid by Williams and Reilly (2000), who highlighted the need to explore implicit selection criteria. Despite this early call, studies focusing specifically on coaches' perspectives remain scarce. A subsequent review by Williams et al. (2020) identified only nine studies over two decades examining the variables coaches and scouts employ to identify talent. Concerning the topic of this dissertation, only four out of the nine studies addressed PCSs (see Table 3.2.1). For this dissertation, an updated literature search was conducted to capture the state of the art (for an overview, see Table 3.2.1). However, that update further confirms the limited scope of research on the coach's eye on PCSs, as only seven additional studies were identified that examined recruiters' criteria, which included PCSs. These studies, encompassing the perspectives of coaches, scouts, and technical directors, reveal considerable variability in the PCSs mentioned by participants. Differences arise in the number of skills identified, the terminology and definitions applied, and the breadth of constructs considered. Commonly cited skills such as game intelligence (alternatively referred to as football intelligence, sports intelligence, game understanding, or game sense), decision-making, and awareness are frequently highlighted. The studies, with some exceptions, did not explicitly define the skills, which makes it difficult to understand their conceptualizations. For example, game intelligence

(Christensen, 2009, p.375) was described as “a non-verbal, spatial-, bodily skill that cannot be measured in isolation from the playing of the game” or game understanding (Larkin et al., 2020 p.8), was defined as to “ have an ability to just, read the cues . . . know that the ball is going to be in a certain spot at a certain time and they’re there when it gets there” and general game understanding (Larkin & O’Connor, 2017, p.5) was described as “understand the game tactically; try to create options; finds space; constantly moving; smart off the ball; correct positioning; support in the right place; being in the right place at the right time.” These descriptions already underscore the intertwined nature of perceptual-cognitive and motor components in PCSs, often accumulated to broader concepts such as game intelligence or game understanding (Kalén et al., 2021). More precisely, these descriptions include a wide range of PCSs, which are separated by general cognitive models (e.g., Harvey, 2019), such as including spatial recognition (e.g., “finds space,” Larkin & O’Connor, 2017, p.5), timing (e.g., ” be in a certain spot at a certain time,” Larkin et al., 2020, p.7) or option-generation (e.g., try to create options, Larkin & O’Connor, 2017, p.5). In the TIDQ-OP (Lethole et al., 2024a), game intelligence was used as the associated description of decision-making, which further underscores the unclear and undefined use of the terminology and its interchangeable usage. Only three studies (Christensen, 2009; Larkin & O’Connor, 2017; Larkin et al., 2020) specifically addressed the coaches’ conceptualization of criteria, including PCSs. In contrast, the other reported studies primarily focused on broader aspects of talent identification, often compiling lists of talent criteria that were described using abstract and generalized terms. This variability may mainly result from methodological reasons. Seven out of eleven studies used semi-structured or in-depth interviews, asking open questions on general talent criteria (e.g., “When you are identifying talent at an under 13 level, what is it you are looking for?”; Larkin & O’Connor, 2017). These studies required participants to consider talent criteria across multiple dimensions (e.g., physiological, psychological, sociological), compelling them to

provide broad responses that can obscure specificity in particular areas, such as PCSs. In one study, responses were restricted to a maximum of five criteria, likely prioritizing prominent factors at the expense of a detailed breakdown of soccer-specific PCSs (Bergkamp et al., 2022a). Additionally, other studies did not openly ask for criteria but instead provided a pre-defined list that was not derived from the coach's knowledge but a scientific review that cannot add understanding to the coach's conceptualizations (Lethole et al., 2024a). To address these limitations and to learn about soccer-specific PCSs in a youth sample, it is crucial to implement methods that facilitate a more detailed exploration. Stimulated interview techniques, such as videos or images, help participants access and articulate tacit or implicit knowledge (Nicholas et al., 2018; Raya-Castellano et al., 2020). These stimuli can prompt memories and deeper insights, enabling a more thorough capture of PCS-related knowledge (Stodter & Cushion, 2017). Despite evidence supporting these techniques, none of the reviewed studies reported to have used stimuli to activate PCS-related insights. Incorporating such methods could enhance understanding of the subtle, often implicit knowledge of coaches and scouts, thereby providing a richer, more comprehensive understanding of soccer-specific PCSs. While these studies underscore the general relevance of PCSs in soccer talent identification, they also highlight challenges, including a lack of unified concepts and inconsistent definitions. Further, only one of the studies could more broadly contribute to understanding subjective, observational assessments of PCSs by coaches and other recruiters (Larkin et al., 2020). Specifically, the study emphasizes the need for sport-specific in-game assessment of skills such as decision-making because laboratory assessments of PCSs seem unlikely to be used by practitioners, given a tendency towards subjective procedures (Larkin et al., 2020). Although much of the existing research on PCSs from a coach's perspective arises in talent identification, this dissertation will adopt a broader focus on general player assessment**,** following the recommended shift from talent to performance identification (Larkin & Reeves, 2018).

Table 3.2.1 Overview of scientific studies on applying a coach's or recruiter's eye on player assessment or talent identification in youth soccer, including PCSs

Publication	Sample	Method	PCSs mentioned
Bergkamp et al. (2022a)	*N* = 125 Dutch scouts	Online questionnaire; "Describe a maximum of five attributes that you take into account when observing a player in your respective age cohort and that you consider to be predictive of future soccer performance."	- Game sense and awareness - Vision, perception, or seeing teammates and opponents, gaze behavior - Positioning or moving without the ball - Speed of handling - Tactical skills - Football intelligence - Decision-making
Christensen (2009)a	*N* = 8 Danish coaches	In-depth interviews; "Taking a concrete example, how would you describe the qualities of a young, talented soccer player?"	- Game intelligence
Eldrige et al. (2023)	*N* = 9 English coaches	Semi-structured interviews: Questions on perceptions and experiences of delivering practice sessions to develop VEA, e.g., "Do you think that visual exploratory activity holds more importance at specific ages?"	- Visual exploratory activity
Fuhre et al. (2022)	*N* = 6 Norwegian coaches	Semi-structured interviews; Asked about which skills characterize a talent in the age group of 13–16 years.	- Creativity - Positioning - Decision-making - Game understanding
Jokuschies et al. (2017)a	*N* = 5 Swiss coaches	Semi-structured inductive interviews; „Thinking about all of your players, is there any player who has something that it takes to achieve peak performance in adult-hood?"	- Cognitive perceptual skills: o Positive pole: Speed of perception o Negative pole: Information processing is too slow - Cognitive perceptual skills/technique: o Positive pole: Recognizing and solving game situations in an optimum way (orientation/game idea) o Negative pole: Player unable to draw attention to himself (too late or misplaced)
Larkin & O'Connor (2017)a	*N* = 8 Australian technical directors and *N* = 12 coaches	Semi-structured interview (part of Delphi method); " When you are identifying talent at an Under 13 level, what is it you are looking for?"	- Decision-making - Technique under pressure - Game sense/awareness - X-factor - Anticipation - General game understanding - Vision - Adaptability - Team understanding - Concentration

Publication	Sample	Method	PCSs mentioned
Larkin et al. (2020)	*N* = 12 Australian Scouts	Inductive semi-structured interviews; "Tell me about how you assess and make judgments on a player's ability?"	- Decision-making
Lethole et al. (2024a)	*N* = 173 South African coaches	Questionnaire: Ratings of importance on a 9-point Likert scale (1-3 points = "least important," 4-6 points = "moderately important," 7-9 points = "most important")	Tactical skills: - Anticipation - Decision making - Creativity - Delay - The transition from attack to defense (and vice versa)
Lethole et al. (2024b)	*N* = 173 South African coaches	Questionnaire: Ratings of importance on a 9-point Likert scale (1-3 points = "least important," 4-6 points = "moderately important," 7-9 points = "most important")	Tactical skills: - Ability to judge the flight of the ball - Ability to start attack - Defensive organization during open play - Defensive organization against set plays - Goalkeeper positioning and angling
Mills et al. (2012)a	*N* = 10 English coaches	Semi-structured interviews; "What personal characteristics or qualities do you believe young footballers require in order to make it to the professional level?"	- Sport Intelligence - Awareness of self and others - Focus
Pulling et al. (2018)	*N* = 303 English Coaches	Online Survey: Mixed open and closed questions on coaches' perception of VEA, e.g., "On a scale from 0-10, how important is it for a player to develop the skill of scanning?"	- Visual exploratory activity

Note: PCSs = Perceptual-cognitive skills; [a] indicates that these studies were already listed in the original review by Williams et al. (2020)

4. Dissertation project

4.2. Research objectives

This dissertation seeks to provide a comprehensive understanding and practical application of domain-specific PCSs in youth soccer, emphasizing an evidence-based approach to player assessment under consideration of current practices (i.e., subjective assessment by coaches and scouts). Despite the widespread acknowledgment of the relevance of soccer-specific PCSs in research and practice, there remains uncertainty about unified, soccer-specific conceptualizations, which is an essential foundation for players' assessment, as well as research on talent identification, development, and expertise (Larkin et al., 2020; Williams et al., 2020). Therefore, the overall research objectives can be described as:

1. To **explore** the breadth and the intertwined nature of PCSs in real-world settings from a coach's perspective, move beyond a narrow focus to encompass a fuller scope of skills dynamically involved in youth soccer performance (Article 1).
2. To **evaluate** the respective importance of each PCS in terms of its involvement in soccer performance and its contribution to assessment procedures (Article 2).
3. To **transfer** the empirical knowledge into systematic, evidence-based methods that support standardized player assessment to bridge theory and practice meaningfully (Article 3).

Addressing these objectives will involve identifying and assessing PCSs methodologically rigorously, grounded in empirical research that aligns with the practical needs of the sport. This dissertation thereby aims to fulfill what Glasgow (2013) describes as intelligent practice - a cycle of extracting theoretical insights from practical experience (see Article 1 and Article 2) and circling them back to practice (see Article 3).

4.2. Underpinning theoretical claims

The theoretical foundation of this dissertation project is grounded in the developmental embodied cognition framework, which posits that cognitive, perceptual, and motor skills are profoundly interconnected and develop dynamically through interaction with the environment (Lux et al., 2021; Musculus et al., 2021). This perspective challenges traditional views that treat cognition and motor skills separately, instead proposing a motor-cognitive continuum, where skills emerge and evolve due to their integration (Musculus & Raab, 2022). Developmental embodied cognition emphasizes three core tenets: the inseparability of cognition and action, the contextual nature of skill development, and the non-linear, adaptive nature of motor-cognitive growth over time (Lux et al., 2021; Musculus et al., 2021; Musculus & Raab, 2022). Central to this framework is the understanding that PCSs, such as decision-making and anticipation, are not isolated constructs but are embedded within and shaped by motor actions performed in specific environmental contexts (Musculus & Raab, 2022). For example, in soccer, the ability to anticipate an opponent's next move depends on perceptual inputs and the player's ability to position themselves appropriately and act decisively in real-time situations (Roca et al., 2013). This integration underscores the importance of studying PCSs within ecologically valid settings that replicate the demands of actual gameplay (Scharfen & Memmert, 2019).

Moreover, developmental embodied cognition recognizes the non-linear nature of motor-cognitive development, which varies across individuals and developmental stages (Musculus & Raab, 2022). Adolescence represents a critical period where rapid physical and cognitive changes interact, creating unique opportunities for skill acquisition and refinement (Lux et al., 2021). This non-linear growth trajectory necessitates age-appropriate investigations to understand better how PCSs evolve and how they can be effectively assessed and nurtured (Musculus et al., 2021). According to the proposed framework, each research can be positioned on three criteria (Musculus & Raab, 2022). First, the dissertation aims to provide a more

multidimensional understanding of soccer-specific PCSs, allocating it to a central position on the *motor-cognitive* continuum. Second, given exploring PCSs in an ecologically valid setting, a *domain-specific focus* will be applied. Third, while this project can inform research on age differences in the future, this foundational work focuses on *age-specific performance* assessment of PCSs.

Further, the following four theoretical claims guiding the methodological selection of the present work will be formulated and presented, informed by the just presented developmental embodied cognition framework and by Wilson's six views of embodied cognition (2002). These claims have received much attention and built the foundation for theoretical development in (e.g., Pizzera, 2016) and outside (e.g., Sullivan, 2018) of the sporting context. These views are (1) cognition is situated, (2) cognition is time-pressured, (3) we off-load cognitive work onto the environment, (4) the environment is part of the cognitive system, (5) cognition is for action, and (6) off-line cognition is body based. In the following, claims will be presented, partly inferred from and inspired by Wilsons' views (2002) but modified based on a recent theoretical understanding and the specific topic within this project.

Claim 1 | Players are highly interlinked with their environment

From a developmental embodied cognition perspective, players are not isolated agents relying solely on internal cognitive processes; they are deeply interconnected with their environment, where cognition, perception, and motor actions evolve through continuous interaction (Raab & Araújo, 2019). This framework emphasizes that cognitive processes are not abstract mental operations but are dynamically shaped by the body and the specific demands of real-world contexts, such as the spatial, tactical, and social complexities of a soccer environment (Shapiro & Spaulding, 2019). Players' perceptions, decision-making, and actions emerge from this embodied interaction, reflecting the intertwined nature of sensory and motor experiences that unfold in real time (Musculus et al., 2021). For example, a player's awareness of teammates, opponents, and the ball's position arises through active engagement with their environment, where perception and action are inseparable components of performance. A developmental embodied cognition perspective suggests that PCSs are not static but emerge and refine through repeated, context-specific practice within sport-specific environments (Musculus et al., 2021). Understanding PCSs as embedded within specific environments provides a holistic view of PCSs in soccer, advocating for sport-specific investigations that account for the unique demands of the game rather than relying solely on domain-general models. This perspective also underscores the importance of observational studies (van Meurs et al., 2022), which capture the nuances of real-game contexts and reveal how cognitive skills are applied and refined in situ (Kalén et al., 2021; van Maarseveen et al., 2018). This claim underpins the investigation of PCSs in real-life gameplay of elite youth soccer players, conducted through video-stimulated semi-structured interviews (see Article 1).

Claim 2 | Perceptual-cognitive skills are not separate but intertwined

PCSs in soccer are inherently interconnected and develop dynamically rather than existing as isolated, static abilities (Bergkamp et al., 2019). Traditional reductionist models often conceptualize cognitive functions—such as memory, attention, and perception—as distinct processes that operate independently and centrally processed by the brain, with the environment treated as a static source of input (Den Hartigh, Cox, & Van Geert, 2017). However, this perspective fails to account for the dynamic, reciprocal interactions between cognition, action, and environmental context, especially in real-world, performance-driven settings like sports (Den Hartigh, Cox, & Van Geert, 2017). From a developmental embodied cognition perspective, cognition is seen as a dynamic interplay of interconnected processes rather than a collection of isolated functions (Musculus et al., 2021). This framework highlights that PCSs are fundamentally intertwined, with individual components—such as memory, attention, spatial awareness, and decision-making—interacting and co-evolving to support effective performance (Heisler et al., 2023). For example, in soccer, a player's ability to anticipate an opponent's next move relies not solely on attentional focus or memory but on the seamless integration with spatial awareness and motor coordination. These skills operate together as part of a unified system, dynamically adjusting to the demands of the game (Musculus et al., 2021). By studying the integrated nature of these skills, researchers can uncover how different PCSs synergize to enhance adaptability and decision-making, particularly in a fluid and fast-paced context (Den Hartigh, Cox, & Van Geert, 2017). This claim supports the exploration of coaches' conceptualizations of real-life game actions to derive insights into the intertwined nature of motor-cognitive skills required to perform in the game's dynamic nature.

Claim 3 | Cognition is expressed by action

Actions are seen as expressions of cognition (Araújo et al., 2006) and are often called cognitive behavior (Araújo et al., 2019). For example, imagine a player on the field scanning the environment to identify the next passing option. When the player initiates the pass, their decision-making process becomes observable; parts of their internal cognitive model are revealed to the external world through action. Observing actions in naturalistic settings, such as real matches, aligns seamlessly with the developmental embodied cognition framework (Lux et al., 2021). These settings capture the behavioral expressions of cognition and how these behaviors are shaped by and interact with environmental constraints (Schmidt & Wrisberg, 2008). Naturalistic studies ensure high ecological validity by situating observations within authentic, context-rich scenarios (Kermarrec & Bossard, 2014). From this perspective, the interplay between perception, cognition, and action is best understood as a dynamic, adaptive process rather than discrete, isolated components. Focusing on players' actions within real-life contexts, such as matches or training sessions, allows researchers to extract the behavioral manifestations of cognition. This is particularly valuable for practical applications like player assessment, talent identification, and development, as it provides a more holistic understanding of a player's skills (McKay et al., 2024). This claim underpinned the emphasis on behavior-based observational assessments of soccer-specific PCSs.

Claim 4 | Experience enhances the accurate interpretation of contextual observations

This dissertation emphasizes the importance of lived experiences in capturing relevant information, particularly in contexts where knowledge is deeply embodied, such as in sports (Kelly & Turnnidge, 2023). Participants with firsthand experiences are more likely to interpret and convey nuanced information appropriately, as their own experiences shape and inform their understanding (Pizzera & Raab, 2012). In soccer, coaches accumulate implicit knowledge over years of experience—a form of expertise derived from real-world observation of countless player interactions (Roberts et al., 2021). Coaches' experiential knowledge, both from observation and own motor experience, provides a valuable lens for understanding the complex and embodied nature of PCSs in soccer, illustrating the dynamic interplay between perception, cognition, and action as it naturally unfolds within the sport (Raab & Araújo, 2019). Moreover, their lived experiences position them well to detect age-specific nuances, enabling the identification of developmental trajectories and contextual factors unique to different stages of player growth (Romand et al., 2009). This claim motivated the involvement of professional and highly experienced soccer coaches to draw on their knowledge and enhance their understanding of soccer-specific PCSs.

4.3. Research program and strategy

This dissertation project is situated at the intersection of sport psychology and cognitive psychology, with a stronger emphasis on the latter. This project follows a two-pronged approach that addresses theoretical and practical needs, encompassing two empirical studies (Articles 1 and 2) and one conceptual article (Article 3). It is aimed to address the gap between scientific knowledge and practical application—often referred to as the research-practice gap (Norman, 2010) —a well-recognized challenge in many fields, including sport psychology (e.g., Lautenbach et al., 2022). While there are promising developments, challenges remain. On the positive side, collaborations between academia and practitioners are increasing, with research now placing greater emphasis on sport-specific considerations in methodological approaches (Huesmann & Loffing, 2024; Kalén et al., 2021) and making efforts to adapt scientific findings for practical application in sports contexts (e.g., handbook of the German Soccer League (DFL) on parent-athlete relationships for soccer academies by Eckardt & Lobinger, 2024). However, a look into the daily routines of German youth soccer academies reveals that scientific insights rarely reach the field systematically. The issue lies less in a lack of interest and more in the accessibility and visibility of scientific work, which still allows the research-practice gap to persist (Bansal et al., 2012; Keegan et al., 2017). Overall, the present research program on PCSs in youth soccer exemplifies usage-inspired basic research, as it is driven by both a quest for understanding fundamental cognitive mechanisms and a commitment to practical application in real-world contexts (Hassmén et al., 2016). This program embodies the principles of "Pasteur's quadrant," where scientific rigor meets practical relevance, providing valuable insights for coaches, scouts, and scientists alike (Stokes, 2011).

From a coach's perspective, PCSs—such as visual search, anticipation, and decision-making—are crucial for young players' performance on the field (Bergkamp et al., 2022a; Christensen, 2009; Fuhre et al., 2022; Larkin & O'Connor, 2017; Larkin et al., 2020). The

research program focuses on an applied and inherently exciting phenomenon: the conceptualization of domain-specific PCSs and their assessment. By uncovering the conceptualization, including their intertwined relations (Article 1) and their relevance for soccer performance and assessment (Article 2), this research sets the stage for broader generative research, such as in expertise or talent identification research. As highlighted by Hassmén et al. (2016), this approach leads to findings acknowledged as valuable by both researchers and practitioners, reinforcing the program's role as foundational for applied practices and talent identification and development research. The doctoral research program was informed and shaped by prior scientific engagement in various research projects with thematic overlaps, including studies on perceptual-cognitive skills and functions in youth soccer players (e.g., Heisler et al., 2023), youth soccer more broadly (e.g., Lobinger et al., 2019; Lobinger & Heisler, 2018a), and work involving soccer coaches (e.g., Lobinger & Heisler, 2018b).

4.4. Research design

While this chapter presents the overall research design, detailed information on the methodology is outlined in the method sections of each article in the forthcoming chapters (Chapters 5, 6, and 7). The dissertation project employed a co-productive approach (Smith et al., 2022) within a mixed-methods study design. Given the limited research on domain-specific PCSs in youth soccer generally, and specifically from a coach's perspective, this dissertation adopted an overall exploratory and descriptive approach, refraining from hypotheses testing (for an overview, see Figure 4.4.1). The first qualitative study used video-stimulated semi-structured interviews with professional soccer coaches to explore the breadth of PCSs involved in real-game situations (Article 1). This study investigated the coaches' conceptualizations and aimed to learn about both the broad range of PCSs involved in real-game scenarios and their intertwined nature. The soccer-specific PCSs identified through these coaches' observations were evaluated in a second online study regarding their importance to soccer. A sample of

experienced coaches and scouts assessed the relevance, frequency of usage during a game, and observability of PCSs operationalized through behavioral descriptions.

Further, the PCSs-related language of coaches was investigated and compared with scientific vocabulary (Article 2). This knowledge was then adapted for practical application to guide recommendations for player assessment as an integral part of professional clubs' daily operations. This has led to an applied conceptual article providing general guidelines to evaluate PCSs through observational assessments (Article 3). The study design incorporated observation-based methods, drawing on insights from van Meurs et al. (2022), who highlight the value of observational studies across various purposes in sports research. Observational approaches are particularly effective in capturing contextualized and field-based knowledge, making them indispensable for understanding complex, real-world dynamics (Bergkamp et al., 2022a). This method enables the collecting of rich, conceptualized data directly from practice, bridging the gap between theoretical frameworks and practical application in the field (van Meurs et al., 2022).

Regarding the dissertation context, this program draws on the insights of professional and highly experienced soccer coaches with extensive experiential knowledge. By involving coaches with practical, field-based expertise in talent identification, selection, and development, the study leverages their observational skills and intuitive understanding of soccer-specific PCSs (Roberts et al., 2021). Purposeful sampling was employed to ensure that participants bring a depth of real-world knowledge valuable for interpreting nuanced PCSs and essential for a co-productive approach (Smith et al., 2022). Moreover, the video material of real-life game sequences, prepared through a multi-step approach (see Chapter 5), originates from an elite male performance context. A standard critique of scientific investigations on talent identification and development is that many studies are conducted outside elite contexts and without elite samples, raising questions about their representativeness and usefulness for

understanding expertise in these settings (Sarmento et al., 2018). Accessing the highly specialized knowledge derived from elite performance environments remains a general challenge in research (Bergkamp et al., 2019). However, this study successfully addressed this challenge by employing a co-productive approach that facilitated collaboration with professional and highly experienced coaches, enabling the collection of rich, practice-based insights.

In this program, soccer is an ideal testbed for studying PCSs due to the high degree of interconnection between cognition and action within its dynamic environment (Jansen et al., 2012). As a sport, soccer requires players to adapt their PCSs to the field's rapid changes constantly, exemplifying embodied cognition principles, where perception and action are tightly coupled (Raab & Araújo, 2019). Beyond its functional use as a test environment, soccer is the world’s most popular sport, engaging millions of youth players and generating significant social impact and interest. This widespread participation underscores soccer’s relevance as a practical and socially impactful context for studying young players' PCSs (Williams et al., 2020).

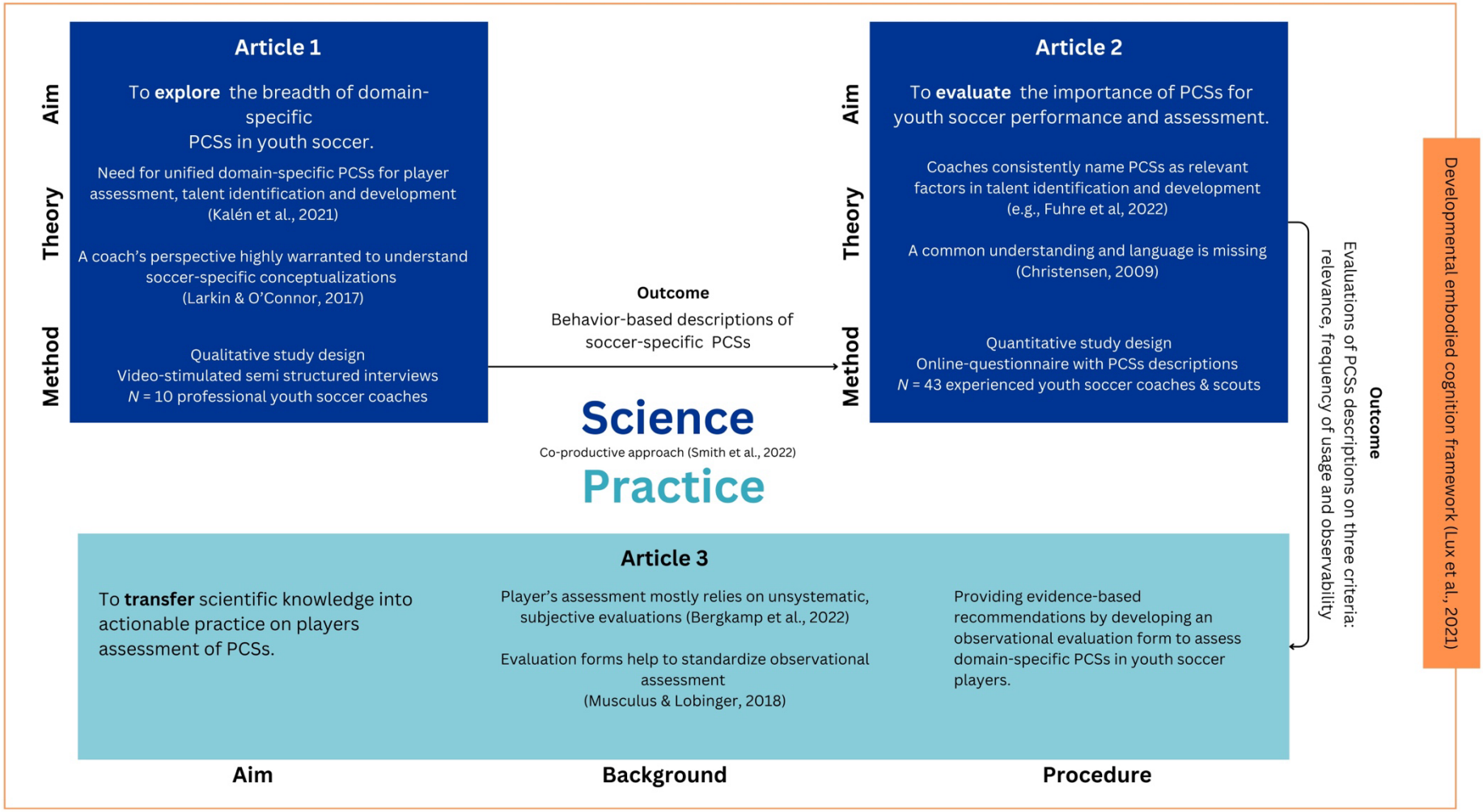

Figure 4.4.1 *Overview of the research program*

5. Article 1

Video-based assessment of perceptual-cognitive skills in youth soccer from professional coaches' perspective

Heisler, S. M., Musculus, L., & Lobinger, B. H.

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Abstract

This study explores the insights of professional coaches on perceptual-cognitive skills (PCSs) in youth soccer through applying a "coach's eye for talent" approach. We investigated soccer-specific PCSs in youths playing of under-14, under-15, and under-16 male players. Ten experienced professional coaches reviewed 14 real-life video sequences, identifying behavioral indicators of PCSs. Thematic content analysis revealed 26 subthemes within four overarching themes: information gathering, processing and planning, action executing, and action adjusting. Findings highlight consistent descriptions of PCSs but reveal a lack of common terminology among coaches. The identified skills are highly intertwined, underscoring the complexity of PCSs in the dynamic play of soccer. Together with existing theoretical conceptualizations of PCSs, the findings underscore the need for domain-specific rather than domain-general considerations of PCSs. Results suggest coaches' education should include fostering a shared knowledge and language when discussing PCSs and can encourage subjective talent assessment through observation. Future research should continue to explore and refine unique sport-specific PCSs, to enhance theoretical understanding and to inform talent identification and development programs.

Keywords: Talent identification, coach's eye, qualitative study, youth soccer

Introduction

"The player is creative. That's intuition. That's what we want" (Coach 9). Similar sentences can be heard on various sidelines about players every weekend. All around the world, coaches and scouts stand next to the field, observing young talents as they pursue their dream of becoming professional players. Along this path, these youths depend on their potential being discovered and nurtured (Unnithan et al., 2012).

Despite technological development, the assessment of young talents is still mostly based on subjective evaluations from soccer experts who, on behalf of their clubs, search for promising players, sign them up, and then systematically develop them (Jokuschies et al., 2017; Lund & Söderström, 2017). Especially in youth soccer, this task is not just about recognizing the current best performance but is especially about discovering potential (Cardoso et al., 2021). A soccer game is characterized by high dynamics and variability, constantly changing situations in which the players must adapt (Musculus, 2018). Therefore, alongside technical abilities, perceptual-cognitive skills (PCSs) have become an increasingly important part of players' assessments (Bergmann et al., 2021).

Which player is outstanding in finding solutions on the field? Who acts quickly and creatively? Coaches observe their protégés every day during practice and every weekend during matches, assess their abilities, monitor their development, and adjust training according to their needs. They also decide who will be on the field on the weekend. Coaches are also significantly involved in the selection processes, hence influencing the decisions of who gets to enter and remain in the talent development program of youth academies (Sarmento et al., 2018).

In the current work, we followed the coach's eye approach (Roberts et al., 2019) and tapped the experience and expertise of coaches to gain access to the comprehensive knowledge of professional youth coaches about PCSs. The *coach's eye (for talent)* is understood as the ability to detect promising potential in athletes that points to future elite performance (Roberts

et al., 2021). Research has identified four main characteristics of the coach's eye: It is intuitive, subjective, experience-based, and holistic (Lath et al., 2021).This perspective has been shown to provide additional knowledge and insight that is lacking in the empirical literature (Eccles et al., 2009), has predictive validity owing to the variety and years of experience of the coaches (Musculus & Lobinger, 2018), and can also guide and complement research (Collins & Collins, 2013; Willmott & Collins, 2017). Applying a coach's perspective has so far been done mainly for personality characteristics (Jokuschies et al., 2017), and little is known about how coaches assess PCS.

PCSs involve the localization, identification, and processing of environmental information (Mann et al., 2007) and have recently been identified as having high significance for soccer (Beavan et al., 2019; Bergmann et al., 2021; Ehmann et al., 2022). For example, concepts such as anticipation (Schumacher et al., 2018; Vítor de Assis et al., 2021) and decision making (Cardoso et al., 2021; Heisler et al., 2023; Musculus, 2018) are widely studied and discussed. Additionally, there is an ongoing debate about the sport specificity of PCSs, indicating that there is a need for sport-specific rather than generalized assessment (Coutinho et al., 2016; Sarmento et al., 2018) as well as for a cognitive portrait of the sport of interest (Scharfen & Memmert, 2019). This debate is supported by empirical evidence showing that expert soccer players do not outperform their less skilled counterparts in all aspects but do so especially in domain-specific cognitive tasks (Kalén et al., 2021; Musculus, 2018). It has also been shown that performance on a computer-based cognitive task did not predict in situ soccer performance, bringing into question the ecological validity of such measures (van Maareseveen et al., 2017).

Given the interest and scientifically described importance of PCSs for soccer (Williams, 2000), we find it surprising that research has often overlooked the perspective of coaches, especially as they are significantly involved in the identification and development of young

soccer players (Musculus & Lobinger, 2018; Sarmento et al., 2018). In an influential review paper by Williams et al. (2020), only nine studies were identified that investigated coaches' and scouts' criteria for talent identification, and none of them explicitly studied PCSs. Musculus and Lobinger (2018) outlined the importance of sound and systematic assessment of coaches' expertise to help bridge the gap between experts' observations and abstract terms—hence the gap between practice and theory. In addition, even within the applied field, among coaches and scouts, there exists neither a common understanding of skills nor a common language (Christensen, 2009) and it remains a challenge to truly grasp and evaluate soccer-specific PCSs (Scharfen & Memmert, 2019).

To capture the strength of the coaches' expertise, a multistep qualitative naturalistic study design (Moesch et al., 2015) was chosen to shed light on the sport-specific PCSs of young soccer players. This approach involved applying an embodied cognition perspective (Shapiro, 2007), which posits that cognitive processes are deeply rooted in the body's interactions with the world. This perspective emphasizes that cognition is not just situated in the brain but is distributed across the body and the environment, and it is expressed through actions (Raab & Araújo, 2019). Embodied cognition suggests that PCSs emerge from the dynamic interplay between an athlete and their environment (Shapiro & Spaulding, 2019). By applying this approach, we aimed to extract critical behavioral descriptions that indicate these skills, thereby illuminating coaches' conceptualization of them. Moreover, we sought to investigate how these skills interact in dynamic, real-game situations, an area that has been relatively underexplored in existing research (Roca et al., 2013). We anticipated that using the coach's perspective would yield a more nuanced understanding and detailed behavioral descriptions of sport-specific PCSs, which will enhance both theoretical frameworks and practical applications by supporting the systematization of subjective assessments.

Philosophical Position

This study was conducted from a pragmatic philosophical position (Giacobbi et al., 2005). This position emphasizes the importance of practical consequences and aims at generating practical meaningful knowledge (Brown et al., 2017). Instead of searching for an objective reality or a universal truth, pragmatism focuses on how theoretical concepts apply and what consequences they have in real life (Riciputi et al., 2016). Pragmatism suggests that past experiences and beliefs shape an individual's behavior, and knowledge is constructed significantly through action and engagement in a specific context (Morgan, 2014). Pragmatism thereby focuses on application and context and addresses practice needs and questions by applying feasible and actionable measures in a real-life setting (Glasgow, 2013). The present work fulfills these key characteristics of pragmatism by investigating a practically relevant research question, within the context of interest, with a sample (a homogeneous, highly experienced group) that represents the community from which the knowledge will be gained. A practical level of truth is gained through agreement within a community (Stecker, 1993).

Method

Materials and Procedure

Prior to conducting expert interviews using a video-stimulated recall technique, a systematic video selection process was implemented. We followed a multi-step approach to ensure a scientifically robust selection of video material. Initially, a literature review was conducted to identify relevant PCSs in soccer. An expert panel then reviewed 22 preselected game sequences of under-14, under-15, and under-16 games, and following consensus discussions, 14 sequences that captured the range of PCSs identified in the literature were chosen for the study. Detailed information on the preparation steps is available in the Supplementary Material (see Appendix Table 5.1).

Participants

In total, N = 10 professional youth soccer coaches (M_{age} = 36.7 ± 9.91 years) from a second-division German soccer club took part in this study. As an inclusion criterion for participation, coaches had to either currently or previously train under-14 to under-16 teams for at least a year. This inclusion criterion was chosen because of the age range of players in the video footage. Coaches had coaching experience of M = 12 years (SD = 6.48). Two participants were currently not working as a head or assistant coach but in another function (i.e., individual coach) with previous coaching experience in the targeted age group. All participants signed the informed consent and filled out a sociodemographic questionnaire prior to the interview. The project was approved by the local ethical review board [072/2021].

Expert Interviews

Expert interviews took place at the facilities of the collaborating German youth academy of a second division (*2. Bundesliga*) professional club between June and September 2021. All coaches were interviewed individually. The coach and the interviewer met in a meeting room with a Panasonic 40-in. flatscreen for video presentation and a mobile device for sound recording. The mean duration of interviews was 116.7 min (SD = 20.52). A break of 10 min was made after half of the trials and in between trials if needed. The instructions were read out loud by the interviewer and a practice sequence was presented for standardization purposes. The instructions included a definition of PCSs, to ensure that all coaches knew about the general concept of interest. Afterward, video sequences were presented in a random order. Participants saw the video five times for observation, before they were asked the first question. If needed, participants were allowed to ask for further presentations. Participants watched sequences on average 12.8 times (SD = 4.66). For each video, the participants were first asked to describe any behavior that they thought was related to PCSs. To obtain more detailed answers, further questions for clarification were “What do you base that on?” or “In which specific actions do

you see that?" Additionally, to gain deeper insight into their perspective, further questions such as "Can you expand on this?" or "Do you have anything to add?" were asked.

Data Analysis

The interviews were audio-recorded and transcribed verbatim, following recommendations on content-semantic transcription (Drehsing & Pehl, 2018). Transcripts were imported into MAXQDA (VERBI Software, 2021) for qualitative analysis. Names and identifying information were removed from transcripts to assure anonymity. Thematic analysis using constant comparative procedures (Corbin & Strauss, 2014) was applied. The thematic analysis employed a mixed approach, combining both inductive and deductive procedures. The initial coding and theme development were largely inductive, allowing the themes to emerge organically from the data. This approach ensured that the analysis remained grounded in the participants' experiences and perspectives.

Subsequently, a mixed inductive and deductive approach was employed during the construction of overarching themes and subthemes. This phase involved integrating existing theoretical frameworks and research findings to contextualize the themes within a broader scholarly context. This dual approach ensured that the analysis was both data driven and theoretically informed, providing a robust and comprehensive understanding of the research topic (Clarke & Braun, 2016). This mixed approach is assumed to support an organized, rigorous, and analytically sound analysis (Bingham & Witkowsky, 2022).

The first author with a background in general psychology and sport psychology as well as 2 years of experience as the sport psychologist in the respective youth academy analyzed the data. The first author was aware of her previous knowledge and always reflected critically on her interpretations. Additionally, the third author, another external researcher with a professional background in soccer, and a scout functioned as critical friends through the whole process, to minimize biases in interpretation (Appleton, 2011). Throughout coding, constant

comparison techniques including comparison of content across themes, within and between individuals, and critical discussions with the third author and external researcher were used to increase methodological rigor (Vaismoroadi & Snelgrovem, 2019).

Results and Discussion

After a thematic content analysis (Braun & Clarke, 2012; Braun et al., 2016) of the data, 26 subthemes emerged, which were then assigned to four overarching themes. To provide a sense of the prevalence of each subtheme, we report the number of participants who mentioned it (Riciputi et al., 2016). In the following, P denotes participant, I denotes interviewer, and V denotes video. For each subtheme, T denotes theme (1-4), and S denotes subtheme (1-26). Additional quotes can be found in Supplementary material.

Theme 1: Information gathering

The first theme encompasses descriptions that primarily included behavior that aims to seek and absorb information on the field. The player explores his environment on the field through gaze behavior but also incorporates other senses. Behavior within this theme mainly focuses on information intake without further processing of this information. At the same time, it becomes evident that the behaviors sorted to this theme function as a foundation for other themes (e.g., see quote in T1S1). According to analysis, this theme contains five subthemes.

T1S1: The player directs his gaze toward relevant positions or objects (e.g., the ball)

In most cases, the descriptions referred to the gaze plus direction or pre-position (e.g., gaze up, down, out, over; gaze toward goal, goalkeeper, teammates). Furthermore, the duration of the gaze was described (e.g., a brief glance), as well as the frequency of the gaze behavior (e.g., once in the gaze, always in the gaze) and whether the gaze was wide, narrow, or fixed. Terms associated with this subtheme included gaze behavior, eye contact, gaze direction, and

gaze control; Also related but because it was mostly separately described is shoulder checking, which is its own subtheme (see T1S3).

> Now, before he receives the ball, his gaze goes up once, that's the decision, I'll take the contact forward... Alright, and then the decision now is to play the ball deep.
>
> [P1, V1404]

From a research perspective, this can be best assigned to concepts such as visual exploratory behavior (Jordet et al., 2013) or gaze behavior (Brams et al., 2019). Studies on these constructs found significant expertise differences. Expert players exhibited higher frequencies of visual exploratory behaviors, which allowed them to gather more information about their surroundings (Jordet et al., 2013). Additionally, expertise differences were shown in terms of the efficiency of gaze behavior in the sense that experts are better at focusing on task-relevant stimuli instead of processing all the information (Brams et al., 2019).

T1S2: The player perceives information in his peripheral vision (e.g., teammates or opponents)

As a specification of the previous subtheme, the participants differentiated peripheral vision as a distinct behavior. While most coaches just shortly mentioned it, one coach described peripheral perception in many sequences, emphasizing its importance to maintaining an overview of one’s surroundings. By perceiving information peripherally, the players gather important insights.

> He has the entire field in his peripheral vision. He knows the entire game situation. Then, he concentrates on the opponent before the ball is in play. And then it's also like this, he plays the ball more or less blindly up front. [P10, V1503]

Peripheral perception has so far rarely been studied in sports (Klatt & Smeeton, 2021; Panchuk & Maloney, 2022; Robalo et al., 2021). The conducted studies showed that skilled players harness their peripheral vision to perceive finer details that are often missed by novices (Klatt & Smeeton, 2021) and emphasized its crucial role in action control (Robalo et al., 2021). Panchuck and Maloney (2022) found expertise differences in the distance of central vision as well as accuracy of peripheral perception.

T1S3: The player orients himself on the field (e.g., through scanning or shoulder checking)

When describing orientation, often also labeled as preorientation, the participants discussed the alignment of orientation (e.g., player oriented, ball oriented, opponent oriented), thus recognizing an attentional component. Furthermore, especially during preorientation, there was mention of purposefully checking one's shoulder to orient oneself on the field, particularly with regard to the next action. In one interview, a general sense of orientation was discussed, implying an ability to navigate the field amid a wealth of information. Scanning was specifically described in relation to gaining a broader overview (e.g., scanning the situation or the field) and evaluating options (e.g., scanning options).

> He must have oriented himself beforehand, otherwise it's not possible in this game situation after winning the ball, you have to orient yourself, where is the next best space to get forward. [P6, V1401]

From a research perspective, this can be assigned to scanning (Aksum et al., 2021). It has been investigated in expertise studies, showing notable differences in scanning frequencies between expert and novice players. Experts engaged in more frequent and systematic scanning, which helped them acquire critical information about the game environment (Lynch, 2024). This behavior is associated with improved situational awareness and more effective decision

making, as experts could anticipate future game actions and respond proactively (McGuckian et al., 2020).

T1S4: The player incorporates various senses into his perception (e.g., hearing, vision, touch)

In this subtheme, participants described how players sometimes incorporated senses other than vision, such as hearing or tactile sensation, in certain moments. Particularly, tactile sensation appears to have been an important source of information for specific situations, aiding orientation without diverting visual attention toward the information source.

> He doesn't take a shoulder check, he doesn't know what's behind him, he just senses it. [P4, V1604]

From a research perspective, this can be best assigned to multisensory integration or multimodal perception (Gray, 2008; Klein-Soetebier et al., 2021). It refers to integrating information from various sensory modalities, such as vision and hearing as well as tactile sources (Pizzera, 2017). To perceive the situation with its full range of characteristics, it has been stated that an integration of different sensory sources is beneficial (Cluff et al., 2015). Still, there exist just a few studies in soccer investigating multisensory integration, and in these, there was a strong focus on visional and auditory cues (e.g., Müller et al., 2024). In a recent study, Quinn and colleagues (2023) showed that goalkeepers were better at multisensory temporal processing compared to outfielders or a control group. The authors traced this result back to the demands on goalkeepers to make fast decisions, often based on partial or missing information.

T1S5: The player focuses his attention on something specific (e.g., opponent)

This subtheme was described less frequently overall. It became apparent that concentrating on a single stimulus was mostly viewed negatively because important additional information could be lost. However, in two cases, focus was described positively when it helped the player filter out irrelevant and concentrate on pertinent information. In both instances, the

necessary learning process or experience was emphasized as critical to the ability to differentiate between relevant and irrelevant information.

> So, the other information would be irrelevant, or rather, the good players only concentrate on the important information because they know what is important for their action. [P10, V1506]

In research this has been labeled and studied as selective attention. It plays a critical role in soccer, particularly in how players process and respond to the dynamic environment on the field (Knöllner et al., 2022). Expert players demonstrate superior selective attention, allowing them to focus on relevant stimuli while ignoring distractions (Williams & Davids, 1998; Williams & Grant, 1999). Different studies have shown that selective attention is understood to enhance other cognitive skills such as decision making (Roca et al., 2011) or anticipation (Memmert, 2009). Additionally, selective attention helps experienced players quickly adapt to changing game situations, improving their tactical responses and overall gameplay efficiency (Roca et al., 2011).

Theme 2: Processing and planning

This theme encompasses all descriptions of behaviors aimed at processing received information to prepare for the next ball action (by oneself or teammates). The player, in their role, acts as a regulator, integrating various received information, making sense of it and planning as well as preparing further action. According to our analysis, this theme is associated with 10 subthemes.

T2S6: The player identifies open spaces

Participants described that players identify spaces and potentially exploit or occupy them. According to the participants, spaces can be seen, sought, found, closed, opened, exploited, and occupied. One participant described how players can create space for themselves.

Overall, from the participants' explanations, it became evident that a central aim of the game is to find free or open spaces and incorporate them into one's play. Some coaches referred to free spaces, but in most cases, "free" was simply omitted and only "space" was mentioned. Little discussion revolved around the size of the spaces, only whether they were tight or wide.

> Then he plays the ball with the outside of his right foot, immediately repositions himself into the open space, recognizes the open space, and wants to receive the ball again immediately. [P5, V1502]

Scientifically, at least according to our literature search, PCSs involved in exploring open spaces in soccer have rarely been studied. The behavior has been connected to spatial awareness, that is, the ability to perceive the space in which a person can act (Stevens-Smith, 2004). Mostly it has been studied from a game analytics perspective, with a focus on tactics (Fernandez & Bornn, 2018). Nevertheless, some investigations have drawn connections to tactical knowledge (Martens et al., 2021) or to visual search behavior, showing that players had longer fixation durations on open spaces (Mann et al., 2007).

T2S7: The player recognizes recurring game situations or patterns of action

This subtheme was described with a focus on recognition, that is, recalling familiar combinations of information (e.g., routines or movement patterns). Although a connection can be made to the subtheme acting tactically (T3S20), the main aim of this described behavior is not to perform but to recognize.

> P: And in the end, you can also say recognizing patterns because there are patterns in the end, maybe from training or whatever.
>
> I: What would be some patterns then? How do I recognize a pattern, for example, as a player on the field?

> P: By the same positioning. It can happen that you're in the build-up play and your left outer midfielder always stands in the same position. So, depending on how the fullback is positioned, I can play the ball behind them or pass it to their feet. [P10, V1603]

From a research perspective, this can be best assigned to pattern recognition. Investigations showed superior pattern recognition in skilled soccer players when compared to less skilled players (Hope, 2016). More precisely, the results demonstrate that elite players can encode localized relationships and subsequently use this information to identify broader, overarching patterns (Hope et al., 2024). The superior ability of pattern recognition allows players to anticipate opponents' actions and make strategic decisions (Hope, 2016). Additionally, it was shown that youth soccer players at the age of 15 years were already able to recognize patterns successfully and were not outperformed by an adult sample (Evans et al., 2012).

T2S8: The player accesses stored knowledge that he perceived shortly before

Participants described how players store or remember information and use it in subsequent actions. Some participants mentioned that players "know" without explicitly using terms such as memory or storing. One participant described how control glances are particularly important for working with stored knowledge, that is, storing knowledge and then before relying on that information performing a short check-up view.

> So theoretically, you can also say that it's something he remembered. You will have seen here that there is a player. If I know that someone is there, I also know that he is still there now. So, I think after that, you only need to glance up, so you know exactly where he is. But probably you will have already perceived that the right side is also occupied. [P1, V1401]

The process of temporarily holding and manipulating information in mind while acting on the field has been defined as working memory (Diamond, 2013). Expert players as compared to less skilled players have been shown to exhibit superior working memory, enabling them to process and integrate complex information quickly and efficiently during play (Furley & Memmert, 2010). Additionally, skilled players can maintain and manipulate relevant information more effectively, facilitating better in-game adjustments, strategies (Vestberg et al., 2012), and decision making (Heisler et al., 2023).

T2S9: The player anticipates or speculates about a situation and thinks several moves ahead

Participants described behaviors related to forward thinking within this subtheme. They differentiated between anticipating and speculating, with it becoming clear that these are defined slightly differently and used with varying frequency. Two participants primarily spoke of speculation, and the rest referred to anticipation. Speculation is described as a specific form of anticipation with less information and higher risk compared to anticipation. According to the participants, players gather information (e.g., positioning, body language, movements) and use it to make assumptions about a future scenario (e.g., behavior or game situation). Players are described as inferring, estimating, or forming a picture of the situation. Spatial positioning appears to be a behavioral indicator of anticipation, as players strategically position themselves based on their assumptions about the future.

> That means from a defensive perspective, it's great behavior, which arises from the fact that he anticipates, that he has thought one step ahead, and still thinks one step ahead compared to his direct opponent, and theoretically also compared to the player who plays the ball, because it could actually be clear to him that by playing to the number 7, if I play my partner here, he will be pressured so much that I actually have to abort and play to the goalkeeper or I play into the center. [P8, V1408]

The field of anticipation in soccer has been richly studied (E. Gonçalves et al., 2015). Research consistently shows that expert players possess superior anticipation abilities, enabling them to predict opponents' actions and game events more accurately. Studies, such as those by Abernethy et al. (2001), identified that expert players effectively use kinematic and situational information to anticipate movements. Roca et al. (2011) also found that expert players exhibit efficient decision making through better visual patterns, reinforcing the importance of anticipation in high-level soccer performance. These cognitive abilities are crucial for maintaining high-level performance during play (Abernethy et al., 2001; Eccles et al., 2006).

T2S10: The player has or follows ideas

This subtheme involves generating an internal image about the future. The participants described how some players have an idea about a future situation (related to anticipation), planning the realization and then initiating actions accordingly. Hence, this subtheme has been assigned to processing and planning, as the main aim of generating ideas appears to be planning future behavior. Additionally, it is often described in connection with imagination, which appears to be closely related to creativity. According to the participants, imagination is either a prerequisite or a consequence of creativity. This differentiation is not entirely clear from the data.

> I: And how do you determine that he has the idea? So how do you see that?
>
> P: I see that because he simply positions himself so that he is not playable for the next action, but for the one after next. [P5, V1504]

From a research perspective, this subtheme cannot be easily assigned to one scientific concept, since the coaches elaborated on a range of different concepts. Connections can be drawn to action planning (Casella et al., 2020), anticipation (Martins et al., 2014; McRobert et al., 2011), creativity (Memmert, 2011), and game intelligence (Kannekens et al., 2009). These findings

collectively underscore that expertise in soccer is characterized by enhanced cognitive and perceptual skills, contributing to superior performance in action planning, anticipation, creativity, and game intelligence.

T2S11: The player is active and remains attentive through various actions. He stays "online" during a set of actions

The participants used specific wording, "stay in the action or situation," indicating that the player remains both attentive and involved, for example, by searching for next-action opportunities or by continuously moving, especially when the situation changes. Not switching off and reengaging were described by one participant each. This implies a generally high level of activity, recognizable from outside primarily through visual search behavior, creating opportunities, making runs, and moving.

> Staying in the game means, I would say, he stays online. He observes and makes his actions when he recognizes them. So, he stays vigilant. Although you don't notice it because he's jogging, but the sudden change in pace shows that he's there. Simply put, he's active. [P3, V1504]

From a research perspective, this can most likely be connected to sustained attention, which refers to maintaining focus over extended periods, a key requirement in soccer (Schumacher et al., 2018). Radic et al. (2015) demonstrated that players with better sustained attention can consistently perform well throughout a match, reducing errors and maintaining high levels of play. Nevertheless, sustained attention can explain the attention level of the subtheme described by coaches, but not the continuous involvement in next actions in the game on a more motor level. Further connections can therefore be made to cognitive flexibility (see also T4S24) given its function of switching between situations and executing an appropriate action accordingly (Huijgen et al., 2015).

T2S12: The player positions himself advantageously

This subtheme stands out as a central behavior that players are continuously engaged in during the game. Particularly noteworthy is advantageous positioning, meaning choosing distances to teammates and opponents to create action options and opportunities for teammates. A key ability within this category is adaptability in the dynamic play. A prerequisite for this is the ability to perceive and assess spaces and distances.

> He always positions himself so that he is always in an advantageous position, I find, so no matter what happens, even if the ball slips through or whatever, he could still intervene (…). [P2, V1603]

From a research perspective, this behavior can be linked to spatial awareness (Clemente et al., 2015). It has been studied in team sports, showing that players actively explore spatial-temporal features of the playing situation to constantly adapt their position and pace advantageously (Travasso et al., 2012). Expert players exhibit superior spatial awareness, allowing them to occupy optimal positions and to adjust dynamically, which enhances team performance (Clemente et al., 2015; Memmert et al., 2017). Additionally, experienced players use effective positioning to create passing lanes, support defensive actions, and generate scoring opportunities, underscoring the importance of spatial understanding in high-level soccer (B. Gonçalves et al., 2014).

T2S13: The player times his actions so that the ball or he arrives at the destination at the right moment

The focus in this subtheme is on appropriately timing the initiation and completion of an action (e.g., run, pass). Specifically, it is about adjusting one's actions so that the player or the ball arrives at the destination at the right moment. Correct timing can be temporal (e.g., the attacker starts running at the moment of contact with the defender) or spatial (e.g., the player

passes the ball to the foot of a running player). According to one participant, timing is measured by the outcome of the situation, meaning that even with early initiation, timing can still be good through corrective behavior (e.g., delaying; see also T4S26).

> If he's too slow, then the player can resolve it, yes, so it's still about timing, the approach behavior, the braking, not just running bluntly through, but shortening the distance to the opponent so that he also has the corresponding distance in time to exert pressure on the ball carrier. [P2, V1501]

From a research perspective, timing has been identified as a crucial skill, but it remains poorly investigated in soccer (Sommer et al., 2018). It is defined as the sensorimotor synchronization ability, which helps coordinate motor actions. In soccer it is crucial to perceive external cues quickly and accurately (e.g., pace of the ball) to select an appropriate action that is well coordinated in time and space (Williams, 2000). It has been stated that players need both external anticipation, which applies to the object of interest, and internal anticipation, which applies to their own movement that is needed to arrive at a targeted location at the same time as the object (Williams, 2000).

T2S14: The player prepares his own actions (e.g., through specific positioning or making a run)

This subtheme was described in terms of players preparing for their own next action. Overall, this topic was described less frequently, and connections to other subthemes are evident. Nevertheless, there were various mentions that letting the ball run or running off the ball are explicitly used by coaches for action preparation, making it distinguishable from other topics such as correction behavior, timing, or positioning.

> And then he buys himself time by letting the ball run through. So, again, it's a reaction to what the opponent does. [P10, V1502]

Scientifically, this can be best connected to research on action or motor planning (Prinz, 1997). Planning is a higher order cognitive process that encompasses the selection and organization of steps needed to carry out an intention or reach a goal. This function requires the ability to integrate perceived information, anticipate a future outcome, and select a certain motor response (Casella et al., 2020). To the best of our knowledge, no scientific investigation has focused specifically on these preparatory actions that are used to improve the execution of a following action in soccer.

T2S15: The player makes decisions

Coaches described this subtheme extensively as players making decisions for or against something (e.g., pass, running path). According to the coaches, their decisions arise from desire, experience, tactics, commands, or the behavior of another player. Coaches recognized that players have made a decision based on their behavior (e.g., a specific movement, constant gaze) and primarily on the outcome of the action. Coaches described decisions usually being made before the player's own action, and sometimes during an existing action. Hence, decision making in soccer appears to be omnipresent. They also differentiated a temporal component, namely, the speed of the decision. In a few cases, participants described players being faced with a decision or having to make a decision.

> I do believe you can perceive that well, because now he's taken the step and at that moment, he's already made the decision. [P1, V1506]

In the context of soccer, the complexity and dynamics of the game constantly present players with situations requiring decisions (Petiot et al., 2021). It is therefore not surprising that this topic is of high interest not just in the current study but also in general (sport-) psychological research. Decision making has been a focal point of research since the 1950s, with consistently high levels of scholarly activity (Raab et al., 2019). Expertise studies have shown that more

highly skilled soccer players make more accurate decisions than novices (Vaeyens et al., 2007). Different underlying or connected mechanisms have been investigated, showing a link to superior visual search behavior (Roca et al., 2018), anticipation (McRobert et al., 2009), and executive functions (Heisler et al., 2023) in experts, to name just a selection. Recent studies have emphasized the importance of domain-specific rather than domain-general decision-making research designs to ensure ecologically valid conclusions in soccer (Kalén et al., 2021).

Theme 3: Action executing

This theme encompasses all behaviors where the observed player actively engages in motor actions that have been planned and or prepared beforehand. The player's action involves interacting with teammates, opponents, and the ball. According to our analysis, this dimension is associated with eight subthemes.

T3S16: The player engages in joint actions with teammates or opponents. Through his actions, he involves them (e.g., by initiating a joint action such as a one–two pass; closing off the inside channel and forcing the opponent outward)

In most cases, the participants initially described the player's perceiving the actions of teammates and adapting his behavior accordingly (e.g., positioning, running patterns). In a few cases, the observed player's action was described as providing an impulse for the teammate, prompting a reaction. Thus, within this subtheme, a distinction can be made between receiving and sending signals on interpersonal coordination.

> I believe that he recognizes this; he slightly delays to give his teammates time to run even further forward, to be able to play him even further into space. For me, it has a lot to do with recognizing, with perceiving. Simply a super clever move. Then [he] plays the ball into the leading foot of the teammate, so also into the space, into the run, and then he probably immediately demands the ball back. So, the teammate also does well

> in that moment by recognizing, hey, my partner, the player I circled around, immediately starts running after his pass, and thus, our circled-around player immediately gets the ball back. [P8, V1502]

In research, studies on interpersonal coordination showed that players on the pitch are understood as parts of a complex dynamic system who create a huge number of patterns as a result of their distinct interactions (Santos et al., 2018).

Expert players demonstrate enhanced spatial awareness and timing, allowing them to engage in coordinated actions with teammates more effectively (Silva et al., 2013). Their advanced skills in dynamic environments enable fluid and timely adjustments in positioning and movement patterns, fostering seamless collaborative play (Duarte et al., 2012). Additionally, experienced players show a heightened ability to create and execute joint actions, enhancing both defensive and offensive strategies through cohesive teamwork (Coutinho et al., 2016).

T3S17: The player reacts to situational factors (e.g., the behavior of teammates or opponents, commands)

Based on the participants' descriptions, reacting typically involves a time component (e.g., quick, slow) and a stimulus (e.g., teammate, opponent, ball). A distinction is made from acting (which is the active initiation of an action). Reacting thus partially carries a negative connotation. At various points, the participants differentiated reacting from anticipating and speculating. In these two behavior categories, the player would thus act on their own rather than reacting to a stimulus. At the same time, quick responsiveness is highlighted as positive when a player quickly grasps a situation and takes action. Evaluation is always based on the duration between receiving information and taking action.

> Well, he reacts to it, not anticipating, because it's deflected, and he sees that the ball then comes to him. [P2, V1505]

Scientifically, reacting fast to situational cues in the dynamic of a soccer match has been shown to be fundamental for overall game performance (Mann et al., 2007; Senel & Eroglu, 2006). The skill can be distinguished as auditory or visual reaction; visual reactions appear to play a more important role in soccer (Spierer et al., 2011). Players who could react faster used more efficient searching strategies and based their decisions on elaborated mental representations of game situations (Lex et al., 2015).

T3S18: The player executes a sequence of actions at the highest speed (e.g., when receiving and passing the ball)

The participants described the speed at which a player performs an action. An indicator of action speed, for example, was playing with the first touch, which typically followed a preorientation phase (see also T1P3. Thus, these two subthemes are closely related.

> He reacts quickly to it, paired with the pass to his teammate, which also happens quickly, directly with the first touch, no second or third, no dribbling, but directly, this combination, the speed of the action, I find it's already special here. [P2, V1505]

In previous research this has been studied in terms of speed of action (Skala & Zemková, 2022) or cognitive-motor performance (Hicheur et al., 2017), defined here as the capacity to rapidly use sensory information and transfer it into efficient motor output. It is assumed that not only the rapid and accurate perception of information but also the execution of an appropriate action determines superior performance. Interestingly, expert coaches' evaluations also correlated with objective measures on cognitive-motor-performance (Hicheur et al., 2017).

T3S19: The player deliberately employs feints and deceptions

The described behaviour in this subtheme involves using movement patterns to deceive opponents. Different terms, feint, faking and deception, were used. Coaches described players misleading opponents with a feint, aiming to gain time in some cases. A prerequisite for using a feint is assessing the situation correctly. Thus, players must anticipate what would be surprising in that situation. Coaches distinguished between body feints and shot feints.

> Yeah, he's doing that fake again. He's faking again, going toward the ball and then letting it run again. So, by doing that, you always win that one second. [P4, V1504]

From a research perspective, deceptive moves have been studied mostly from the perspective of an opponent who needs to detect the deception quickly (Wright & Jackson, 2014). There is less research on the players using deception consciously to trick their opponents (Wright et al., 2013). Using deception has been associated with creativity given its surprising and hardly predictable function (Rasmussen et al., 2020).

T3S20: The player acts tactically. It is recognizable, for example, through rehearsed sequences of actions or tactical positioning

The participants assessed actions as tactical if they followed a known and game-leading sequence (e.g., shifting play, positional play). They distinguished between individual and group tactical behaviour, meaning the observed player acted either in isolation according to a given pattern or together with other teammates (related to subtheme T3S16). Furthermore, coaches generally described a game or football tactic, which can be understood as an overarching game idea. This subtheme is related to knowledge and experience accumulated over time (in training and play).

> That might also be a tactical move in that moment to say, okay, we're getting out of the pressure and shifting. Maybe in terms of football tactics, if he had glanced over his

> shoulder, oriented himself, he would have played the ball through the center, and now his red players would be running alone towards the goal. [P8, V1403]

From a research perspective, this is closely connected to tactical knowledge (Rechenchosky et al., 2021). Science differentiates between declarative tactical and procedural tactical knowledge, that is, first facts, hence "knowing what to do," and second specific movements "doing it" (Américo et al., 2017). Expertise studies have shown that expert players outperform less skilled players (Kannekens et al., 2009) and that higher tactical knowledge in players is associated with better overall performance (McPherson & Thomas, 1989; Williams et al., 1993).

T3S21: The player demonstrates creative and surprising behavior for the situation

A creative behavior involves something surprising or unusual. In various descriptions, courage and willingness to take risks were also described as necessary prerequisites for creativity. One coach reported on the problems that arise when creative players play with noncreative players, because they have different ideas about possible courses of action. Thus, creativity is closely related to the realm of ideas and fantasies. However, some coaches described creativity as intuitive and therefore unconscious, and they emphasized that experience is needed to develop creativity.

> Creativity also has something to do with courage. Whether I'm willing to take that risk and try it out, and also whether I can live with it if it goes wrong. And yes, if I never try it, then I will never be creative. [P5, V1504]

Previous research has investigated creativity in soccer. It has been studied in terms of creative decision making, determined by the originality, flexibility, and fluency of players' decisions (Roca & Ford, 2021; Roca et al., 2021). Additionally, tactical creativity was defined as the ability to produce relatively novel solutions that are original (i.e., statistically rare and

surprising) and appropriate (i.e., useful, adequate; Memmert & Roca, 2019). The importance of creativity in soccer has been highlighted, showing that successful teams use creative actions more often to score a goal (Kempe & Memmert, 2018). One study found a connection between creativity and years of experience in soccer-specific unstructured training environments when compared to formal settings (Roca & Ford, 2021).

T3S22: *The player acts intuitively, meaning spontaneously and automatically*

Intuition was described as a gut feeling. It was not defined very precisely overall. From the descriptions, it is clear that it is related to experience, difficult to objectify, and also associated with creativity.

> So, I also believe that he just does it intuitively because he sees that the ball is not played well. But I think that's already an important skill of good players. [P4, V1503]

From a research perspective, this can be linked to intuitive skills (Grève, 2023) and intuitive judgments (Raab et al., 2019). It has been characterized as, for example, being associative, fast, effortless, spontaneous, and unconscious (Abernathy & Hamm, 1995). Intuition is highly linked to knowledge and training, which are both increased with experience in a specific domain, such as sports (Grève, 2023). In soccer, it has been associated with creativity, showing that intuitive decisions and creativity conceptually overlap (Klatt et al., 2019).

T3S23: The player finds a solution to problems on the field (e.g., freeing himself from opponent or space pressure)

Problem solving, according to the descriptions, is related to pressure (time, opponent, or space pressure). A source of pressure triggers a problem, which the players solve through their behaviour. The chosen solution can then have different qualities (e.g., good or poor solution), typically measured by the outcome (e.g., loss of possession, renewed pressure).

Problem solving was distinguished from simply resolving a situation (e.g., exploiting a numerical advantage) or disengaging from something (e.g., opponent).

> But despite not having it, he still found a very good solution to his problem, quite ly even. Although he actually just wanted the ball to run onto, he has now solved a situation with the opponent, which also means that he has adapted very well to the situation, his own situation. [P7, V1604]

From a research perspective, this behavior can be best linked to problem-solving investigations (Hagyard, 2019). Problem-solving skills were described as vital for successfully performing on the field, given the dynamically changing environment (Price et al., 2023). Theoretically, it is assumed that this ability is closely linked to experiences and thereby to gained knowledge, both declarative and procedural (Price et al., 2023).

Theme 4: Action adjusting

This theme includes subthemes describing actions that build on previous behavior and mainly function in terms of adaptation or optimization of a started action. This theme contains three subthemes.

T4S24: The player switches between two game situations (e.g., from offense to defense; after a mistake)

The descriptions of the coaches primarily focused on a player transitioning from one situation to another (e.g., offensive to defensive). The starting point is the perception of the changing situation (e.g., loss of possession), closely related to reaction. It is distinguished from mere reaction by requiring an adjustment. One participant explicitly mentioned flexibility in this context.

> Then he perceives that his teammate wins the ball and he can switch from defending to attacking, I see that in his stopping movement. [P5, V1401]

From a research perspective, this can be assigned to cognitive flexibility, one of three so-called executive functions (for an overview, see Diamond, 2013). One important function of cognitive flexibility is to switch rapidly between tasks, which is needed, for example, to switch between offense and defense (Beavan et al., 2020). Although expertise differences have been found on domain-general tests, the use and validity of these measures for soccer-specific performance has been questioned lately (Beavan et al., 2020; Kalén et al., 2021). In a recent study, cognitive flexibility was tested in an ecologically valid test setting with stress induction. Results indicate that elite youth players could flexibly switch between tasks even when under stress (Knöbel et al., 2024).

T4S25: The player interrupts a once-initiated action if necessary (e.g., pass, shot, running path)

Here, coaches described various, albeit only a few, situations in which either players interrupted their own action, or the situation required an interruption. They described both the "what," meaning interrupting a simple action (e.g., halting a run), and the "why," meaning the reason for the interruption (e.g., seeing another space and occupying it).

> And now, he could interrupt his run, the one he has toward the ball. If he's quick in his mind, he should recognize over his left shoulder that there is space and a need for the ball there. [P8, V1402]

From a research perspective, this can also be assigned to executive functions (Diamond, 2013). Here, it can be linked to inhibition, also called inhibitory control, which has been studied extensively in the last decade (Kalén et al., 2021). Multiple studies on differences between higher skilled compared to less skilled athletes revealed expertise effects in domain-general tasks (e.g., Huijgen et al., 2015; Kida et al., 2005; Verburgh et al., 2014).

T4S26: The player corrects his action if needed (e.g., by changing pace or adjusting positioning)

The central focus of the coaches' description of this subtheme is the recognition that the planned action, in its initiated form, will not lead to the action aim, and therefore a correction is necessary. This correction can involve body posture, positioning, or tempo. It is closely related to timing.

> That's maybe...yes, maybe it's adaptability after all, that he simply adjusts the movement to the playing situation again in that situation. So it's perhaps a bit comparable to penalty takers. They approach and then react again in the shot or just before the shot, maybe to what the goalkeeper does, which corner he offers. Do they actually have something else in mind, but then they adjust their ankle at the last moment. [P5, V1404]

From a research perspective, this theme can also be connected to executive functioning, namely, to cognitive flexibility (Diamond, 2013). This function, defined as the ability to adapt to situational features and to switch between tasks (see T4S24), has been described as crucial for successful soccer performance (Vestberg et al., 2012). Cognitive flexibility allows the player to adapt a preplanned action through the adjustment of movements if necessary (e.g., wait to make a move; Huijgen et al., 2017).

Soccer-specific heuristic model

Based on the findings of this study a domain-specific heuristic model of PCSs in soccer has been developed (see Figure 5.1). The model suggests that during a game, players utilize various PCSs from the four overarching domains to execute soccer actions. These domains interact with each other and are influenced by environmental (e.g., game location) and situational factors (e.g., opponent pressure). The model suggests that while there is a general sequence in which these domains are activated (i.e., information intake typically precedes processing, which precedes action execution), this sequence is not rigid. Players may switch back and forth between domains as required by the dynamic nature of the game. Importantly, not all domains may be engaged simultaneously during every action.

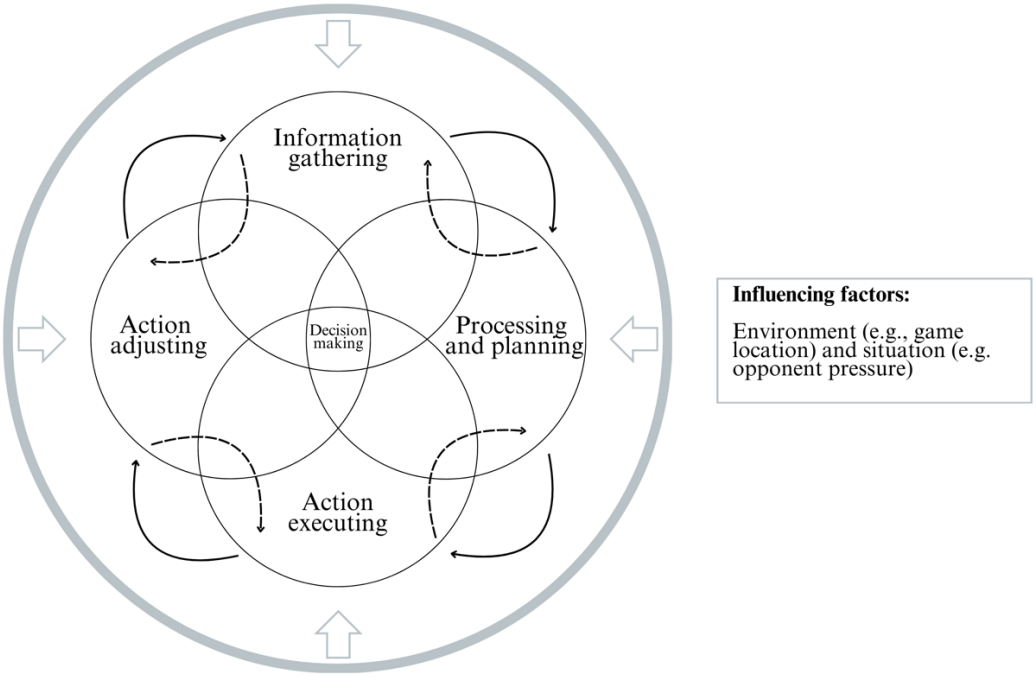

Figure 5.1 Youth soccer-specific heuristic model of intertwined perceptual-cognitive skills (PCSs)

A crucial aspect of this model is the role of decision-making across all four domains. The centered position reflects the coaches' description of decision-making being involved during every phase of a soccer action, although conceptually it has been assigned to processing and planning. For example, a player may decide to increase their frequency of shoulder checks, maintain attention throughout different phases, choose to execute a specific play, or alter their intended action, such as switching from a pass to a dribble. Hence, decision-making is fundamental to adapting to the continuously changing situations on the field.

Overall Discussion

The aim of the present study was to explore whether professional soccer coaches are able to infer PCSs of youth soccer players from observing them in real-life game footage. Results show that coaches identified 26 PCSs (subthemes), which were assigned to four overall domains (themes). Given that most of the studies so far have either focused on domain-general cognitive skills or not applied the coach's eye approach on sport-specific skills, this study adds unique insights. These insights hold theoretical added-value as they add a level of behavioral description to the perceptual-cognitive constructs. Furthermore, the qualitative approach allows for a more nuanced picture of the interrelations of PCSs in soccer. Additionally, the study contributes to the applied field through a list of theoretically informed and empirically based behavioral descriptions that can guide coaches in the assessment of PCSs.

PCSs of soccer players can be observed and described by coaches

PCSs are fundamental to a player's performance in soccer, and coaches play a crucial role in observing and interpreting these skills from players' behaviors on the field (Sarmento et al., 2018). Through their extensive experience and involvement during both training and matches, coaches are uniquely positioned to assess these cognitive processes directly through observable actions (Roberts et al., 2019). The present research underlines the richness and value

of the coaches' knowledge with the number and details of descriptions. Even when watching short video sequences, coaches consistently observed and described a broad range of PCSs. Their detailed descriptions made it evident that they "know where to look." Coaches differed with regard to which PCSs they deemed important and labeled explicitly, and how they inferred them. They consistently named indicators such as body position, direction and duration of a player's gaze, pace of movement and changes in pace, and distances, to name just a few, to infer PCSs. For example, they were able to describe anticipation by a player's positioning and timing of movements. Across the range of PCSs, some were elaborated in more detail, as well as named more often, than others. For example, players' visual search behavior and orientation, their anticipation, positioning, and reactions as well as timing appear to have been easier to observe than multisensory perception, peripheral perception, pattern recognition, or memory-related skills. There are different possible explanations for this. First, coaches mostly relied on changes in behavior to infer PCSs; for instance, looking up was an indicator for visual search. But, for example, a no-change (gaze straight) followed by a no-look pass was used to infer peripheral vision. Second, their descriptions are knowledge-dependent, since expression of thoughts needs language (Widjajanti, 2020). Most of the more difficult to observe PCSs, such as suppressing an action (i.e., inhibition) or focusing on specific stimuli (i.e., selective attention) are less prominent in the daily life of coaches. Coaches gain knowledge through education (i.e., licensure, studies, further education) and there is a strong focus on some PCSs such as decision making, anticipation, scanning, and creativity within these programs (DFB-Akademie, 2024). This hypothesis is supported by the fact that some of the coaches who had just recently participated in further education explicitly used wording referring to executive functions, a topic that has received more attention in the applied field in the last years. This work highlights a significant challenge in this area: the lack of a common language among coaches (Christensen, 2009). This can lead to inconsistencies in how these skills are interpreted and coached. Further,

a diversity in terminology reflects the subjective nature of observational assessments and underscores the need for a more standardized approach to describing and evaluating PCSs.

PCSs in soccer are highly intertwined

What has been already stated in previous research is that the separation of individual PCSs limits domain-specific conceptualizations (Roca et al., 2013). Theoretically, it has been well reported that PCSs in the context of soccer highly interact with each other or build a foundation for each other (van Maarseveen et al., 2018). Given the complexity of a soccer match and the dynamically changing environment, there is a constant need for the players to execute movements while perceiving new information that needs to be processed. Verheijen (2020) called this a two-way information exchange between the living environment (teammates and opponents) and the actor. The qualitative research approach in this project allowed for a detailed understanding of how different PCSs interact dynamically during actual gameplay, an aspect often missed in controlled experimental setups (Williams & Hodges, 2005). In our study, various meaningful connections between different constructs were identified (e.g., joint action relied on anticipation, information search and positioning) and displayed in the developed heuristic model (see Figure 5.1). In addition to PCSs being intertwined, it was evident that they shared different subcomponents. For example, it can be seen from the coaches' descriptions that positioning on the field includes a perceptual component (i.e., searching for open space or seeing other players), an information-processing component (i.e., anticipating what could happen next), a decision-making component (i.e., deciding on the best position), and a motor component (i.e., moving into that position). The highly intertwined nature emphasizes the need to take the unique interplay of components into account when both understanding them conceptually and evaluating them.

Limitations

All participating coaches came from a single club, which likely resulted in a homogeneous knowledge base regarding the topic. Additionally, the study focused solely on male players and coaches because of the German youth soccer system's emphasis on promoting male talent at the professional level. Future research should include female youth soccer players to provide a more comprehensive understanding.

Conclusion and Future Directions

The present study demonstrates that professional youth soccer coaches can infer PCSs from video sequences of real-life games. The identification of 26 different descriptions highlights the wide range of PCSs involved in the dynamic play of soccer. However, these skills are highly intertwined, challenging previous reductionist approaches in science that test these skills in isolation. This research has laid the groundwork by investigating PCSs from a coach’s perspective. Future studies should aim to build on this foundation, offering detailed analyses and robust modeling. From an applied perspective, there is a need to enhance knowledge, improve systematic assessment, and develop consistent conceptualizations of PCSs for coaches and scouts. In the future, the PCSs with the highest value for coaches' assessment should be identified and systematically considered in talent identification and development programs in soccer.

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Appendix

Supplementary Material

Method and procedure

We first conducted an (unsystematic) literature review to capture the wealth of PCSs investigated in soccer research. This review revealed a huge number of results, with inconsistencies in labels and conceptualizations. Therefore, the most prominent skills were extracted and then assigned to superordinate constructs according to Purves et al. (2013), resulting in a list of 23 different skills (see Supplementary Material). In Step 2, we presented preselected real-life video sequences ($N = 22$) of boys' under-14, under-15, and under-16 games to an expert panel ($N = 4$). Experts were then asked to mark the skills from the predefined list that were in their opinion displayed in the video sequences. After reviewing the sequences, in Step 3 we made a final selection of the video material ($N = 14$) according to a predefined criterion (see Video Selection). In Step 4, we conducted video-based semi-structured interviews with coaches ($N = 10$). Data were analyzed in Step 5.

Video selection

Video sequences of boys' under-14 to under-16 matches from one youth academy were viewed and short sequences extracted. In total, 45 sequences of typical game situations (e.g., switching situation from defense to offense, build-up plays or switch plays) were edited. Importantly, in all sequences the key player was from the opposing team, to reduce the probability of coaches' bias due to knowledge about this player. After a first evaluation, in cooperation with a game analyst all sequences were excluded that (1) showed behavior that led to possession switch (e.g., mispass), (2) showed exclusively defense behavior, or (3) did not show one main actor. After this, 22 sequences remained, which were prepared for the expert panel. Sequences were cut so that the action of interest had a clear starting and end point (e.g.,

started with a winning ball, ended with a pass to a teammate). If a sequence in reality ended with a goal shot, the sequence was cut to avoid bias, given that goal situations are generally perceived as most important (Decroos et al., 2019). The mean duration of sequences was 9.71 s (*SD* = 2.30; range = 7–16 s).

Expert panel

The aim of the expert panel was to have a theoretically based selection of video sequences that covered a broad range of different skills. The researchers (*N* = 4), of whom two were Ph.D. students and two post docs, were all experts in cognitive psychology and sport psychology. The expert panel took place virtually, owing to COVID-19 regulations. All 22 video sequences were presented one after another with shared screens. Participants received the list of skills and were asked to indicate for each skill if they were displayed/relevant in the presented sequences. After every researcher had made their individual decision, results were openly discussed until consensus was reached (Trautwein et al., 2019). If the discussion did not end in consensus, the video sequence was excluded from the expert interviews. Finally, *n* = 14 sequences were chosen for expert interviews. This final selection included video sequences of *n* = 4 under-14, *n* = 6 under-15, and *n* = 4 under-16 teams. Among all sequences, the subordinate categories (Purves et al., 2013) of skills were equally distributed. All 14 sequences were edited to start with a 3-s frozen image to visually highlight the player of interest.

Table 5.1 Subthemes with an additional quote from the coaches' descriptions

Subthemes	**Quote**
The player directs his gaze towards relevant positions or objects (e.g., the ball).	Yes, because he dribbles very forward and, it feels like, from his gaze behavior, he's just waiting to play the ball into that space. And he doesn't see the two players on the right at all. [P5, V1506]
The player perceives information in his peripheral vision (e.g., teammates or opponents).	But then there's this peripheral perception because he recognizes it in his peripheral vision, that there are one, two, or three...players a meter behind him. [P10, V1502]
The player orients himself on the field (e.g., through scanning or shoulder checking).	He takes a shoulder check, which tells him that there's no other player from...who can intervene. [P5, V1504].
The player incorporates various senses into his perception (e.g., hearing, vision, touch).	He's constantly anticipating the pressure from the opponent, even though he doesn't constantly look around, he still feels his opponent and uses his body well. He seeks physical contact because he feels comfortable doing so. It could be compared to posting up in basketball. So, seeking contact to know where he can pivot out. [P3, V1603]
The player focuses his attention on something specific (e.g., opponent).	He doesn't even look around, which means he's totally focused on the ball and he doesn't consider any other options, but it's clear to him that he somehow turns around the opponent. [P4, V1603]
The player identifies open spaces.	And he uses this period, this short period, to quickly scan, to look on the right side where someone is coming, putting pressure on me, but at that moment he also recognizes that where the player is coming from, a space is opening up and he takes the ball there brilliantly. [P8, V1506]
The player recognizes recurring game situations or patterns of action.	Yes, yes, because that is something that, for me, characterizes the recognition of game situations. I have to keep an eye on the opponents, the ball, and the space [P2, V1502]
The player accesses stored knowledge that he perceived shortly before.	Because, the ball comes from his own half, from the...half, and he knows from the situation that preceded, in which he found himself, that many of his teammates, but also many of his opponents, linger in his own half. [P8, V1602]
The player anticipates or speculates about a situation and thinks several moves ahead.	I don't know. The question is whether you want to make a distinction between anticipating and speculating? Maybe speculating is a little more extreme. For example, I speculate that a cross will come through because the defender in front of me doesn't touch the ball, so that I'm still there even if he does touch it. So, I'm speculating more on an error from an opponent, and I anticipate more from experience, from the past, or from known situations, that a fullback plays along the line or makes the pass to the center. [P1, V1505]
The player has or follows ideas.	Maybe he already has the idea there or probably he already has the idea there, where the ball is going. Because he knows, okay if he's close and then just makes that decision. So he easily comes/so he already had the idea beforehand, what he wants to do now. [P10, V1503]

The player is active and remains attentive through various actions. He stays "online" during a set of actions.	So, he's in the game. He's totally active. He's not like the player earlier, but he wants to participate in the game. He wants to make himself available for a pass. He moves into spaces where he's open for a pass. [P5, V1502]
The player positions himself advantageously.	He is in a good position, he has good contact with his opponent, so he positions himself cleverly in terms of distance. He is ready for both options, which is evident. He is ready to press the opponent but also for a deep ball. So, I must say his brain is very well engaged in thinking about which options the opponent might use. [P7, V1505]
The player times his actions so that the ball or he arrives at the destination at the right moment.	For me, it's crucial to be there simultaneously or almost before the ball (to win possession). With the first touch, and now you're there. So, a quarter of a second more and he could have played it again, but now that you're back in time, you put him under such pressure that he can no longer find the solution. [P1, V1501]
The player prepares his own actions (e.g., through specific positioning or making a run).	He has to prepare the situation himself first so that he can play it deep again. [P10, V1403]
The player makes decisions.	I: How do you determine that he has made a decision? P: Simply because he has focused, his gaze. He looks once, twice (to make sure). [P3, V1602]
The player engages in joint actions with teammates or opponents. Through his actions, he involves them (e.g., by initiating a joint action such as a one-two pass; closing off the inside channel and forcing the opponent outward).	And then he recognizes the new situation, that his teammate has prevailed, adjusts to it, and sees that we have a three-on-two situation, and they play it out. But he does it superbly. [P5, V1601]
The player reacts to situational factors (e.g., the behavior of teammates or opponents, commands).	Well, it's very high because he adjusts his running behavior to what's happening, and that's a high agility and activity; he's not sluggish, but he reacts quickly to what's happening, and what's happening is passing the opponent and that's the signal for him. [P2, V1601]
The player executes a sequence of actions at the highest speed (e.g., when receiving and passing the ball).	Because beforehand it's relatively clear for him, he also recognizes the space beforehand, now the situation relatively quickly, demands the ball, acts quickly, and then plays the ball into it. [P10, V1602]
The player deliberately employs feints and deceptions.	So, then it's simply the fake, letting the ball run through. That is certainly a creative solution in the situation, which, yes, a bit difficult to say, could have gone wrong just as well, and the ball could bounce against the defender. [P5, V1604]
The player acts tactically. It is recognizable, for example, through rehearsed sequences of actions or tactical positioning.	And he does it smartly, because he's relatively close and makes it difficult for the defender to get around him. So, in terms of individual tactics, he does it really well. [P5, V1604]
The player demonstrates creative and surprising behavior for the situation.	I: What characterizes creativity here? P: Doing the unexpected. So, he looks somewhere else but stores it differently. This makes it surprising because no one expects it. So, because his body posture is different, you expect a different action. [P3, V1404]
The player acts intuitively, meaning spontaneously and automatically.	But the boy is creative. That's intuition. That's what we want. [P9, V1501]

The player finds a solution to problems on the field (e.g., freeing himself from opponent or space pressure).	He's under pressure from the striker, and I'm not sure if he recognized the short option through the number 6 and has too much focus on the ball.... I think he didn't see and recognize any options, and then made the movement as a reaction. Still, well solved. [P3, V1504]
The player switches between two game situations (e.g., from offense to defense; after a mistake).	It's just a transition play from the Blues, and normally if the ball goes out, it would, so to speak, end the situation for the defending team. In this case, they react quickly. They take the ball, make a throw-in, play it out, and score a goal from it or not. [P4, V1602]
The player interrupts a once-initiated action if necessary (e.g., pass, shot, running path).	That means, even though he then retreats here, interrupts this run, maybe even a tad late, but breaks off the run. Then [he] also receives the pass in the first contact but is also not oriented. [P8, V1403]
The player corrects his action if needed (e.g., by changing pace or adjusting positioning).	So, he runs backward, takes the steps and then corrects his running behavior backward when he realizes that the ball can come to him from behind and his teammate can play him, and then slows down. [P2, V1403]

Note: P = Participant, V = Video; The four numbers are an internal code for the assignment of the videos. The first two digits represent the age group of the players shown in the video (under-14, under-15, under-16), and the second set of digits is a sequential number within the age category.

6. Article 2

Coaches' evaluation of domain-specific perceptual-cognitive skills in youth soccer

Heisler, S. M., Lobinger, B. H., Siebler, M., Raab, M., & Musculus, L.

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Abstract

This exploratory study investigated how $N = 43$ experienced youth soccer coaches evaluated 35 domain-specific perceptual-cognitive skills (PCSs) of youth players. Coaches evaluated PCSs, operationalized as behavioral descriptions, in terms of their relevance, frequency of usage, and observability. Key skills such as switching, preorientation, and decision making consistently emerged as crucial for youth player performance, being highly rated across all variables. Their consistency across evaluations highlights their importance for talent identification and development. However, other skills, such as anticipation and activity, presented more complex profiles. Anticipation was evaluated as highly relevant, frequently used, but hard to observe, whereas activity, was moderately relevant and moderately often used but easy to observe. This suggests a nuanced approach for criteria selection and the need for more structured observation tools to ensure accurate assessment. The study also highlights a heterogeneity in how coaches label PCSs, pointing to a potential gap between practical and scientific terminology. This emphasizes the need for standardized vocabulary to enhance consistency and comparability in player assessment. Furthermore, the study findings generally support a shift toward behaviorally based assessments, focusing on observable actions rather than abstract concepts, which would make evaluations more reliable and align talent identification more closely with research.

Keywords: Player's assessment, coach's eye, perception and cognition

Introduction

Toni Kroos, a former German national player and winner of multiple Champions League finals, is remembered as a player with an outstanding ability to read the game, find the best solutions, and time his passes perfectly. When assessing the qualities of excellent players, it is no longer just athletic and technical characteristics that are mentioned, but also those that relate to perception and cognition. This is reflected in an increasing consideration of perceptual-cognitive skills (PCSs) in talent identification of youth players (Bergkamp et al., 2022). Talent identification in youth soccer is mostly based on subjective, observational assessments by coaches and scouts (Murr et al., 2018) and often lacks systemization (Johnston et al., 2018; Musculus & Lobinger, 2018). More precisely, for PCSs there exists a lack of both a common understanding of the constructs and a scientifically driven selection of criteria (Christensen, 2009; Fuhre et al., 2022). Hence, to further support a reliable and objective talent assessment of PCSs in youth soccer, we sought to holistically evaluate a multidimensional range of soccer-specific PCSs concerning their relevance, frequency of usage during a game, and observability. Analyzing the evaluation of PCSs supports a scientifically driven, ecologically valid, and practically feasible assessment of these skills, serving as one crucial component in identifying young soccer players with the potential to become senior professionals.

PCSs enable a player to process and interpret multifaceted sensory information to make quick and effective decisions in the highly dynamic game of soccer (Mann et al., 2007). These include, for example, spatial awareness, which helps players understand and adjust their position relative to other players and the ball (Stevens-Smith, 2004); anticipatory skills, which enable them to predict opponents' moves and adjust their own actions accordingly (Gonçalves et al., 2015); and decision making, which allows them to choose the best course of action in the dynamic, often pressured game (Musculus et al., 2019). Importantly, we share the theoretical position that these skills are understood as domain specific, meaning they are highly specialized

and tailored to the unique demands of soccer, developing through extensive practice and experience within that specific context (Kalén et al., 2021; Ward & Williams, 2003). As such, these PCSs may not necessarily transfer to other sports or activities, as they rely on recognizing and responding to the specific patterns, cues, and dynamics of the soccer environment (Roca et al., 2013). Recently, the use of domain-general assessment of perception and cognition has been questioned and the need for domain-specific conceptualizations has been emphasized (Beavan et al., 2020; Kalén et al., 2021). It has been shown meta-analytically that domain-specific skills have higher explanatory power for expertise differences between higher and lower skilled players, outperforming domain-general cognitive functions (Kalén et al., 2021). The authors of the meta-analysis concluded there is no empirical reason to use domain-general assessment for talent identification. When considering PCSs in a sport-specific manner, applying a coach's perspective to improve player assessment becomes crucial, as their experiential insights can provide a nuanced understanding of domain-specific requirements that complements and enhances the theoretical conceptualizations (Musculus & Lobinger, 2018).

The *coach's eye for talent* (Roberts et al., 2019, 2021), as it has been labeled, is the intuitive and observational skill of soccer coaches identifying and evaluating young players' potential (Bergkamp et al., 2022). This approach heavily relies on the coach's experience and expertise in recognizing key attributes and has been shown to hold prognostic validity (Lath et al., 2020; Schorer et al., 2017). The literature on the coach's eye approach has consistently shown that when asked to identify the most important talent criteria, coaches frequently name PCSs among the wide range of existing attributes (Fuhre et al., 2022; Jokuschies et al., 2017; Larkin & O'Connor, 2017). For example, PCSs have been identified as one of seven key criteria that coaches look for in talents, encompassing skills such as orientation, perception, information acquisition, processing speed, anticipation, solution recognition, and correct decision making (Jokuschies et al., 2017). In line with this categorization, Norwegian coaches identified decision

making as the most crucial talent criterion, along with game understanding, creativity, and positioning (Fuhre et al., 2022). Similarly, research has highlighted the importance of decision making, attention, anticipation, and game understanding as key attributes for young players (Larkin & O'Connor, 2017). These study results show that coaches do indeed consider and refer to perceptual-cognitive criteria. Nevertheless, such studies typically employ inductive methods, utilizing a free-recall technique that prompts coaches to express their knowledge comprehensively. Given the vast number of constructs related to PCSs (e.g., see Mann et al., 2007), the coaches' responses are likely influenced by the most recognized and familiar criteria, rather than reflecting the full spectrum of relevant constructs (Endres et al., 2020).

In a recent study (Heisler et al., 2024), in which the multidimensional nature of PCSs in soccer was captured, a video-stimulated interview technique was applied with coaches. In the study, a standardized set of 14 videos of male under-14, under-15, and under-16 (U14–U16) youth soccer game footage was presented to $N = 10$ professional youth coaches. Coaches were asked to describe what, if any, ongoing PCSs they perceived, how they would define them, and, most importantly, what behavioral anchors they had used to spot the respective PCSs. This standardized protocol and a qualitative analysis of the results revealed 35 behavioral descriptions of distinct skills that were categorized into four overarching domains (see Figure 6.1): information gathering, processing and planning, action executing, and action adjusting. According to a heuristic working model (see Figure 6.1) that was derived from the data, these domains are highly intertwined and tend to unfold sequentially during a soccer action. However, they are connected through feedback loops, meaning that a single domain can be repeatedly involved throughout the process.

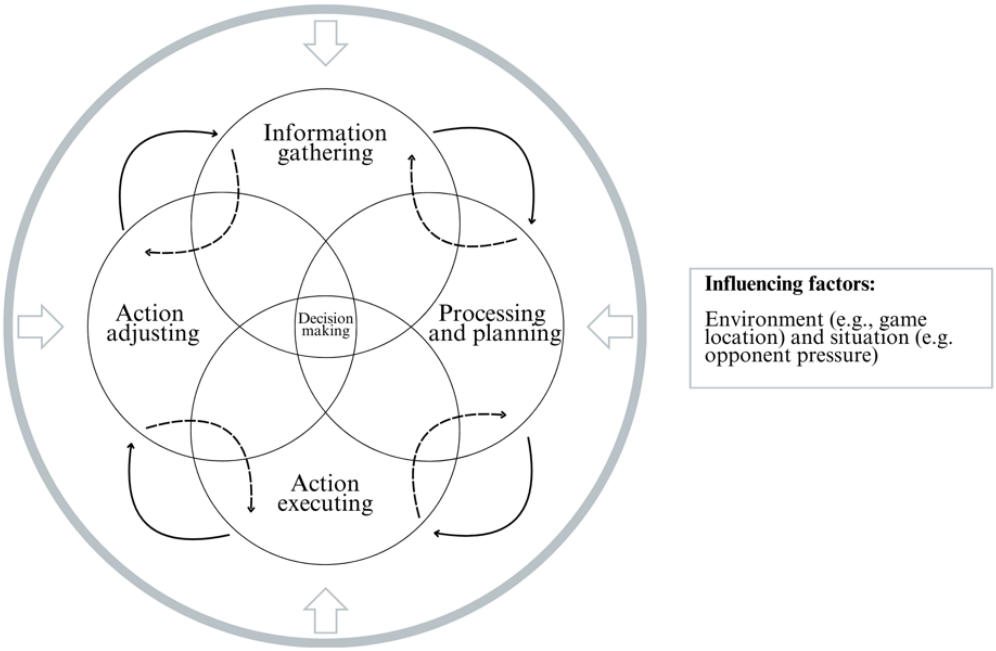

Figure 6.1 *Youth soccer-specific heuristic model of intertwined domains of perceptual-cognitive skills. From Heisler et al. (2024)*

The Present Study

The aim of this study was to investigate how coaches evaluate domain-specific PCSs in youth soccer, focusing on their relevance, frequency of usage, and observability. By examining the relevance of PCSs, we sought to explore their differentiated importance for soccer performance, an area largely overlooked by current talent-identification models that do not sufficiently distinguish within the broad category of PCSs (MacNamara & Collins, 2015; Williams & Reilly, 2000). This study represents a novel approach by examining an extensive list of PCSs, operationalized as behavioral descriptions, rather than limiting the focus to a few selected abstract terms. Besides the relevance, we also investigated the frequency of usage of these skills during play, noting that in other domains, more frequently used skills, such as dribbling, tend to have higher relevance for performance and success (Huijgen et al., 2009). Importantly, other skills such as shooting, though infrequently used during games, have a

disproportionately high impact on game outcomes (Paisal et al., 2024). By exploring this relationship, we aimed to clarify how frequency and relevance interact in the context of PCSs.

Finally, we assessed the observability of these skills, which is crucial in player' assessment since coaches and scouts often rely on their experience-based observations to identify potential in players or to evaluate current performance levels (Christensen, 2009; Larkin & Reeves, 2018). Given limits in evaluating multiple criteria at the same time (Lawlor et al., 2021), coaches must prioritize, with observability being one respective criterion. By examining relevance, frequency of usage, and observability we aimed to make players' assessment as part of the talent-identification process more consistent and scientifically grounded.

Theoretically, the present study builds on previous research indicating the importance of PCSs in talent identification (Larkin & O'Connor, 2017; Ward et al., 2002). However, prior studies have often relied on a selected few, such as decision making and anticipation, which fail to capture the complexity of individual PCSs. By recognizing the multidimensional nature of these skills, we sought to provide a more nuanced understanding of how specific PCSs contribute to soccer performance.

On a methodological level, we used behavioral descriptions of PCSs to enhance ecological validity and minimize evaluation biases arising from coaches' preconceptions. These descriptions are contextualized and domain specific, reflecting the situation-specific cognitive demands inherent in real-world game situations, such as incorporating multiple senses into perception (e.g., seeing, hearing, body contact). In this study we applied an underrepresented coach's perspective, which is critical because coaches are the primary evaluators of talent, relying on implicit knowledge that is often neglected in empirical research (Nash & Collins, 2006). Moreover, by using behavioral descriptions, we aimed to ensure that the findings would

be easily understood and communicable, making the results more transferable and usable for future practices.

In an exploratory quantitative study design with a sample of experienced youth soccer coaches, we aimed at answering the following research questions: Which PCSs, operationalized as behavioral descriptions, are considered (1) the most relevant, (2) the most frequently used during play, and (3) easiest to observe? Further, we investigated (4) the differences in relevance, frequency of usage, and observability across domains, as well as (5) the relationships of these three variables. Last, we aimed at capturing (6) the language of coaches by descriptively analyzing the labels coaches assign to the behavioral descriptions.

Method

Participants

A total of $N = 43$ male participants with an average age of 29.14 years ($SD = 6.99$) completed an online questionnaire. One female participant started the questionnaire but had to be excluded because she did not meet the inclusion criteria. Inclusion criteria were (1) at least 1 year of experience in the respective role in soccer, (2) at least 1 year of experience in the respective role with the U14–U16 age group, (3) at least 1 year of experience as a coach or assistant coach, and (4) possession of a Union of European Football Associations C license or higher licenses. The inclusion criteria followed Parker et al. (2012) and Turnnidge and Côté (2019). On average, the participants had 8.58 years ($SD = 4.57$) of coaching experience. Although all participants had a history as a coach, their current positions were diverse. Among them, there were 24 head coaches, 17 assistant coaches, five scouts, six video analysts, and three department heads or sports directors. (Note, a participant could have multiple roles simultaneously in their club, so the sum of different roles exceeds the number of participants.) Twenty-eight participants worked in a professional youth academy (65.12%). All participants held a valid coaching license: C license ($n = 3$), B license ($n = 18$), B+ license ($n = 13$), A

license (*n* = 7), or A+ license (*n* = 2). Most of the participants had an academic degree (*n* = 28; and 19 of those degrees were in the field of “sport” or “coaching”). A further 10 participants had graduated from high school and five had completed an apprenticeship.

Instruments

An online questionnaire was developed to assess the coaches’ evaluation of 35 different PCSs. This list of PCSs was developed after a literature review and a preceding qualitative study in which professional soccer coaches were asked to describe behavioral indicators of perception and cognition in real-game soccer footage (Heisler et al., 2024). The initial thematic analysis of the interviews led to the identification of 35 skills (see Table 6.1), which were then extracted for the current study. Instead of using abstract terminology (e.g., pattern recognition or search behavior), the questionnaire employed descriptions to present these skills (e.g., the player quickly recognizes recurring game situations and applies familiar solutions, or the player directs his gaze toward relevant stimuli such as the ball or opponent). In this way we ensured a general understanding of the PCSs and used the wording of coaches. The online questionnaire was created using SoSci-Survey (Leiner, 2024) and consisted of three parts: (a) sociodemographic questions, verifying the inclusion criteria, (b) the body of 35 skill descriptions and subsequent questions, and (c) labeling the skill descriptions.

A short introductory video explained the aim and context of the study as well as the following procedure. The 35 skills descriptions were presented each on a separate page, along with the following questions: (1) "How **important** do you consider this skill for soccer players?" (2) "How **frequently** is this skill used in the game?" (3) "How easily can this skill be **observed**?" On each page, right below the skill description, participants were explicitly reminded to answer with respect to the U14–U16 age group. Questions were rated on a Likert scale ranging from 1 ("very unimportant," "very rarely," "very poorly") to 9 ("very important," "very frequently," "very well"). This scaling was adapted from Larkin and O'Connor (2017).

At the end of each page, participants were asked to provide a name for each skill: (4) "What would you **name** this skill?" The 35 skills were presented in a randomized order to control for potential confounding factors such as fatigue or loss of motivation and to minimize systematic biases (e.g., position effects). Given there is still no common language to describe these skills (Christensen, 2009), for the results presentation we have used established scientific wording if available, otherwise labels from practice (for an overview see Table 6.1).

Procedures

The local ethics committee approved the study on April 25, 2023 [055/23]. Data were collected over a period of 6 months, in consideration of temporal restrictions of many potential participants in the field of youth soccer. Each participant provided informed consent before starting the questionnaire. The mean duration to complete the questionnaire was 30.84 min (*SD* = 9.85).

Table 6.1 Overview of the perceptual-cognitive skill labels and their behavioral descriptions

Domain	**Scientific label**	**Behavioral description of perceptual-cognitive skill** (items of the online questionnaire)
PP	Spatial awareness	The player positions himself in open spaces (i.e., with appropriate distance from the opponent) and plays balls into open space (e.g., into the movement of a teammate).
PP	Sustained attention	The player remains attentive throughout various game actions and stays "engaged" in the play.
PP	Activity	The player is constantly moving (e.g., by making runs and creating passing options).
PP	Anticipation	The player can think ahead in several situational stages. He initiates actions before the outcome of the previous situation is clear, based on key information from others.
PP	Speculation	The player acts before gathering all the necessary information. showing a willingness to take risks.
PP	Preparedness	The player prepares his actions well (e.g., by taking a purposeful first touch, letting the ball run through, or moving away from the opponent).
PP	Estimation	The player correctly estimates distances, times, and speeds of the ball, as well as of teammates and opponents.
PP	Working memory	The player draws on recently stored knowledge and uses it in his next action (e.g., one-touch passes or no-look passes).
PP	Pattern recognition	The player quickly recognizes recurring game situations and applies familiar solutions (e.g., opponent always shoots with his left foot, so the defender directs them to the right).
PP	Option generation	The player positions himself in ways that give him multiple advantageous action options.
PP	Decision making	The player makes correct decisions for the game situation.
PP	Positioning	The player adjusts his positioning advantageously, choosing distances from teammates and opponents sensibly to maintain a positive influence on the game.
PP	Timing	The player adjusts the speed of the pass or his own movement so that the ball or player reaches the target at the right time.
PP	Imagination	The player gives the impression that his actions are driven by an underlying idea.
IG	Gaze behavior	The player directs his gaze toward relevant information (e.g., toward the ball, opponent).

Domain	**Scientific label**	**Behavioral description of perceptual-cognitive skill** (items of the online questionnaire)
IG	Peripheral perception	The player perceives information in his peripheral vision (i.e., out of the corner of his eye) without looking directly.
IG	Multimodal perception	The player incorporates multiple senses into his perception (e.g., seeing, hearing, body contact).
IG	Preorientation	The player regularly scans his surroundings (ideally 360°) and this behavior increases just before his action (e.g., through shoulder checks).
IG	Selective attention	The player focuses his attention on one stimulus (e.g., marking a specific opponent during a set piece).
AE	Reactions	The player reacts to situational factors (e.g., behavior of teammates or opponents, commands, changes in the situation) at maximum speed.
AE	Speed of action	The player executes his actions at maximum speed (e.g., controlling and passing the ball).
AE	Tactical knowledge	The player acts tactically, as evident in rehearsed actions or tactical positioning.
AE	Procedural knowledge	The player shows appropriate movement patterns for the situation. He knows how to move.
AE	Goal-directed action	The player acts purposefully and does not deviate from his plan during the action, making it seem as if he is following a set action plan.
AE	Feinting	The player uses feints and deceptive moves purposefully, and they seem automatic.
AE	Interpersonal coordination	The player adapts his actions to those of teammates and opponents, involving them in his play (e.g., initiating a one-two pass or pushing the opponent wide).
AE	Perspective taking	The player puts himself in the shoes of his teammates or opponents, using that information to adjust his own behavior (e.g., predicting the next action from body posture).
AE	Problem solving	The player quickly finds solutions to problems on the field (e.g., freeing himself from opponents or space pressure).
AE	Creativity	The player shows surprising, sometimes risky solutions for the situation.

Domain	**Scientific label**	**Behavioral description of perceptual-cognitive skill** (items of the online questionnaire)
AE	Intuition	The player acts spontaneously and automatically, without double-checking his actions.
AE	Motor control	The player is able to control his motor skills and use his abilities appropriately for the situation.
AA	Switching	The player switches quickly between two game situations (e.g., from offense to defense; after a mistake).
AA	Cognitive flexibility	The player reacts flexibly to situational factors (e.g., after a position change or player substitution).
AA	Inhibition	The player stops an already initiated action if necessary (e.g., pass, shot, run).
AA	Corrective behavior	The player corrects his actions if necessary (e.g., by adjusting his speed or positioning).

Note. PP = Processing and planning; IG = Information gathering; AE = Action executing; AA = Action adjusting; a German version can be found in Table 14.2, see Appendix C.

Data analysis

As a first step, we conducted tests for normality, which revealed nonnormally distributed data for all 35 skills across the three variables relevance, frequency of usage, and observability. For relevance, the Shapiro–Wilk test indicated that the variables were not normally distributed ($p < .05$), except for speculation ($p = .071$). For frequency, most of the variables were not normally distributed ($p < .05$); the exceptions were selective attention ($p = .086$), speculation ($p = .091$), and intuition ($p = .053$). For observability, again most of the variables were not normally distributed ($p < .05$), except for multimodal perception ($p = .083$), speculation ($p = .068$), and goal-directed action ($p = .094$). As a result, nonparametric methods were chosen for subsequent analyses. Spearman's rank correlation was used to explore the relationships between the variables relevance, frequency, and observability. This nonparametric measure was chosen because it does not assume linear relationships or normally distributed data, making it suitable for the current data set. To assess differences in the evaluations given by coaches within the three variables relevance, frequency, and observability, the Friedman test was applied. This nonparametric test does not require normally distributed data. The Friedman test produces a chi-square statistic and a corresponding p value, assessing whether there were statistically significant differences in the mean ranks of coaches' evaluations.

In case the Friedman test revealed significant differences ($p < .05$), post hoc stepwise testing was conducted to identify which specific skills contributed to the observed differences. A Bonferroni correction was applied to control for Type I error due to multiple comparisons. This correction adjusted the p-value threshold, ensuring that any significant findings were robust against false positives.

We were also interested in test differences in mean ranks for the overarching domains (see Figure 6.1) information gathering, processing and planning, action executing, and action

adjusting. Again, we used the nonparametric Friedman test and applied post hoc tests with a Bonferroni-corrected alpha level.

Last, regarding the labels, individual responses from coaches were descriptively analyzed. The qualitative analysis of individual labels will begin to address the lack of a common language for discussing PCSs (Christensen, 2009).

Results

Table 6.2 provides the means and standard deviations of coaches' evaluations of relevance, frequency, and observability of individual PCSs and domains.

Relevance

The most relevant PCSs were switching, problem solving, preorientation, decision making, and spatial awareness. The Friedman test revealed a significant difference in relevance scores between all 35 PCSs, $\chi^2(34) = 434.22$, $p < .001$, Kendall's $W = 0.37$. The post hoc comparison using a stepwise step-down procedure with Bonferroni correction for multiple testing revealed no significant differences.

Regarding the mean relevance of domains, action adjusting was rated as the most relevant, followed by processing and planning, information gathering, and action executing. A significant difference between domains was identified with the Friedman test for related samples, $\chi^2(3) = 25.32$, $p < .001$, Kendall's $W = 0.20$. The post hoc test using pairwise comparison with alpha-level Bonferroni correction for multiple testing revealed significant differences between information gathering and action adjusting ($p = .009$), between processing and planning and action executing ($p = .027$), and between action executing and action adjusting ($p < .001$). These results indicate that in general, coaches evaluated the PCSs related to the four domains as differently relevant with emphasis on the importance of action adjusting.

Table 6.2 Descriptive results of coaches' evaluation of relevance, frequency, and observability of individual PCSs and domains

Variable	Relevance		Frequency		Observability	
	M	*SD*	*M*	*SD*	*M*	*SD*
PCS (Domain)						
Switching (AA)	8.56[a]	0.73	8.26[a]	1.00	8.14[a]	0.99
Problem solving (AE)	8.49[a]	0.67	8.02	1.14	7.65	1.29
Preorientation (IG)	8.42[a]	0.79	8.23[a]	1.00	8.16[a]	0.92
Decision making (PP)	8.32[a]	1.70	8.65[a]	0.72	7.65	1.15
Spatial awareness (PP)	8.28[a]	0.73	8.12[a]	0.91	7.72[a]	1.24
Preparedness (PP)	8.21	0.94	7.79	1.26	7.53	1.26
Timing (PP)	8.21	0.91	7.88	1.24	7.40	1.20
Option generation (PP)	8.16	1.00	7.67	1.19	7.21	1.21
Estimation (PP)	8.14	0.97	8.07[a]	1.10	6.91	1.38
Positioning (PP)	8.14	1.04	7.91	1.15	7.30	1.23
Sustained attention (PP)	8.12	0.93	7.79	1.19	6.70	1.82
Corrective behavior (AA)	8.09	0.89	7.79	1.19	6.53	1.64
Anticipation (PP)	8.05	1.09	7.58	1.38	5.84	2.03
Reactions (AE)	7.93	1.01	7.70	1.17	7.12	1.65
Gaze behavior (IG)	7.91	1.17	8.07[a]	1.18	6.88	1.76
Speed of action (AE)	7.91	1.29	7.56	1.58	7.47	1.39
Multimodal perception (IG)	7.91	1.25	7.58	1.74	5.60	2.19
Motor control (AE)	7.86	1.01	7.65	1.36	6.77	1.54
Peripheral perception (IG)	7.72	1.18	7.30	1.52	4.72	2.51
Pattern recognition (PP)	7.70	0.99	7.12	1.29	6.51	1.76
Cognitive flexibility (AA)	7.67	1.19	7.26	1.53	6.91	1.64
Working memory (PP)	7.58	1.07	7.16	1.17	6.44	1.76
Imagination (PP)	7.58	1.24	7.16	1.62	5.79	2.02
Interpersonal coordination (AE)	7.56	1.16	7.37	1.38	6.86	1.39
Activity (PP)	7.56	1.53	7.30	1.64	8.05[a]	1.00
Inhibition (AA)	7.53	1.24	7.02	1.24	7.09	1.57
Procedural knowledge (AE)	7.53	1.14	7.53	1.52	6.77	1.70
Creativity (AE)	7.47	1.20	6.33	1.58	7.23	1.48
Perspective taking (AE)	7.37	1.41	7.05	1.56	5.14	2.43

Feinting (AE)	7.19	1.18	6.37	1.36	7.67[a]	1.46
Tactical knowledge (AE)	6.37	1.70	6.91	1.44	7.07	1.50
Speculation (PP)	6.19	1.62	5.60	1.87	5.81	1.75
Intuition (AE)	6.12	1.85	5.95	2.09	6.02	1.54
Goal-directed action (AE)	5.74	2.01	5.88	1.62	6.19	1.72
Selective attention (IG)	5.72	1.99	5.56	2.00	6.26	1.85
Domain						
Information gathering	7.53	0.79	7.53	0.93	6.33	1.27
Processing and planning	7.57	1.32	7.38	0.96	6.87	0.90
Action executing	7.44	0.66	7.22	0.76	6.96	0.80
Action adjusting	7.97[b]	0.86	7.58[b]	0.66	7.17[b]	0.99

Note. PCS = Perceptual-cognitive skill; IG = information gathering; PP = processing and -planning; AE = action executing; AA = action adjusting. [a] indicate the highest five values for all PCSs per column and [b] indicate highest value for domains per column.

Frequency

According to the coaches' evaluations, the most frequently used PCSs during a game were decision making, switching, preorientation, spatial awareness, and gaze behavior. The Friedman test revealed a significant difference in relevance scores between all 35 PCSs, $\chi^2(34) = 386.48$, $p < .001$, Kendall's $W = 0.26$. The post hoc comparison using a stepwise step-down procedure with Bonferroni correction for multiple testing revealed no significant differences.

Regarding the mean frequency of usage between domains, action adjusting was evaluated as the most frequently used domain, followed by processing and planning, information gathering, and action executing. A significant difference between domains was identified with the Friedman test for related samples, $\chi^2(3) = 8.81$, $p = .032$, Kendall's $W = 0.07$. The post hoc test using pairwise comparison with alpha-level Bonferroni correction for multiple testing revealed only one significant difference, between action executing and action adjusting ($p = .027$). Hence, coaches evaluated PCSs from the domain of action adjusting as those most

frequently used. This was statistically significant when compared to action executing but not to the other domains.

Observability

The most easily observed PCSs were preorientation, switching, activity, spatial awareness, and feinting. The Friedman test revealed a significant difference in relevance scores between all 35 PCSs, $\chi^2(34) = 374.43$, $p < .001$, Kendall's $W = 0.26$. The post hoc comparison using a stepwise step-down procedure with Bonferroni correction for multiple testing revealed no significant differences.

Regarding the mean observability of domains, action adjusting was rated as the most easily observed, followed by action executing, processing and planning, and information gathering. A significant difference between domains was identified with the Friedman test for related samples, $\chi^2(3) = 27.72$, $p < .001$, Kendall's $W = 0.21$. The post hoc test using pairwise comparison with alpha-level Bonferroni correction for multiple testing revealed significant differences between information gathering and all three other domains, namely, processing and planning ($p = .040$), action executing ($p = .009$), and action adjusting ($p < .001$).

Relationships between ratings of relevance, frequency, and observability

To investigate relationships between the evaluations of relevance, frequency, and observability, Spearman's rank correlations were performed. Results for each of the variables can be found in Table 6.3. To interpret the general relationship between the three evaluation criteria, we assessed mean correlations. The results indicate that relevance and frequency demonstrated a mean correlation of $r = .66$ ($SD = .10$; $z = 26.79$, $p < .001$), suggesting a moderate level of agreement across the variables with relatively low variability. Relevance and observability exhibited a mean correlation of $r = .32$ ($SD = .16$; $z = 10.98$, $p < .001$), indicating a lower level of agreement with moderate variability, and frequency and observability showed

a mean correlation of $r = .32$ ($SD = .17$; $z = 10.62$, $p < .001$), reflecting similar agreement and variability. The findings suggest that relevance and frequency exhibited the highest relationship, and both the relationship of relevance and observability and the relationship of frequency and observability had lower but still significant levels of correlation, despite their higher variability. When looking at individual PCSs, interpersonal coordination had the highest correlations for all variable combinations.

Table 6.3 Spearman's rank correlation for all 35 PCSs across the combinations of evaluation criteria

PCS (domain)	Relevance * Frequency	Relevance * Observability	Frequency * Observability
Goal-directed action (AE)	$r = .836$ ($p < .001$)[b]	$r = .160$ ($p = .304$)	$r = .223$ ($p = .151$)
Interpersonal coordination (AE)	$r = .822$ ($p < .001$)[b]	$r = .508$ ($p = .001$)[b]	$r = .594$ ($p = .000$)[b]
Switching (AA)[a]	$r = .782$ ($p < .001$)[b]	$r = .500$ ($p = .001$)	$r = .473$ ($p = .001$)
Speed of action (AE)	$r = .773$ ($p < .001$)[b]	$r = .435$ ($p = .004$)	$r = .495$ ($p = .001$)
Intuition (AE)	$r = .757$ ($p < .001$)[b]	$r = .168$ ($p = .281$)	$r = .233$ ($p = .133$)
Activity (PP)[a]	$r = .756$ ($p < .001$)	$r = .247$ ($p = .110$)	$r = .231$ ($p = .135$)
Peripheral perception (IG)	$r = .737$ ($p < .001$)	$r = .040$ ($p = .798$)	$r = -.065$ ($p = .677$)
Decision making (PP)[a]	$r = .736$ ($p < .001$)	$r = .297$ ($p = .053$)	$r = .370$ ($p = .015$)
Motor control (AE)	$r = .726$ ($p < .001$)	$r = .210$ ($p = .177$)	$r = .254$ ($p = .101$)
Imagination (PP)	$r = .718$ ($p < .001$)	$r = .577$ ($p = .000$)[b]	$r = .503$ ($p = .001$)[b]
Cognitive flexibility (AA)	$r = .705$ ($p < .001$)	$r = .554$ ($p = .000$)[b]	$r = .588$ ($p = .000$)[b]
Inhibition (AA)	$r = .703$ ($p < .001$)	$r = .411$ ($p = .006$)	$r = .504$ ($p = .001$)[b]
Preparedness (PP)	$r = .687$ ($p < .001$)	$r = .363$ ($p = .017$)	$r = .467$ ($p = .002$)
Gaze behavior (IG)[a]	$r = .685$ ($p < .001$)	$r = .322$ ($p = .035$)	$r = .206$ ($p = .184$)
Procedural knowledge (AE)	$r = .685$ ($p < .001$)	$r = .275$ ($p = .074$)	$r = .326$ ($p = .033$)
Tactical knowledge (AE)	$r = .684$ ($p < .001$)	$r = .229$ ($p = .140$)	$r = .388$ ($p = .010$)
Speculation (PP)	$r = .680$ ($p < .001$)	$r = .102$ ($p = .517$)	$r = .223$ ($p = .151$)
Feinting (AE)[a]	$r = .673$ ($p < .001$)	$r = -.053$ ($p = .737$)	$r = -.001$ ($p = .994$)
Pattern recognition (PP)	$r = .663$ ($p < .001$)	$r = .525$ ($p = .000$)[b]	$r = .475$ ($p = .001$)
Spatial awareness (PP)	$r = .650$ ($p < .001$)	$r = .400$ ($p = .008$)	$r = .409$ ($p = .006$)
Positioning (PP)	$r = .644$ ($p < .001$)	$r = .426$ ($p = .004$)	$r = .393$ ($p = .009$)
Multimodal perception (IG)	$r = .639$ ($p < .001$)	$r = .490$ ($p = .001$)	$r = .343$ ($p = .024$)
Corrective behavior (AA)	$r = .638$ ($p < .001$)	$r = .175$ ($p = .262$)	$r = .110$ ($p = .484$)

PCS (domain)	Relevance * Frequency	Relevance * Observability	Frequency * Observability
Working memory (PP)	$r = .635$ ($p < .001$)	$r = .093$ ($p = .554$)	$r = .037$ ($p = .812$)
Problem solving (AE)[a]	$r = .631$ ($p < .001$)	$r = .458$ ($p = .002$)	$r = .400$ ($p = .008$)
Timing (PP)	$r = .611$ ($p < .001$)	$r = .362$ ($p = .017$)	$r = .411$ ($p = .006$)
Estimation (PP)[a]	$r = .591$ ($p < .001$)	$r = .306$ ($p = .046$)	$r = .107$ ($p = .494$)
Reactions (AE)	$r = .587$ ($p < .001$)	$r = .330$ ($p = .031$)	$r = .470$ ($p = .001$)
Anticipation (PP)	$r = .568$ ($p < .001$)	$r = .282$ ($p = .067$)	$r = .107$ ($p = .496$)
Perspective taking (AE)	$r = .555$ ($p < .001$)	$r = .353$ ($p = .020$)	$r = .226$ ($p = .144$)
Pre orientation (IG)[a]	$r = .542$ ($p < .001$)	$r = .381$ ($p = .012$)	$r = .418$ ($p = .005$)
Sustained attention (PP)	$r = .520$ ($p < .001$)	$r = .599$ ($p = .000$)[b]	$r = .398$ ($p = .008$)
Selective attention (IG)	$r = .519$ ($p < .001$)	$r = .307$ ($p = .045$)	$r = .515$ ($p = .000$)[b]
Option generation (PP)	$r = .460$ ($p = .002$)	$r = .144$ ($p = .358$)	$r = .386$ ($p = .011$)
Creativity (AE)	$r = .364$ ($p = .017$)	$r = .153$ ($p = .326$)	$r = .100$ ($p = .523$)

Note. PCS = Perceptual-cognitive skill; IG = information gathering; PP = processing and planning; AE = action executing; AA = action adjusting. [a] designate those PCSs that were ranked in at least one variable's top five values (see Table 6.2); [b] designate the top five correlations for each combination of variables.

Coaches' PCS labels

The aim of the label analysis was to examine the language used by coaches to describe PCSs and to investigate the consistency of terminology across various descriptors. Overall, the results reveal a high heterogeneity in the terms used to describe PCSs, with alignment emerging for only a few skills. Additionally, when we examined the use of the scientific terms by coaches, only a few instances demonstrated consensus (for details, see Table 6.4).

For the most relevant PCSs, a high degree of homogeneity in coaches' labels was found. For instance, switching (item: "The player switches quickly between two game situations [e.g., from offense to defense; after a mistake]") was labeled consistently as switching behavior, with 20 mentions, and all other variations of the label included the term switching. Similarly, decision making (item: "The player makes correct decisions for the game situation") was labeled with high consistency, receiving 25 mentions of the term decision making or variations

such as decision behavior or decision quality. Additionally, four participants referred to this skill as game intelligence. There was also alignment in the labeling of preorientation (item: "The player regularly scans his surroundings [ideally 360°] and this behavior increases just before his action (e.g., through shoulder checks)"]. Coaches labeled this skill as preorientation (n = 12), scanning (n = 12), or simply orientation (n = 6).

In contrast, a high degree of heterogeneity in coaches' labels was identified for most of the PCSs. The greatest variation in labeling was observed for pattern recognition, with n = 33 different labels, followed by goal-directed action, interpersonal coordination, and working memory, each with n = 31 different labels. Pre-orientation (n = 10), peripheral perception (n = 14), and creativity (n = 15) showed the lowest diversity in labels. Overall, 22 out of 35 PCSs were described with more than half of the participants providing unique labels.

Interestingly, perspective taking (item: "The player puts himself in the shoes of his teammates or opponents, using that information to adjust his own behavior [e.g., predicting the next action from body posture]"} was also frequently described as anticipation (n = 17). A similar pattern was found for problem solving (item: "The player quickly finds solutions to problems on the field [e.g., freeing himself from opponents or space pressure]"), which was labeled as speed of action, with 20 mentions. Only six responses referred explicitly to the concept of problem solving. This indicates a limited consensus regarding the scientific terminology for this PCS. In many cases, coaches used the same term for different items, such as perspective-taking and problem-solving. Similar overlaps were observed with terms like perception, game intelligence, decision-making, and anticipation, all of which were applied to various PCSs. For example, perception was assigned to n = 23 different PCSs, and game intelligence to n = 21 different PCSs. Due to space constraints, additional results are presented in Table 6.4.

Table 6.4 Overview of coaches' labels for the 35 PCSs, the amount of consensus with scientific terms, and additional labels

PCS (domain)	Consensus[a]	Most mentioned label	Additional labels
Switching (AA)	8	Switching behavior (22)	Switching (8) Speed of action (8) Switching ability task focus (3) Switching play (3) Reaction ability (2) Further labels (10)
Problem solving (AE)	2	Action speed (20)	Decision making (6) Solution finding (2) Problem solving (2) Creativity (2) Game intelligence (2) Adaptability (2) Further labels (12)
Preorientation (IG)	12	Scanning (13)	Preorientation (12) Orientation (6) Further labels (7)
Decision making (PP)	25	Decision making (25)	Decision behavior (4) Game intelligence (4) Decision-making ability (3) Decision quality (2) Further labels (11)
Spatial awareness (PP)	4	Spatial awareness (4)	Spatial sense (3) Space interpretation (3) Game understanding (2) Game intelligence (2) Scanning (2) Spatial behavior (2) Spatial recognition (2) Further labels (19)
Preparedness (PP)	3	Preorientation (12)	Orientation (7) Preparation (4) Preparedness (3) Game intelligence (2) Further labels (24)
Timing (PP)	8	Timing (8)	Differentiation ability (4)

PCS (domain)	Consensus[a]	Most mentioned label	Additional labels
			Game intelligence (3) Passing quality (2) Dosage (2) Further labels (22)
Option generation (PP)	0	Positioning (11)	Game intelligence (7) Orientation (4) Game understanding (2) Positional play (2) Further labels (19)
Estimation (PP)	0	Perception ability (7)	Anticipation (6) Observation (4) Orientation (4) Timing (3) Assessment ability (3) Spatial sense (2) Differentiation ability (2) Further labels (11)
Positioning (PP)	11	Positioning (11)	Game intelligence (7) Positioning play (4) Game understanding (3) Further labels (16)
Sustained attention (PP)	6	Activity (9)	Sustained attention (6) Concentration ability (6) Attention (5) Being online (5) Concentration (4) Focus (3) Stability (2) Vigilance (2) Further labels (7)
Corrective behavior (AA)	0	Adaptability (13)	Game intelligence (3) Reaction (2)

PCS (domain)	Consensus[a]	Most mentioned label	Additional labels
			Flexibility (2) Adjustment (2) Further labels (20)
Anticipation (PP)	17	Anticipation (17)	Game intelligence (4) Forward acting (2) Forward playing (2) Forward thinking (2) Further labels (13)
Reactions (AE)	3	Adaptability (6)	Action speed (5) Flexibility (3) Reaction speed (3) Reactions (3) Perception (2) Further labels (17)
Gaze behavior (IG)	0	Scanning (7)	Orientation (5) Perception (5) Focusing (4) Attention (3) Further labels (14)
Speed of action (AE)	7	Speed of action (7)	Execution speed (3) Dynamics (3) Speed (2) Determination (2) Intensity (2) Technical skills (2) Movement speed (2) Maximum speed (2) Further labels (16)
Multimodal perception (IG)	0	Perception (11)	Sensory perception (7) Cognitive perception (2) Environmental perception (2)

PCS (domain)	Consensus[a]	Most mentioned label	Additional labels
			Attention (2) Further labels (17)
Motor control (AE)	2	Coordination (10)	Coordinative abilities (2) Adaptability (2) Motor control/motor skills (2) Movement control (2) Body awareness (2) Further labels (23)
Peripheral perception (IG)	7	Peripheral vision (11)	Peripheral perception (7) Perception (7) Scanning (4) Awareness (3) Perception from the corner of the eye (2) Further labels (8)
Pattern recognition (PP)	2	Game intelligence (7)	Learning ability (6) Pattern recognition (2) Perception (2) Observation (2) Comprehension (2) Further labels (27)
Cognitive flexibility (AA)	0	Adaptability (22)	Game intelligence (3) Flexibility (2) Adaptability (2) Tactical adjustment (2) Further labels (10)
Working memory (PP)	0	Preorientation (10)	Game intelligence (3) Creativity (3) Scanning (2) Anticipation (2) Further labels (25)
Imagination (PP)	0	Game understanding (6)	Game intelligence (5) Purposeful action / Determination (5) Goal-setting of actions (3) Creativity (2) Decision-making behavior (2) Further labels (20)
Interpersonal coordination (AE)	0	Game understanding (4)	Group tactical behavior (3) Game intelligence (2) Action speed (2) Anticipatory action (2)

PCS (domain)	Consensus[a]	Most mentioned label	Additional labels
			Connection (2) Further labels (23)
Activity (PP)	13	Activity (13)	Off-the-ball movement (2) Positioning (2) Willingness to run (2) Further labels (17)
Inhibition (AA)	4	Adaptability (8)	Inhibition (4) Decision-making (2) Flexibility (2) Game intelligence (2) Action speed (2) Situation-dependent action (2) Error correction (2) Further labels (17)
Procedural knowledge (AE)	0	Motor skills (4)	Game intelligence (3) Movement talent (2) Automatism (2) Coordination (2) Experience (2) Further labels (22)
Creativity (AE)	20	Creativity (20)	Willingness to take risks (4) “Spielwitz” (playfulness) (3) Courageous (3) Further labels (11)
Perspective taking (AE)	0	Anticipation (17)	Observation (4) Perception (4) Empathy (2) Further labels (19)
Feinting (AE)	8	Feinting (8)	Automatism (6) Creativity (5) Automated actions (2) Dribbling (2) Further labels (20)
Tactical knowledge (AE)	0	Tactical understanding (5) Game understanding (5)	Tactical competence (3) Tactical intelligence (2) Tactical skills (2) Further labels (20)
Speculation (PP)	6	Willingness to take risks (6)	Courage (4) Anticipation (3)

PCS (domain)	Consensus[a]	Most mentioned label	Additional labels
		Speculation (6)	Being ready to act (2) Risk management (2) Further labels (19)
Intuition (AE)	7	Intuition (7)	Willingness to take risks (5) Automatism (3) Instinct (3) Creativity (2) Automated actions (2) Further labels (20)
Goal-directed action (AE)	3	Determination (8)	Goal-directed action (3) Assertiveness (2) Goal orientation (2) Implementation of strategy/ match plan (2) Further labels (26)
Selective attention (IG)	0	Focus (18)	Concentration (3) Selective attention focus (3) Attention (2) One-dimensional focus (2) Directed attention focus (2) Further labels (11)

Note. PCS = Perceptual-cognitive skill; IG = Information gathering; PP = Processing and planning; AE = Action executing; AA = Action adjusting; PCSs are sorted according to their relevance ratings (see Table 6.2). [a] Consensus is defined as the number of coaches' mentions of the scientific PCS terms. Only labels mentioned at least twice are displayed in the table for clarity. "Further labels" refers to the number of labels that were mentioned only once. The complete dataset is available upon request.

Discussion

The aim of the present study was to investigate how coaches evaluate domain-specific PCSs in youth soccer, focusing on their relevance, frequency of usage, and observability and investigating the relationships among these three evaluation variables. Additionally, the study explored the language of coaches by looking at the labels coaches assigned to the behavioral descriptions of PCSs. Thereby similarities to and differences from the existing scientific vocabulary were captured.

Relevance of PCSs in youth soccer

Coaches identified several key PCSs as particularly relevant, with skills such as switching, problem solving, preorientation, decision making, and spatial awareness standing out as the most important ones. These findings align with prior research, indicating that these skills are crucial for quickly adjusting to changing game conditions (Fuhre et al., 2022; Larkin & O'Connor, 2017). In contrast to existing literature (Gonçalves et al., 2015), anticipation, although rated highly, was ranked 13th and was therefore not considered one of the most important skills in the present study. The same was true for creativity, which was ranked 27th, despite previous research emphasizing its relatively high importance for soccer performance (Rasmussen et al., 2020). It is important to note that these results must be interpreted cautiously owing to the ceiling effect in relevance ratings and the absence of significant differences in post hoc stepwise comparisons. Out of 35 PCSs, coaches rated 24 higher than 7 on a scale from 1 to 9. Although these results make it difficult to provide a precise ranking, they underline the overall high relevance of PCSs for youth soccer performance.

In terms of the different domains, action adjusting was rated the most relevant. This domain encompasses skills such as switching and corrective behavior. The high relevance of action adjusting likely reflects the specific demands of soccer, where players must rapidly shift

between offensive and defensive roles and adapt to evolving game situations (Huijgen et al., 2015). These relevance ratings, both for individual PCSs and at the domain level, further contribute to the development of a domain-specific, multidimensional cognitive profile that includes crucial skills such as switching and decision making (Scharfen & Memmert, 2019).

The analysis of frequency ratings revealed some overlap but also notable differences when compared to relevance ratings. Coaches rated decision making, switching, preorientation, and spatial awareness as the most frequently used skills. However, instead of problem solving, estimation and gaze behavior rounded out the top five (these skills shared the fifth rank owing to similar means). These results emphasize the central role of decision making in soccer, which has been well described in previous studies (e.g., Musculus et al., 2021; Petiot et al., 2021; Travassos et al., 2013).

Further, correlation results reinforce the general connection between relevance and frequency of usage for certain skills. Moderate correlations were observed across PCSs, suggesting that skills frequently used during gameplay are often rated as highly relevant. Interestingly, the relationships were highest for skills other than the most highly rated in terms of relevance. The moderate correlations between relevance and frequency suggest that although there is some overlap between how important skills are and how often they are used, this relationship is not absolute. Skills such as decision making and switching, which are both highly relevant and frequently used, demonstrate a strong connection. However, the finding that the highest correlations occur for skills not ranked among the most relevant may imply that these moderately rated skills—such as estimation and gaze behavior—are consistently involved in gameplay and therefore play an important supporting role, even if they are not the most critical in terms of direct impact. This discrepancy could reflect the nuanced nature of soccer, where certain skills are required constantly (e.g., gaze behavior and estimation) but do not stand out as the most decisive factors in game-changing situations. Coaches may rely on these skills

regularly, yet they may not consider them as vital as those that influence key moments in a match. This finding underscores the importance of considering both the relevance and frequency of skills when evaluating player performance, as frequently occurring skills may support the execution of more impactful but less frequent skills.

Furthermore, we also examined the observability of PCSs, recognizing that in talent identification, it is essential to focus not only on the most relevant or frequently used skills but also on those easiest to detect. Observability ratings showed some differences compared to relevance and frequency. Whereas switching, preorientation, and decision making were rated highly in all categories, some skills, such as feinting and activity—despite being lower in relevance and frequency—were rated as easiest to observe. This has practical implications, as it raises the question of whether coaches and scouts may unintentionally prioritize more observable skills over those that are harder to detect but potentially more important. The relatively low correlation between relevance and observability highlights the need for coaches to critically assess whether their focus is on easily observed behaviors, which might not always be the most impactful. This study encourages the development of tools to help capture skills that are less visible but crucial. For skills that are relevant yet hard to observe, more structured observation methods or video analysis may be necessary (e.g., peripheral perception or perspective taking). As already suggested by Musculus and Lobinger (2018), we propose a shift toward behaviorally based assessments, where coaches focus on specific observable actions rather than abstract concepts. This approach would enhance the comparability and reliability of evaluations. In summary, a careful consideration of evaluation criteria is important to understand their specific involvement and impact in soccer. When bringing all three variables together, they show unique patterns of connections. For example, anticipation was evaluated as highly relevant, frequently used, but hardest to observe, whereas activity, was moderately relevant and moderately often used but among the easiest to observe. This suggests that even

though anticipation is highly relevant and frequently used during play, it remains a critical skill to be observed by coaches and scouts. In contrast, activity was considered moderately relevant and moderately frequently used, but it was very easy to observe. This may cause coaches to overlook important skills that are difficult to observe or to overvalue skills like activity, which may be less relevant but easier to notice.

In summary, switching, preorientation, and decision making were consistently rated highly across all variables—relevance, frequency of usage, and observability—making them key candidates for talent identification through observational assessments. These skills are not only crucial for performance but also frequently used and easily detected in gameplay, which further solidifies their importance in youth soccer evaluation. These findings underscore the need for a nuanced approach to evaluating PCSs, combining relevance, frequency, and observability to comprehensively assess player potential.

The need for a common language in PCSs

A notable finding of this study was the significant variation in how coaches labeled PCSs. For example, some terms, such as perception or game intelligence, were used to label multiple PCSs. This result could indicate that coaches generally conceptualize PCSs in broader terms, encompassing different behaviors. This assumption is based on the fact that coaches used the game intelligence label to describe behaviors such as anticipation, pattern recognition, option generation, decision making, and imagination. These PCSs share different functional and conceptual characteristics, which was shown for pattern recognition and anticipation (North et al., 2016), option generation and decision making (Musculus et al., 2019), and anticipation and imagination (Rominger et al., 2021). Further, these PCSs tend to interact within the dynamic nature of the game (Roca et al., 2013).

Another assumption that can be drawn from coaches using the same terms, such as perception, for different PCSs is that there may be a lack of variety in their language. It appears that terms such as gaze behavior and multimodal perception are not part of typical coaching vocabulary. Although it remains uncertain whether these scientific labels are suitable for practical use, the results highlight the need to determine whether coaches are conceptually grouping similarly labeled PCSs together or if this reflects a lack of differentiated language. Based on a previous qualitative study, where coaches described behavior rather than labeling it and revealed distinct conceptualizations, these results likely indicate a limited vocabulary.

When comparing scientific labels with those used by coaches, there were six PCSs with high agreement. Decision making, creativity, and anticipation had the most mentions, followed by activity, preorientation, and positioning. Interestingly, activity was the only label that did not originate from scientific works but from practical use in soccer, meaning it had no scientific counterpart. This demonstrates that the concept, as defined by coaches, requires further exploration and a scientific definition. This is an important finding as it highlights that a coach's conceptual perspective can provide valuable insights into domain-specific PCSs that might otherwise be overlooked. This variability in labels underscores the need for a standardized vocabulary in the context of talent assessment and identification. Without a common language, different coaches may report the same PCSs differently, even when referring to the same observable skills. This inconsistency could hinder the objectivity and comparability of assessments across different coaches and scouts (Christensen, 2009; Musculus & Lobinger, 2018).

The study's findings also critically reflect on previous research using free-recall methods, where coaches describe PCSs on the basis of their own experiences and language preferences (e.g., Christensen, 2009). Free recall can lead to biases, as coaches may emphasize the skills, they are most familiar with, rather than providing a comprehensive evaluation of all

relevant PCSs. The observed variability in terminology suggests that coaches' evaluations may be influenced by subjective interpretations, making it difficult to ensure consistency across different evaluations when working with abstract terms rather than behavioral indicators, as mentioned above.

Conclusion

In conclusion, this study offers valuable insights into how youth soccer coaches evaluate domain-specific PCSs, with a particular focus on relevance, frequency of usage, and observability. Key skills (e.g., switching, preorientation, and decision making) consistently emerged as central to player performance, being highly rated across all variables, making them promising criteria for talent identification, whereas others (e.g., anticipation and activity) presented a more complex profile, highlighting the need for a nuanced approach. Certain essential skills may require more structured observation tools, such evaluation sheets, guidelines, or video analysis to ensure accurate assessment.

Additionally, the study sheds light on the variability in how coaches label PCSs, revealing a potential gap between practical and scientific terminology. It appears that PCSs are often conceptualized in less specific terms by coaches. Furthermore, the study's findings call for a shift toward behaviorally based assessments, where coaches focus on observable actions rather than abstract concepts. This approach would not only make evaluations more reliable but also align coaching practices more closely with empirical research.

Overall, the findings highlight the importance of combining relevance, frequency, and observability when assessing youth players PCSs, ensuring that skills critical to performance are identified and accurately evaluated. By developing more structured observational tools and working toward a common language, the process of talent identification in youth soccer can become more precise, objective, and effective.

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7. Article 3

Observational assessment of perceptual-cognitive skills in youth soccer players: Empirically informed, theory-based recommendations

Heisler, S. M., Musculus, L., & Lobinger, B. H.

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Abstract

The assessment of perceptual-cognitive skills (PCSs) in youth soccer is becoming increasingly essential as these skills significantly impact player performance in the fast-paced game environment. Youth players undergo regular evaluations throughout their development. However, these evaluations are often subjective, with coaches and scouts relying on intuition rather than systematic assessment. This research aims to support more structured evaluation practices, drawing on findings from a comprehensive research project at the German Sport University Cologne. Key recommendations include defining a cognitive player profile and agreeing on standardized, behavior-based conceptualizations and terminology. Target PCSs for player assessment in soccer should be selected from four core domains: information gathering, processing and planning, action executing, and action adjustment. Embedding these selected skills into an evaluation form could foster systematic, standardized assessment. This approach aims to improve the reliability, validity, and objectivity of what has traditionally been dominated by subjective procedures with limited standardization.

Keywords: Player's assessment, scouting, research practice transfer

Introduction

In the competitive sport of soccer, player assessment is a key part of the system. Evaluations occur regularly, either to assess a player's potential and their current skill level or to monitor their ongoing development within the sport (Williams et al., 2020). Traditionally, player assessments in youth soccer have relied on the subjective judgments of coaches and scouts, making them pivotal in shaping players' career paths. The evaluations are mostly based on observations during games or practice and are loosely structured or unsystematized (Musculus & Lobinger, 2018). Research has described the value of the experience-driven ability of coaches to assess players' skills in a variety of domains, such as technical, tactical, physical, and psychological (Roberts et al., 2021). This evaluation process is shaped by the coaches' personal experiences, expert knowledge, and contextual factors, enabling them to identify key qualities that they consider meaningful and relevant for high-level performance with predictive validity (Lath et al., 2020; Schorer et al., 2017; Sieghartsleitner et al., 2019). However, even though coaches and scouts possess essential knowledge, and their observations are highly valuable, there is a risk that this approach lacks objectivity and reliability (Musculus & Lobinger, 2018). For example, there is seldom standardization regarding which criteria are applied, how they are weighted, or whether these criteria are consistently used across different players (Peringa et al., 2024), which has been shown to result in discrepancies of evaluations between assessors (Lüdin et al., 2023). Among the various aspects considered in the coaches' and scouts' assessment, perceptual-cognitive skills (PCSs), such as decision making, anticipation or spatial awareness have been recognized as particularly important (Fuhre et al., 2022).

This article aims at sharing key findings from the research program POTENTIAL, which was developed to systematically explore the area of PCSs in order to support the development of structured, observation-based assessment procedures in youth soccer. By

integrating the perspectives of experienced coaches with scientific methods in a coproductive approach (Smith et al., 2022), the program aims to bridge the gap between research and practice and to enhance the applicability of player evaluation in real-world settings—specifically in the area of PCSs. A central aim was also to provide a comprehensive overview of the PCSs that are involved in actual gameplay situations, as perceived and described by experienced coaches.

PCSs refer to a player's ability to perceive, process, and respond to rapidly changing game situations—such as identifying passing options under pressure or adjusting positioning based on the opponent's movements (Mann et al., 2007). These skills encompass a range of interconnected components, including visual search behavior, spatial awareness, anticipation, decision-making, or creativity (Roca et al., 2013; Bergkamp et al., 2022). From an embodied cognition perspective, these processes are closely linked to motor behavior, with perception, cognition, and action forming an integrated system shaped by real-time interaction with the environment (Voigt & Raab, 2024). This view emphasizes that cognitive performance in soccer cannot be fully understood without considering the physical and situational context in which it unfolds (Lux et al., 2021). The indispensable role of PCSs in soccer becomes evident when observing players in action. Take, for example, a midfielder in possession of the ball: the player scans the field, assesses distances to teammates and opponents, anticipates movements, and decides to attempt a through ball—all in a matter of seconds. If the pass is intercepted, they must immediately switch to defensive mode. Such rapid transitions require the tightly coordinated use of multiple PCSs, including scanning, anticipation, decision-making, and flexible action adjustment (Casanova et al., 2009; Pruna & Bahdur, 2016).

Although PCSs are widely acknowledged as essential for soccer performance, much of the scientific research has focused on domain-general cognitive processes, such as executive functions, which are not inherently sport-specific and have limited ecological validity (Kalén et al., 2021). While there is some evidence for links between executive functions and aspects of

soccer performance—such as sport-specific decision making or motor adaptation (Heisler et al., 2023; Schumacher et al., 2024)—the predictive utility of general cognitive testing remains controversial (Furley et al., 2023). A recent meta-analysis concluded that general, non-sport-specific cognitive function tests do not meaningfully predict future sports performance (Kalén et al., 2021, p. 1290). This reinforces the need for soccer-specific conceptualizations and assessments that capture the unique demands of the sport.

In response, research has increasingly focused on developing context-specific approaches that better reflect the perceptual-cognitive requirements of soccer. These methods aim to simulate the interaction between perception, cognition, and action under realistic conditions. Promising examples include video-based decision-making tasks (Musculus et al., 2019; Murr et al., 2021), temporal occlusion paradigms for anticipation (Causer et al., 2017; Suss & Ward, 2013), and eye-tracking to measure scanning behavior (Aksum et al., 2021; Lynch, 2024). Complementary approaches have embedded cognitive processes such as executive control within soccer-relevant scenarios like small-sided games or pressure-laden decision tasks (e.g., Heilmann et al., 2022; Knöbel & Lautenbach, 2024). Collectively, these studies mark a methodological shift toward more ecologically valid assessment tools that align with the sport's cognitive demands.

Despite these advancements, the practical integration of such tools into routine player assessment remains limited. In everyday practice, coaches still primarily rely on subjective observation, guided by intuition and experience rather than standardized, evidence-based procedures (Bergkamp et al., 2022). While attempts have been made to structure these observations using rating forms and defined criteria (Musculus & Lobinger, 2015), implementation guidance remains scarce—particularly in the domain of perception and cognition (Musculus & Lobinger, 2018). As a result, the gap between scientific tool development and its application in youth academies persists, underscoring the need for

translational research that supports reliable, feasible assessment strategies (Lautenbach et al., 2022).

To help address this gap, the POTENTIAL (German Sport University Cologne; see OSF[3]) research program focused on identifying soccer-specific PCSs from the perspective of experienced coaches and translating these insights into structured, observation-based assessment recommendations. The program combines practical relevance with scientific rigor to support more consistent and ecologically valid player evaluations in youth soccer.

The research program POTENTIAL

The research program POTENTIAL (German Sport University Cologne, Institute of Psychology, Department of Performance Psychology) was initiated in 2021 to explore soccer-specific PCSs for player assessment in youth soccer, explicitly incorporating the perspective of coaches. The program is grounded in a developmental embodied cognition framework (Lux et al., 2021; Musculus & Raab, 2022), which conceptualizes perception and cognition as deeply embedded in sensorimotor processes and continuously shaped by the interaction between the player and their environment. This perspective emphasizes the importance of context-specific, action-oriented understanding of cognition, aligning closely with the dynamic nature of soccer.

To ensure the practical relevance of the research, POTENTIAL adopted a co-productive approach (Smith et al., 2022), bringing together stakeholders from both research and practice. The project team included the first author (an applied sport psychologist and doctoral student), experienced coaches and scouts from professional youth academies, as well as researchers with expertise in cognitive psychology, talent development, and applied sport science. This structure aimed to bridge the gap between scientific theory and applied expertise, responding to calls for

[3] https://osf.io/sznp4/?view_only=68e808be8d944a1398c654a90dc9887f

research that integrates the lived experiences of practitioners (Christensen, 2009; Kelly & Turnnidge, 2023).

In a first, qualitative study, video-stimulated interviews with 10 experienced coaches from a German youth academy were conducted (Heisler et al., 2024a). The coaches were presented with real game sequences of male youth players in the under-14 to under-16 age groups, allowing them to describe and identify PCSs through observation. The coaches' responses were analyzed using reflexive thematic analysis (Braun et al., 2016). The analysis yielded 26 specific PCSs (see Table 7.1), which were then organized into four primary categories (see Figure 7.1): information gathering, processing and planning, action executing, and action adjustment. These categories were described as highly intertwined, reflecting the interconnected nature of perceptual-cognitive processes in soccer as postulated in prior research (Mann et al., 2007; Vestberg et al., 2012). The heuristic model illustrates that PCSs from four distinct domains—each with its own primary function—are used in an intertwined and flexible manner. Rather than following a fixed sequence, players dynamically draw on these domains as needed, adapting continuously to the demands of the game. In line with embodied cognition claims, this highlights how perception, cognition, and action are deeply interconnected and shaped by the context of real-time interaction. Importantly, coaches emphasized that decision making plays a central role across all phases of play. Its central position in the model (Figure 7.1) reflects its constant integration into soccer-specific behavior.

A second, quantitative study was then conducted (Heisler et al., 2024b) to evaluate how coaches rate the identified PCSs in terms of their relevance, frequency, and observability in competitive matches. Using an online survey, 43 experienced coaches assessed behavioral descriptions of the PCSs and provided the corresponding labels they use in practice, helping to capture the language and terminology common in applied settings (see Table 7.1).

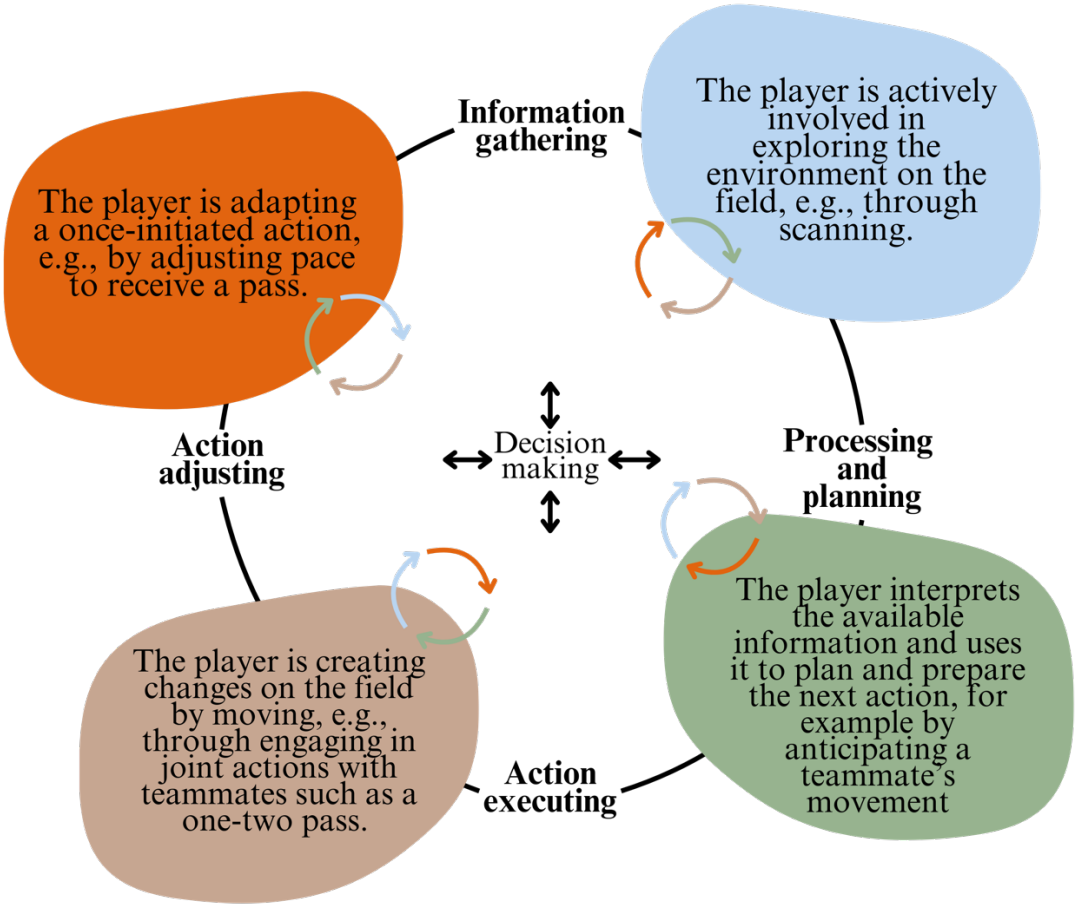

Figure 7.1 A heuristic model of intertwined perceptual-cognitive skills in youth soccer

Recommendations for the observational assessment of PCSs in youth soccer

Here we present our recommendations based on these empirical results and theoretical underpinnings, to inform the applied field. We further make use of the practical experiences of the first and second authors as sport psychologists in German youth academies, the third author's extensive experience in coach education, and the knowledge of an active elite youth scout for an additional applied perspective. We outline the process of developing an empirically derived evaluation form (see Appendix) and provide general recommendations for clubs on how to adapt and implement this process to create a customized form (for an overview, see Figure 7.2). The following section outlines each stage of the process, highlighting how these steps contribute to a structured, standardized approach that addresses the limitations of traditional, subjective assessment methods.

Aligning knowledge and language

Subjective evaluations are a central yet debated aspect of player assessment. While coaches' experiential knowledge can yield judgments with predictive validity (Sieghartsleitner et al., 2019), the lack of standardization and transparency often limits objectivity and comparability across contexts (Bergkamp et al., 2022). To enhance objectivity, it is essential that all stakeholders—such as coaches, scouts, and sport psychologists—share a consistent understanding of the characteristics being measured. This requires unified conceptualizations and definitions of the skills and attributes under evaluation. An observational assessment approach based on behavioral descriptions, underpinned by scientific research, addresses this need by ensuring that criteria are assessed in contexts resembling real-world game situations (Musculus & Lobinger, 2018). Observational assessments consider the complexity of soccer, in which cognitive and motor skills are inseparably connected (Scharfen & Memmert, 2019), and cognition is expressed through action (Araújo et al., 2006; Seifert et al., 2017). Research has supported this approach, arguing that behavior-based observational assessments, conducted in realistic settings, more accurately capture the skills necessary for success in soccer than traditional assessments that focus on isolated tasks (Kalén et al., 2021). Moreover, the ecological validity of this approach allows for the evaluation of a player's ability to process information and make decisions in high-pressure environments, a crucial aspect of performance in soccer (Williams & Ford, 2013).

Consequently, we see the first fundamental step as bringing together all relevant stakeholders (i.e., sporting directors, coaches, analysts, scouts, sport psychologists, and others involved in players' on-field development) in a workshop to introduce and discuss the behavioral descriptions of PCSs. Table 7.1 plays a central role in this process: it presents a comprehensive list of soccer-specific perceptual-cognitive skills, structured into two columns. The scientific labels were assigned through expert discussions based on theoretical concepts,

while the coaches' labels were empirically derived from responses gathered in the quantitative study (Heisler et al., 2024b) and reflect the terminology coaches naturally use in practice. This dual structure makes visible the persistent discrepancy between scientific terminology and applied language, which we consider a critical insight of the study.

Rather than prescribing fixed terminology, Table 7.1 is intended to serve as a starting point for discussion during the recommended workshops. The behavioral descriptions serve as clear, observation-based definitions of specific PCSs and provide a consistent foundation for structured assessment. The presence of persistent discrepancies between scientific and applied language highlights a broader challenge in player development—namely, the lack of shared terminology across domains. This project does not aim to fully resolve these inconsistencies, but rather to make them visible and offer a structured basis for ongoing dialogue. As previous research suggests, alignment between research and practice language is a gradual process, shaped by continued collaboration, reflection, and mutual learning (Christensen, 2009; Kelly & Turnnidge, 2023). We therefore encourage clubs to treat this table as a practical tool and discussion starter—one that helps initiate internal alignment efforts and supports the development of a shared, context-sensitive language over time.

Defining the clubs' own cognitive player profile

Starting with defining what to assess seems straightforward. Nevertheless, most criteria in player assessment are implicitly applied by coaches and scouts who, based on years of experience, know what to look for without necessarily selecting them explicitly (Christensen, 2009; Musculus & Lobinger, 2018). We argue that to improve the validity of assessments, clubs should define the cognitive profile of players, thereby explicitly formulating relevant criteria. This profile should encompass the PCSs essential for high-level performance, including skills ranging from perception to action (Petiot et al., 2021). Cognitive demands in soccer often involve real-time information gathering, processing, and decision making under pressure,

making it essential to establish a clear profile that includes these skills. By defining on-field cognitive demands explicitly, clubs can more effectively select and assess the relevant skills. Importantly, different clubs can also define different cognitive profiles for their players, depending on their playing system and philosophy. Further, we recommend defining different cognitive profiles by age group. We focus our recommendations on the age group U14–U16, which corresponds to the sample used in the underlying studies. This age range is particularly relevant in youth soccer, as it marks a developmental phase where cognitive, perceptual, and motor demands increase—often in parallel with structural transitions in training and competition (e.g., full-pitch 11v11 formats). While age structures can vary by system, we emphasize that assessment methods should generally be sensitive to both the developmental stage and the specific perceptual-cognitive demands associated with it (see Huizinga et al., 2006; Mata et al., 2011; Musculus, 2018).

We recommend that all relevant stakeholders engage in a structured discussion to first identify and define the specific on-field performance demands (e.g., a 14-year-old player should scan the field before receiving a pass). To support this, stakeholders could select the necessary skills from the provided list (see Table 7.1) that align with these identified demands [e.g., The player orients himself on the field (e.g., through scanning or shoulder checking)]. After stakeholders have selected the relevant skills from the list, we further recommend prioritizing the most relevant ones to account for the time constraints inherent in the players' assessment process and the resulting need for efficient evaluations. This prioritization can either involve an additional internal relevance assessment within the club or rely on the empirical results of the second POTENTIAL study (see Heisler et al., 2024). These findings provide a valuable basis for determining the most essential skills. This stepwise reduction ensures the identification process remains efficient without compromising diagnostic precision (Coaley, 2014; Musculus & Lobinger, 2018).

Table 7.1 Behavioral descriptions of perceptual-cognitive skills, domains, and coaches' and scientific labels

Domain	Behavioral description The player…	Coaches' label	Scientific label
Information gathering	… directs his gaze toward relevant positions or objects (e.g., the ball).	Orientation[a]	Gaze behavior
	… perceives information in his peripheral vision (e.g., teammates or opponents).	Peripheral vision	Peripheral perception
	… orients himself on the field (e.g., through scanning or shoulder checking).	Scanning[b]	Preorientation
	… incorporates various senses into his perception (e.g., hearing, vision, touch).	Sensory perception	Multimodal perception
	… focuses his attention on something specific (e.g., opponent).	Focus	Selective attention
Processing and planning	… identifies open spaces.	Spatial perception	Spatial awareness
	… recognizes recurring game situations or patterns of action.	Game intelligence	Pattern recognition
	… accesses stored knowledge that he perceived shortly before.	Preorientation	Working memory
	… anticipates or speculates about a situation and thinks several moves ahead.	Anticipation	Anticipation/ Speculation
	… has or follows ideas.	Game understanding	Imagination
	… is active and remains attentive through various actions. He stays "online" during a set of actions.	Activity	Activity
	… positions himself advantageously.	Positioning	Positioning
	… times his actions so that the ball or he arrives at the destination at the right moment.	Timing	Timing
	… prepares his own actions (e.g., through specific positioning or making a run).	Preparation[c]	Preparedness
	… makes decisions.	Decision making	Decision making
Action executing	… engages in joint actions with teammates or opponents. Through his actions, he involves them (e.g., by initiating a joint action such as a one-two pass[1]; closing off the inside channel and forcing the opponent outward).	Group tactical behavior	Interpersonal coordination
	… reacts to situational factors (e.g., the behavior of teammates or opponents, commands).	Reaction speed	Reactions
	… executes a sequence of actions at the highest speed (e.g., when receiving and passing the ball).	Speed of action	Speed of action
	… deliberately employs feints and deceptions.	Feinting	Feinting

Domain	Behavioral description The player…	Coaches' label	Scientific label
	… acts tactically. It is recognizable, for example, through rehearsed sequences of actions or tactical positioning.	Tactical understanding	Game understanding
	… demonstrates creative and surprising behavior for the situation.	Creativity	Creativity
	… acts intuitively, meaning spontaneously and automatically.	Intuition	Intuition
	… finds a solution to problems on the field (e.g., freeing himself from opponent or space pressure).	Finding solutions[d]	Problem solving
Action adjustment	… switches between two game situations (e.g., from offense to defense; after a mistake).	Switching behavior	Switching
	… interrupts a once-initiated action if necessary (e.g., pass, shot, running path).	Inhibition[e]	Inhibition
	… corrects his action if needed (e.g., by changing pace or adjusting positioning).	Adaptability	Corrective behavior

Note: Superscript letters indicate that the most frequently mentioned label was not used. Instead, when coaches labeled different behaviors the same, we selected the next most commonly used term. Most often named terms are [a]scanning, [b]perception, [c]preorientation, [d]speed of action, [e]adaptability. One-two pass = Doppelpass[l]

Development of evaluation form

To ensure consistency and objectivity in players' assessment, it is necessary to use standardized tools that reliably assess players' skills defined as relevant by the cognitive profile (Babu & Nimkar, 2020). An evaluation form, built around the cognitive requirements profile, enables scouts and coaches to systematically evaluate specific PCSs through observation (Musculus & Lobinger, 2018). By using standardized metrics, clubs can ensure that assessments are structured, reducing the influence of subjective biases. Research has shown that assessment tools improve the accuracy and objectivity of player evaluations (Babu & Nimkar, 2020). In scouting, standardized tools allow for more reliable comparisons between players, as they define clear instructions and procedure for evaluating and recording observable behaviors (Coaley, 2014; Musculus & Lobinger, 2018). These tools also help coaches and scouts focus on predefined skills, reducing the risk of overlooking key criteria (Lawlor et al., 2021).

Moreover, using standardized tools could increase the reliability of ratings, meaning that different scouts or coaches evaluating the same player are more likely to reach similar conclusions (Huffcutt et al., 2013). This reliability is particularly important in soccer, where multiple scouts often assess players at different points in time. To further enhance reliability, assessments should be conducted across multiple observations or by multiple observers, as this reduces the risk of any single evaluation being skewed by situational factors (Bergkamp et al., 2022). We therefore recommend creating an evaluation form that is tailored to the club's developed cognitive profile. On the basis of empirical findings from the POTENTIAL program (Heisler et al., under review; Heisler et al., 2024), we suggest clustering the PCSs according to their involvement in real-life soccer actions, guided by the four overarching domains we defined above, namely, information gathering, processing and planning, action executing, and action adjustment (see Figure 7.1).

We recommend using an extensive evaluation form for a yearly evaluation of each player (Appendix A) and relying on a short version (Appendix B) when assessing multiple players at the same time, a common practice (Owen et al., 2024). The long form was created on the basis of results of the POTENTIAL project (see Figure 7.2), exchange with professional scouts, and a piloting phase. Following this expert-based procedure, the wording of scientifically derived descriptions was refined and the list was reduced from 26 to 23 items.

The short evaluation form contains select items based on the results of the quantitative study (Heisler et al., 2024). This empirical selection led us to include one item each for information gathering and action adjustment, four items for processing and planning, and two for action executing. The resulting instrument covers all three evaluation criteria: relevance, frequency of occurrence during play, and observability. This approach addresses the need to balance reliability with the practical demands of scouting.

Additionally, to further increase the objectivity and reliability of assessments, we suggest coaches and scouts structure their scouting reports according to the domains provided. It is also possible that the presented documents can be used as underlying guidelines for observational assessment, by functioning as a mental structure for observations and reporting, when forms are not directly applied. We thereby strongly encourage clubs to use the presented recommendations in a highly adaptive manner, tailoring them to the unique demands of their resources and processes.

Last, to improve the validity of diagnostic measures we recommend linking criteria to other relevant factors. For instance, to increase predictive validity, it would be beneficial to connect PCS assessments with indicators of success and performance, such as contract signings, highest team level achieved, or goals and assists (Vestberg et al., 2017). Additionally, some clubs already use computer-based assessments (e.g., the Vienna Test System) of domain-general cognitive skills (Lautenbach et al., 2022). Although their value for talent identification has recently been questioned (Kalén et al., 2021), clubs could correlate findings of the observation-based assessment by scouts and coaches with computer-based scores to further investigate their relationships.

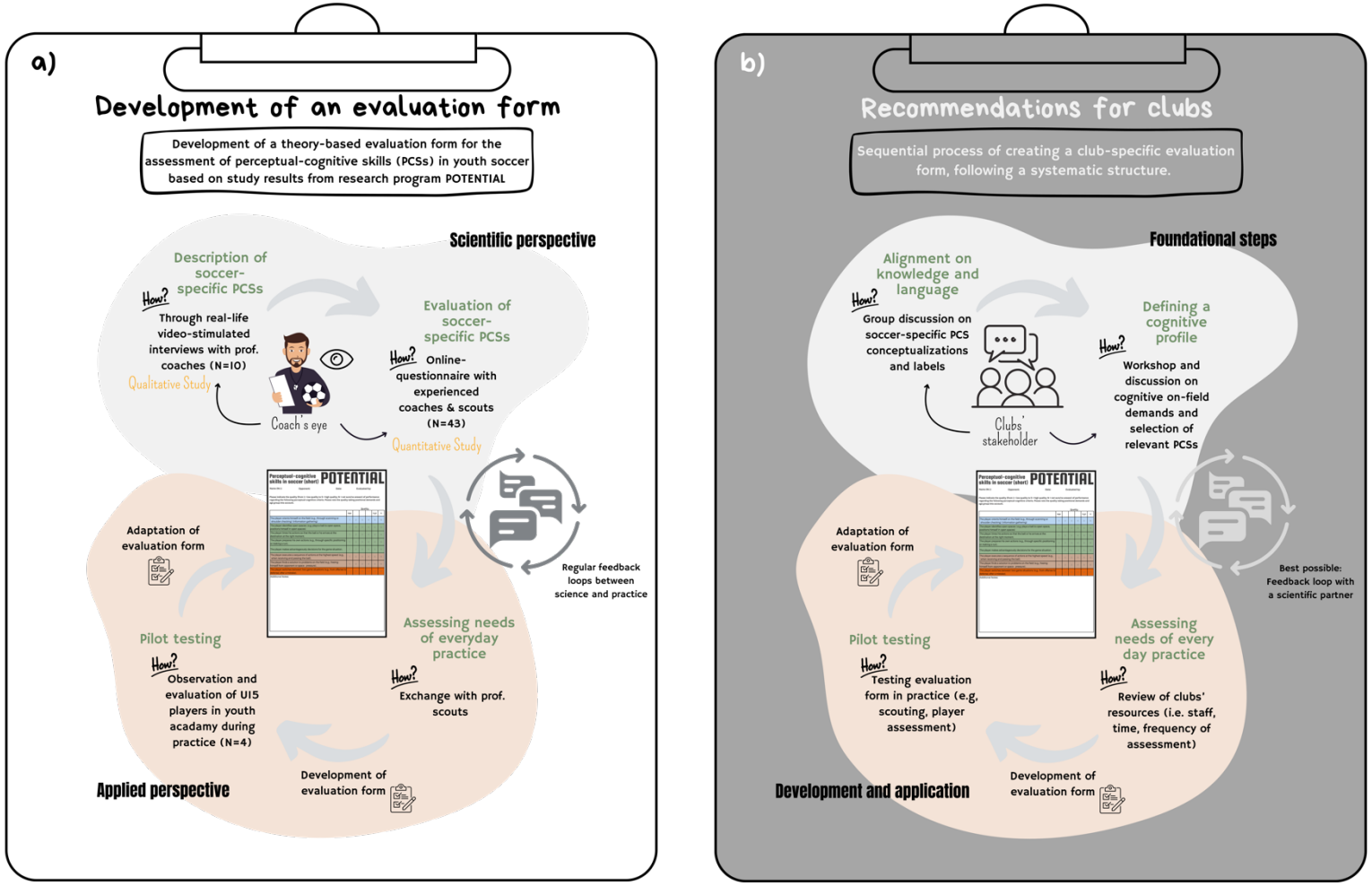

Figure 7.2 *Overview of (a) the scientific developmental process of an evaluation form to assess soccer-specific perceptual-cognitive skills (PCSs) in youth soccer and (b) procedure recommendation on how to develop a club-specific evaluation form*

Conclusion

Our goal was to transfer scientific research findings into actionable strategies for youth soccer player assessment. By focusing on soccer-specific PCSs, we sought to provide clubs and their respective stakeholders with practical tools to systemize observational PCS assessment. The integration of research findings into the daily life of soccer clubs is essential for aligning practices with the latest research, ensuring that methods are evidence based, and enhancing the systematization of procedures (Lautenbach et al., 2022). By doing so, professionals can make more informed decisions, reduce variability in outcomes, and consistently apply best practices. This approach not only bridges the gap between theory and practice but also fosters a behavior-based observational assessment of PCSs (Musculus & Lobinger, 2018).

One of the key recommendations from the research is to ensure a unified conceptualization and language for discussing PCSs among involved stakeholders in one club. Therefore, the study's findings could also be considered for coach education programs or internal education to standardize the conceptualizations and language used to describe and evaluate PCSs, based on the provided behavioral descriptions (see Table 7.1). To enhance the usability of the assessment tool, clubs should tailor the evaluation criteria to their specific needs. For example, clubs may prioritize certain PCSs that align with their playing philosophy or team dynamics, hence creating their own short list from the extensive list provided (Table 1). Lastly, we emphasize that the validation of assessment tools should not fall to individual clubs. Instead, such efforts should be coordinated at a broader, institutional level—in collaboration with scientific partners—to ensure methodological rigor and to make validated tools widely accessible (Lautenbach et al., 2022).

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Appendix:

Figure 7.3 *Long evaluation form including 23 perceptual-cognitive skills in four domains*

Perceptual-cognitive skills in soccer POTENTIAL

Name (Nr.): **Opponent:** **Date:** **Evaluated by:**

Please indicate the quality (from 1 = low quality to 5 = high quality; N = not sure/no answer) of performance regarding the following perceptual-cognitive criteria. Please rate the quality taking positional demands and age group into account.

	Quality					
	low				high	N
Information gathering						
The player perceives information in his peripheral vision (e.g., teammates or opponents).	1	2	3	4	5	N
The player orients himself on the field (e.g., through scanning or shoulder checking).	1	2	3	4	5	N
The player is focused to search for important information on the field (e.g., open spaces)	1	2	3	4	5	N
Processing and planning						
The player identifies open spaces (.e.g, plays a ball to open space, positions himself in open spaces)	1	2	3	4	5	N
The player recognizes recurring game situations or patterns of action.	1	2	3	4	5	N
The player accesses stored knowledge that he perceived shortly before.	1	2	3	4	5	N
The player anticipates or speculates about a situation and thinks several moves ahead.	1	2	3	4	5	N
The player is active and remains attentive through various actions. He stays "online" during a set of actions.	1	2	3	4	5	N
The player positions himself advantageously.	1	2	3	4	5	N
The player times his actions so that the ball or he arrives at the destination at the right moment.	1	2	3	4	5	N
The player prepares his own actions (e.g., through specific positioning or making a run).	1	2	3	4	5	N
The player makes advantageous decisions for the game situation.	1	2	3	4	5	N

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Perceptual-cognitive skills in soccer POTENTIAL

Name (Nr.): **Opponent:** **Date:** **Evaluated by:**

Please indicate the quality (from 1 = low quality to 5 = high quality; N = not sure/no answer) of performance regarding the following perceptual-cognitive criteria. Please rate the quality taking positional demands and age group into account.

	Quality					
	low				high	N
Action executing						
The player engages in joint actions with teammates or opponents. Through his actions, he involves them (e.g., by initiating a joint action such as a one-two pass; closing off the inside channel and forcing the opponent outward).	1	2	3	4	5	N
The player reacts fast to situational factors (e.g., the behavior of teammates or opponents, commands).	1	2	3	4	5	N
The player executes a sequence of actions at the highest speed (e.g., when receiving and passing the ball).	1	2	3	4	5	N
The player deliberately employs feints and deceptions.	1	2	3	4	5	N
The player acts tactically. It is recognizable, for example, through rehearsed sequences of actions or tactical positioning.	1	2	3	4	5	N
The player demonstrates creative and surprising behavior for the situation.	1	2	3	4	5	N
The player acts intuitively, meaning spontaneously and automatically.	1	2	3	4	5	N
The player finds a solution to problems on the field (e.g., freeing himself from opponent or space pressure).	1	2	3	4	5	N
Action adjusting	1	2	3	4	5	N
The player switches between two game situations (e.g., from offense to defense; after a mistake).	1	2	3	4	5	N
The player interrupts a once-initiated action if necessary (e.g., pass, shot, running path).	1	2	3	4	5	N
The player corrects his action if needed (e.g., by changing pace or adjusting positioning).	1	2	3	4	5	N
Addtional Notes:						

Sinikka Heisler, German Sport University Cologne

Figure 7.4 *Long evaluation form including 23 perceptual-cognitive skills in four domains (German)*

Perzeptuell-kognitive Fertigkeiten POTENTIAL

Name (Nr.): **Gegner:** **Datum:** **Beurteilt von:**

Bitte gib die Qualität der Leistung in Bezug auf die folgenden Fertigkeiten an (von 1 = niedrige Qualität bis 5 = hohe Qualität; N = unsicher/keine Angabe). Bitte bewerten Sie die Qualität unter Berücksichtigung der positionsspezifischen Anforderungen und der Altersgruppe.

Qualität

	Niedrig				Hoch	N
Informationssuche						
Der Spieler nimmt Informationen in seinem peripheren Blickfeld wahr (z.B. Mit - oder Gegenspieler).	1	2	3	4	5	N
Der Spieler orientiert sich auf dem Feld (z.B. durch scanning oder Schulterblick).	1	2	3	4	5	N
Der Spieler ist darauf fokussiert, gezielt nach wichtigen Informationen auf dem Spielfeld zu suchen (z. B. freie Räume).	1	2	3	4	5	N
Verarbeitung und Planung						
Der Spieler erkennt freie Räume (z. B. spielt den Ball in einen freien Raum oder positioniert sich selbst in freien Räumen).	1	2	3	4	5	N
Der Spieler erkennt wiederkehrenden Spielsituationen oder Handlungsmuster.	1	2	3	4	5	N
Der Spieler greift auf abgespeichertes Wissen zurück, das er kurz zuvor wahrgenommen hat.	1	2	3	4	5	N
Ein Spieler antizipiert oder spekuliert auf eine Situation und denkt mehrere Stationen voraus.	1	2	3	4	5	N
Der Spieler ist aktiv und bleibt über verschiedene Aktionen aufmerksam. Er bleibt in der Aktion oder Situation „drin“.	1	2	3	4	5	N
Der Spieler positioniert sich vorteilhaft.	1	2	3	4	5	N
Der Spieler timt sein Handeln so, dass Ball bzw. er zum richtigen Zeitpunkt beim Zielort ankommen.	1	2	3	4	5	N
Der Spieler bereitet seine eigene Handlung vor, beispielsweise durch eine bestimmte Positionierung oder ein Freilaufen.	1	2	3	4	5	N
Der Spieler trifft vorteilhafte Entscheidungen in Bezug auf die Spielsituation.	1	2	3	4	5	N

Sinikka Heisler, Deustche Sporthochschule Köln

Perzeptuell-kognitive Fertigkeiten POTENTIAL

Name (Nr.): **Gegner:** **Datum:** **Beurteilt von:**

Bitte gib die Qualität der Leistung in Bezug auf die folgenden Fertigkeiten an (von 1 = niedrige Qualität bis 5 = hohe Qualität; N = unsicher/keine Angabe). Bitte bewerten Sie die Qualität unter Berücksichtigung der positionsspezifischen Anforderungen und der Altersgruppe.

Qualität

	Niedrig				Hoch	N
Handlungsauführung						
Der Spieler beteiligt sich an gemeinsamen Aktionen mit Mitspielern oder Gegenspielern. Durch sein Handeln bezieht er sie mit ein (z. B. durch das Einleiten einer gemeinsamen Aktion wie einem Doppelpass oder das Schließen des Zentrums, um den Gegner nach außen zu lenken).	1	2	3	4	5	N
Der Spieler reagiert schnell auf situative Faktoren (z.B. Verhalten von Mit- oder Gegenspielern, Kommandos, Situationswechsel).	1	2	3	4	5	N
Der Spieler führt eine Folge von Aktionen im höchsten Tempo aus (z.B. bei Ballan- und mitnahme + Pass).	1	2	3	4	5	N
Der Spieler setzt Finten und Täuschungen gezielt ein.	1	2	3	4	5	N
Der Spieler agiert taktisch. Erkennbar ist es beispielsweise an einstudierten Handlungsabläufen oder taktischem Positionsspiel.	1	2	3	4	5	N
Der Spieler zeigt für die Situation kreatives und überraschendes Verhalten.	1	2	3	4	5	N
Der Spieler handelt intuitiv, das heißt spontan und automatisch.	1	2	3	4	5	N
Der Spieler findet für Probleme auf dem Feld eine Lösung (z.B. befreit sich aus Gegner- oder Raumdruck).	1	2	3	4	5	N
Handlungsanpassung						
Der Spieler schaltet zwischen zwei Spielsituationen um (z.B. von Offensive zu Defensive; Nach Fehler)	1	2	3	4	5	N
Der Spieler bricht, wenn notwendig, eine einmal gestartete Handlung ab (z.B. Pass, Torschuss, Laufweg).	1	2	3	4	5	N
Der Spieler korrigiert, wenn nötig, seine Handlungen (z.B. durch Tempoveränderung oder angepasste Positionierung).	1	2	3	4	5	N

Zusätzliche Notizen:

Sinikka Heisler, Deustche Sporthochschule Köln

Figure 7.5 *Short evaluation form including eight perceptual-cognitive skills*

Perceptual-cognitive skills in soccer (short) POTENTIAL

Name (Nr.): **Opponent:** **Date:** **Evaluated by:**

Please indicate the quality (from 1 = low quality to 5 = high quality; N = not sure/no answer) of performance regarding the following perceptual-cognitive criteria. Please rate the quality taking positional demands and age group into account.

	Quality					
	low				high	N
The player orients himself on the field (e.g., through scanning or shoulder checking).	1	2	3	4	5	N
The player identifies open spaces (e.g., plays a ball to open space, positions himself in open spaces).	1	2	3	4	5	N
The player times his actions so that the ball or he arrives at the destination at the right moment.	1	2	3	4	5	N
The player prepares his own actions (e.g., through specific positioning or making a run).	1	2	3	4	5	N
The player makes advantageous decisions for the game situation.	1	2	3	4	5	N
The player executes a sequence of actions at the highest speed (e.g., when receiving and passing the ball).	1	2	3	4	5	N
The player finds a solution to problems on the field (e.g., freeing himself from opponent or space pressure).	1	2	3	4	5	N
The player switches between two game situations (e.g., from offense to defense; after a mistake).	1	2	3	4	5	N
Additional Notes:						

Note: Colors indicate domains (blue = information gathering, green = processing and planning, brown = action executing, **orange** = action adjusting)

Sinikka Heisler, German Sport University Cologne

Figure 7.6 *Short evaluation form including eight perceptual-cognitive skills (German)*

Perzeptuell-kognitive Fertigkeiten POTENTIAL

Name (Nr.): **Gegner:** **Datum:** **Beurteilt von:**

Bitte gib die Qualität der Leistung in Bezug auf die folgenden Fertigkeiten an (von 1 = niedrige Qualität bis 5 = hohe Qualität; N = unsicher/keine Angabe). Bitte bewerten Sie die Qualität unter Berücksichtigung der positionsspezifischen Anforderungen und der Altersgruppe.

	Qualität					
	low				high	N
Der Spieler orientiert sich auf dem Feld (z.B. durch scanning oder Schulterblick).	1	2	3	4	5	N
Der Spieler erkennt freie Räume (z. B. spielt den Ball in einen freien Raum oder positioniert sich selbst in freien Räumen).	1	2	3	4	5	N
Der Spieler timt sein Handeln so, dass Ball bzw. er zum richtigen Zeitpunkt beim Zielort ankommen.	1	2	3	4	5	N
Der Spieler bereitet seine eigene Handlung vor, beispielsweise durch eine bestimmte Positionierung oder ein Freilaufen.	1	2	3	4	5	N
Der Spieler trifft vorteilhafte Entscheidungen in Bezug auf die Spielsituation.	1	2	3	4	5	N
Der Spieler führt eine Folge von Aktionen im höchsten Tempo aus (z.B. bei Ballan- und mitnahme + Pass). when receiving and passing the ball).	1	2	3	4	5	N
Der Spieler findet für Probleme auf dem Feld eine Lösung (z.B. befreit sich aus Gegner- oder Raumdruck).	1	2	3	4	5	N
Der Spieler schaltet zwischen zwei Spielsituationen um (z.B. von Offensive zu Defensive; Nach Fehler)	1	2	3	4	5	N
Zusätzliche Notizen:						

Hinweis: Farben beziehen sich auf die Kategorie (**blaue** = Informationssuche, **gründ** = Verarbeitung und Planung, **braun** = Handlungsausführung, **orange** = Handlungsanpassung)

Sinikka Heisler, German Sport University Cologne

8. General discussion

This dissertation project aimed to *explore* and *evaluate* domain-specific PCSs in youth elite soccer from a coach's perspective and to *transfer* the knowledge gained into practical applications of player assessment. Taking a multidimensional view of PCSs through a coach's perspective, rather than focusing on a specific selection of skills, is a unique strength of this dissertation. This approach is crucial for advancing player assessment involved in expertise, talent identification, and developmental research and practices (Williams et al., 2020). It helps establish a foundation for a shared understanding of these skills' breadth and, particularly, their behavior-oriented nature. Throughout this discussion, the research objectives are first addressed on a general level before theoretical, methodological, and applied contributions are showcased in greater detail (for an overview, see Table 8.1).

For the first exploratory objective, the research project leveraged elite youth soccer coaches' experience-based, in-depth knowledge (Roberts et al., 2021). The study aimed to gain insights into soccer-specific PCSs conceptualizations and language in an ecologically valid setting. To achieve this, video-stimulated interviews allowed coaches to reflect on and articulate their observations and interpretations in actual gameplay. The study results (Article 1) reveal a list of 26 PCSs with behavior-based descriptions. While there exist overviews on general PCFs (see Harvey, 2019) or a holistic framework of relevant skills that includes PCSs (see Mota et al., 2023), a general cognitive framework on PCSs in elite (youth) soccer has just recently been provided (Habekost et al., 2024)[4]. Thereby, study 1 contributes to foundational knowledge within this field, answering calls by fellow researchers (Christensen, 2009; Larkin & O'Connor, 2017; Pulling et al., 2018; Roberts, 2019). Another objective of the dissertation was to explore the language used in science and practice, which revealed discrepancies between the

[4] At the time of submission this dissertation, the publication had been announced by *Frontiers* but was not yet published.

perspectives of coaches and scientists on certain PCSs. For instance, spatial awareness (i.e., the player positions himself in open spaces [i.e., with appropriate distance from the opponent] and plays balls into open space [e.g., into the movement of a teammate]) and preparedness (i.e., the player prepares his actions well [e.g., by taking a purposeful first touch, letting the ball run through, or moving away from the opponent]) were rated as the most important PCSs by coaches. However, such an evaluation is not reflective of scientific work.

Conversely, selective attention (i.e., the player focuses his attention on one stimulus [e.g., marking a specific opponent during a set piece]) was ranked as the least important by coaches, even though it is widely recognized in research as a foundational cognitive function (e.g., Knöllner et al., 2022; Reigal et al., 2019; Schumacher et al., 2024). This discrepancy raises questions about how PCSs are conceptualized. From a scientific perspective, attentional processes are often considered the foundation for higher-order processes (e.g., decision-making, anticipation), emphasizing their underlying contribution to soccer-specific skills (e.g., Schumacher et al., 2024). Coaches, however, appear to evaluate these skills on the same level rather than recognizing the hierarchical relationships between them. For example, coaches considered the ability to focus on specific elements far less critical than the ability to move effectively within space. The concept that one skill underpins the other was not reflected in their evaluations; instead, it was described as functioning in combination, as described in the first study (see Article 1). These differences in descriptions emphasize the need for sport-specific models of perception and cognition that consider the context and, crucially, the purpose of utilizing these skills—namely, the execution of game-enhancing actions in soccer (Habekost et al., 2024). At the same time, the distinction between PCSs and PCFs is emphasized once again. This work underscores the critical need for a clear separation between these two perspectives, often ambiguously conflated (e.g., Spitz et al., 2018). The overlap and blending between these concepts are evident in terms like "domain-specific perceptual-cognitive functions" (e.g., Vona

et al., 2024) and "domain-general perceptual-cognitive skills" (e.g., Spitz et al., 2018), which illustrate how these classifications are frequently combined, blurring their boundaries. This inconsistency in terminology and the lack of a clear distinction obscure theoretical understanding and complicates empirical research, as identical concepts may be framed differently depending on the context or study. To address this issue, this dissertation deliberately concentrated on exploring behavior-oriented, soccer-specific PCSs, intentionally refraining from concluding the underlying PCFs. This approach contributes to a more differentiated and focused investigation of these distinct constructs. By adopting this differentiated approach and advocating for the separate development of models, this work aimed to contribute to a more precise and systematic framework. Such efforts are essential to advance theoretical clarity and foster robust, delineated research.

Table 8.1 Overview of theoretical, methodological, and applied contributions of this dissertation.

Contribution	Article 1	Article 2	Article 3
Theoretical	• Overview of 26 soccer-specific PCSs with behavioral descriptions assigned to four overarching domains. • Development of a heuristic model of soccer-specific PCSs (see Chapter 5). • Indication of the intertwined nature of PCSs in soccer actions. • Comparative analysis of applied and scientific concepts.	• Evaluation of PCSs to inform assessment in youth soccer based on three criteria: o Relevance o Frequency of usage during the game o Observability • Understanding the criteria relationship, with relevance and frequency sharing the most robust connection. • Coaches use less precise and differentiated language to describe individual PCSs compared to the terminology used in scientific contexts.	Providing a framework for evidence-based transfer of scientific knowledge into actionable strategies.
	Developmental embodied cognition perspective (Lux et al., 2021; Musculus et al., 2021): Enhancing understanding of the motor-cognitive interaction by identifying 26 PCSs in real-game play, as demonstrated by players aged 13-16 within an elite sample.		
Methodological	Advancing methodology of coach's eye (Lath et al., 2021): - Focusing on one domain (PCSs) for an in-depth understanding - Stimulated interview technique using real-life game footage - Elite sample (players and coaches)	• Operationalization of PCSs with behavioral descriptions instead of abstract terms. • Including observability as an additional evaluation criterion.	Development of a behavior-based assessment tool.
	Co-productive approach (Smith et al., 2022): Collaborative engagement of scientists and practitioners, incorporating iterative feedback loops and perspective comparisons to provide actionable and ecologically valid results.		
Applied	• Overview of a comprehensive list of PCSs with behavioral descriptions to guide recruiters' assessment (i.e., coaches and scouts). • Supporting shift from computer-based to behavior-based PCSs assessment.	Supporting the systemization of empirical-based criteria selection and definition for player assessment: - Based on experienced soccer coaches' evaluation criteria - By agreeing on the same language	• Recommendations on implementing results into observational assessment (talent identification) and training methodology (talent development). • Communication between research and practice on perception and cognition (Lautenbach et al., 2022).

This approach facilitates the transfer of scientific knowledge to enhance practical relevance, as demonstrated in the third article. By investigating soccer-specific PCSs from the perspective of highly experienced coaches, this work emphasized the importance of utilizing practitioners' valuable knowledge and providing actionable recommendations, aligning with calls in the literature (e.g., Williams et al., 2020). Beyond its practical implications, this perspective provides theoretical value by offering insights into how practitioners prioritize and conceptualize PCSs, bridging the gap between theoretical constructs and real-world applications. It enriches the understanding of the alignment—or misalignment—between scientific frameworks and practical needs. Additionally, the flexibility to adapt the transfer of knowledge to meet the target group's specific needs and context—such as annual player assessments by coaches—was highlighted. This adaptability ensures that the knowledge exchange remains relevant and applicable, particularly given the diverse philosophical positions and methodological approaches adopted by different clubs (e.g., Flatgård et al., 2020). These considerations underscore the importance of tailoring scientific outputs to fit the unique demands of practice without compromising rigor. The following sections will explore these aims in greater detail, where the theoretical, methodological, and applied contributions are presented.

8.2. Theoretical contributions

A developmental embodied cognition perspective

An overall developmental embodied cognition perspective underpinned the research project (Lux et al., 2021; Musculus et al., 2021; Musculus & Raab, 2022). This application helps to inform the creation of soccer-specific PCSs models (see Figure 5.1 in Chapter 5) by considering motor-cognitive interactions (e.g., scanning involves both movement and attention), recognizing contextual factors (e.g., environmental constraints such as time pressure), enhancing realism (e.g., base models on empirical data with ecological validity), displaying the intertwined nature of PCSs (e.g., feedback-loops between overarching domains) and making them applicable to practical purposes. Several claims driving the methodology selection have been formulated (see Chapter 4.2). First, a developmental embodied cognition perspective posits that cognition must be studied within real-game contexts, as it emerges from the player's interaction with its sport-specific environment (Hicheur et al., 2017). Further, not only are players and their environments highly connected, but an intertwined nature of skills has been proposed (). Both claims have been considered when presenting coaches with real-life game footage to explore and describe the PCSs involved in actual dynamic game situations. The first study (see Article 1) revealed that coaches described a set of 26 PCSs in a real-life setting, showing their distinct components and interrelations as displayed by their allocation to four overarching themes, which appear to be connected during soccer actions. Besides developing a domain-specific PCSs heuristic model, this dissertation provides a comprehensive overview of PCSs with behavioral indicators recognizing the embodied nature in their conceptualization.

Further theoretical claims that build the foundation for this work were that cognition is expressed by actions (Araújo et al., 2009), and own experiences enhance accurate interpretation of contextual observation (Pizzera & Raab, 2012). Therefore, observations by experienced

coaches have been the chosen methodological approach (van Meurs et al., 2022). The results further support the theoretical assumption that actions can observe cognition, as coaches could use behavioral indicators to infer PCSs. The rich, detailed elaborations of the overlaps in conceptualization further underline this assumption.

Additionally, this research contributes significantly to the developmental embodied cognition perspective by advancing our understanding of the PCSs profile in elite youth soccer players aged 13 to 16. The findings demonstrate that these players possess and actively use 26 distinct nut interconnectedly used PCSs, including motor-cognitive components, in real-game contexts. Further, the coaches' evaluation of these skills offers valuable insights into the nuanced skillsets required for youth soccer performance. Focusing on a crucial age range within cognitive development (Mata et al., 2011), this work addresses a critical gap in the literature, which has often relied on adult-focused research to inform assessments and development programs for youth players (Marasso et al., 2014). The findings enable the derivation of age-tailored implications for youth player assessment and training, supporting a more precise and developmentally appropriate approach. While a developmental perspective aims to understand age-specific trajectories, ideally through longitudinal studies, it also emphasizes the importance of in-depth investigations within specific age ranges (Musculus & Raab, 2022). Accordingly, this dissertation should be regarded as foundational groundwork for future research on age-related differences and developmental trajectories of PCSs, providing a basis for prospective studies to systematically track skill progression over time (Hirose et al., 2011).

Domain-specific conceptualizations

Closely connected to embodied cognition principles, the need for domain-specific rather than domain-general conceptualizations and investigations has been requested for scientific and practical purposes (Kalén et al., 2021; Vaeyens et al., 2008). First, it has been shown that domain-general PCFs fail to contribute to predicting future performance (Kalén et al., 2021). Further, most scientific methodologies do not reflect the reality in the field, where subjective observational assessments dominate (Bergkamp et al., 2019). This dissertation aimed to address these shortcomings through an in-depth investigation of soccer-specific PCSs in youth players, which serve as the basis for coaches' evaluations in practice. While the results from this project reveal some general overlaps in scientific and coaches' conceptualizations, they also brought new knowledge to light. For example, the PCS labeled "activity*"* has no scientific counterpart. It could be best connected to situated attentional engagement (Nicolini & Mengis, 2024), which has not been explicitly studied in soccer to the best of my knowledge. From a coach's perspective, the activity includes a component of sustained attention and constant motor engagement by, for example, constantly adapting positions. This conceptualization, which has been similarly described across participants, hints at the valuable domain-specific knowledge of coaches, helping to inform the understanding of PCSs. The first study has intensively provided these overlaps to existing conceptualizations; for a detailed discussion, see Article 1. These conceptualizations are important for general definitions and methodology development, both in research and practice. These results can guide stimuli, response, and task selection and development (Kalén et al., 2021). For example, to assess soccer-specific activity in a laboratory setting, the stimuli should mimic real-life conditions (e.g., soccer players or open spaces on a soccer field), the response should include a motor component (e.g., positioning oneself in space), and the task should require both attention and motor activity (e.g., to wait for the best moment to make a passing offer). It is noteworthy to refer to Kalén et al. (2021) when

developing methodological approaches, who showed that sport-specific stimuli selection was more important than response selection.

In practice, where subjective assessments still dominate player evaluations, soccer-specific conceptualizations of PCSs play a critical role in shaping talent identification and development procedures (Larkin & O'Connor, 2017). However, the lack of consensus, non-unified language, and the absence of standardized guidelines or assessment tools contribute to the generally unsystematic evaluation of PCSs in soccer (Christensen, 2009; Musculus & Lobinger, 2018). The findings of this dissertation reveal that, although coaches demonstrated the ability to provide detailed and nuanced descriptions of their observations (see Article 1), their use of differentiated and precise labels for PCSs (see Article 2) was notably limited. Coaches often relied on broad, overarching terms such as "game intelligence" or "perception" to describe several distinct PCSs, highlighting their terminology's lack of variety and specificity. This limitation raises essential questions about whether the restricted vocabulary reflects a linguistic gap or indicates a conceptual phenomenon. For instance, it may suggest the inherently intertwined nature of these skills or a broader conceptualization that resists the detailed distinctions typically drawn in cognitive psychology (Purves et al., 2013). While cognitive psychology often differentiates between essential cognitive functions (e.g., processing speed) and higher-order cognitive functions (e.g., decision-making), coaches did not explicitly articulate this hierarchical structure. Instead, coaches tended to label multiple PCSs with umbrella terms. Further research is needed to investigate whether these observed limitations in terminology stem from a lack of specific education or exposure to scientific classifications or if they reflect a practical understanding of how PCSs operate in dynamic, real-world contexts (see Table 10.1). Clarifying this issue could provide valuable insights into how practitioners conceptualize these skills and enhance efforts to align scientific and practical models.

Sport-specific cognitive profiles

Building on the theoretical contributions presented earlier, which explore domain-specific PCSs from a developmental embodied cognition perspective in youth soccer, cognitive requirement profiles can be derived to support player assessment and training. These profiles form the basis for effectively evaluating and enhancing players' skills (e.g., Vestberg et al., 2017), providing a structured approach to identifying the cognitive demands specific to soccer (Scharfen & Memmert, 2019). This understanding also supports the development of age-specific and position-specific adaptations (Schumacher et al., 2018), as discussed earlier in the context of developmental trajectories. For instance, profiling young athletes within a particular age range (e.g., 13–16) enables targeted assessments and training interventions that match their developmental stage and their specific cognitive tasks. This approach surpasses generic strategies by offering tailored solutions that enhance standardized assessment processes and skill acquisition (Lacome et al., 2018). Within this dissertation, coaches highlighted switching, problem-solving, preorientation, decision-making, and spatial awareness as the top five relevant skills.

Interestingly, when looking at the overarching domains to which these PCSs are assigned, it becomes apparent that at least one PCS represents each domain in the top five. This observation suggests that these domains and their associated PCSs are combined to successfully execute soccer actions. Regarding cognitive profiles, one conclusion could be that the interplay of various skills, each with different primary focuses (e.g., information gathering, processing, planning, action executing, and action adjusting), forms the core of sport-specific behavior.

Detailed investigations of cognitive profiles are also crucial for comparing cognitive demands across sports (Williams et al., 2011). By highlighting nuanced differences, cognitive profiling enhances the understanding of the unique challenges posed by various disciplines (Hodges et al., 2021). In this regard, the question of the generalizability of the present results

emerges. From a developmental embodied cognition perspective that emphasizes the context specificity of motor-cognitive development, generalizing the findings from one to another sporting domain is limited (Musculus et al., 2021). Although researchers also highlight universal cognitive functions underlying domain-specific PCSs, generalizations must be made cautiously, considering the unique characteristics of each domain (Musculus & Raab, 2022). Based on the present research results, it can be assumed that the general organization of PCSs into the four overarching domains of "information gathering," "processing and planning," "action execution," and "action adjustment" can be applied to other open-skill sports. This assumption is supported by their connection to the general perception-action cycle (Dicks et al., 2019) and their reflection on the nature of open-skill sports actions, including operating in space, interacting with teammates and opponents, and performing under pressure. Given that these characteristics informed PCSs conceptualizations, it is reasonable to assume that generalizations can be made to other sports sharing these features, as already proposed in science (Hodges et al., 2021).

Informing talent identification and development research

One area that garners significant attention in sports psychology and sports science is talent identification and development (e.g., Williams & Reilly, 2000). In today's soccer landscape, players are being transferred for record-breaking sums, with Neymar Jr. leading the list with €222 million e, exemplifying this trend (Transfermarkt, n.d.). It is, therefore, unsurprising that both research and practice are intensely focused on identifying indicators in youth that could predict such extraordinary development (Unnithan et al., 2012; Williams et al., 2020). However, a significant critique of this field lies in its reliance on static talent models that assume fixed criteria assessed at a single, often undefined, time point can reliably predict future performance (Larkin & Reeves, 2018). This approach fails to account for talent development's inherently dynamic and non-linear nature, particularly during critical developmental stages in

youth sports (Musculus et al., 2021). From a developmental embodied cognition perspective, talent must be reconceptualized as fluid, evolving through the continuous interaction of PCSs and motor abilities. PCSs are pivotal in distinguishing elite performance and should be viewed as dynamically developing capacities rather than fixed attributes. This perspective aligns with Larkin and Reeves' (2018) call to shift focus from "talent identification" to "performance identification," emphasizing the need to evaluate observable behaviors in real-world contexts rather than relying on abstract, static criteria. Performance identification recognizes the dynamic interplay of skills and the contextual dependencies that shape their application, offering a more adaptive and evidence-based approach to evaluating players. Critically, PCSs must be integrated into talent identification frameworks as context-sensitive and age-specific constructs, reflecting their evolving nature. Future research should investigate the prognostic validity of criteria assessed in youth soccer players to determine their reliability in predicting long-term success. This would provide essential insights for refining criteria selection, ensuring that assessments are not only developmentally appropriate but also effective in identifying players with the potential to excel at higher levels of competition.

8.3. Methodological contributions

Coach’s eye as a methodological framework

In addition to its theoretical contributions, the dissertation provides methodological added value. A key focus of the present research was to explore and interpret the extensive knowledge of coaches and scouts in the field. The ability of coaches and recruiters to evaluate performance and identify players with the potential to excel in the sport is often referred to as the coach's or recruiters’ eye (e.g., Christensen, 2009; Larkin et al., 2020). This intuitive, experience-based, subjective, and holistic assessment has been recognized as an important source of knowledge for understanding sport-specific performance and talent criteria (e.g., Lath et al., 2021; Larkin & O’Connor, 2017). Applying a coach’s perspective offers unique

advantages that enhance the depth and applicability of research findings. It provides insight into real-world performance contexts, which positively influences the ecological validity of studies (Peringa et al., 2024). Coaches' lived experience and ability to assess nuanced and dynamic situations in the field make them critical contributors to grounding research in the realities of sports practice (Kelly & Turnnidge, 2023).

Furthermore, coaches rely on context-specific knowledge essential for tailoring research to specific sports, which science has repeatedly requested (e.g., Kalén et al., 2021). Additionally, the coach's eye framework helps bridge the persistent gap between research and practice, ensuring that findings are relevant and usable for practitioners (Cushion et al., 2012). While most research in this area has been situated within the context of talent identification and development, this dissertation broadened the focus to encompass player assessment more generally. The coach's eye was utilized as a general methodological framework to explore PCSs in-depth (Lath et al., 2021). Thereby, it advances the coach's eye approach to not only holistically investigate talent criteria of several domains but also apply it to a detailed understanding within one domain.

Further, it has been advanced in terms of a detailed exploration of behavior instead of investigating abstract concepts broadly (e.g., speaking about game intelligence without elaborations). Most conducted studies on the coach's eye are qualitative and exploratory, leading to a general tendency to gather detailed knowledge about aspects often overlooked by solely quantitative data (Lath et al., 2021). Nevertheless, once coaches have qualitatively explored a topic, adding quantitative measures is recommended (Bakhsh et al., 2024). This approach has been conducted in the present dissertation by first exploring the coaches' conceptualizations of domain-specific PCSs and then evaluating them with a bigger sample (see Articles 1 and 2).

Furthermore, a coach's eye perspective encourages developmentally sensitive methodologies. Through years of observing athletes at different stages of their development, coaches are uniquely positioned to highlight age-appropriate criteria for player assessment and development (Jones et al., 2003). This is particularly valuable given the critiques of static talent models and the need for a dynamic understanding of players' progression (Larkin & Reeves, 2018; Lath et al., 2021). Additionally, involving coaches enhances the credibility and acceptance of findings within the sports community. Practitioners are more likely to adopt evidence-based methods when they see their expertise reflected in the research process (Roberts et al., 2019). Coaches' involvement also helps refine research instruments and protocols, making them more user-friendly and applicable to real-world usage in practice. By incorporating the coach's eye as a methodological framework, this research deepens the understanding of player assessment in domain-specific PCSs. It ensures that the findings are actionable, sport-specific, and practically relevant. Therefore, applying a coach's perspective is one operationalization of the co-productive approach (Smith et al., 2022), which advocates for scientific collaboration between researchers and practitioners. This approach aligns with explicit calls for such cooperation in cognitive psychology research within soccer (Lautenbach et al., 2022).

Video-stimulated interviews

An innovative approach in the context of the coach's eye methodology during the semi-structured interviews was using real-life video sequences from an elite player population. These videos were selected and prepared through a theoretically informed and multi-step process for the present study (see Article 1). This approach increased the likelihood that coaches explored the wide range of PCSs involved in actual gameplay. Further, it enhanced the transferability of findings to this target group. This method was chosen because research consistently shows that stimulated interviews are particularly effective in activating the depth of implicit knowledge,

which might remain inaccessible in purely verbal interviews (e.g., Lyle, 2003). Stimulated interviews utilize external stimuli, such as video or image-based prompts, to focus the interviewee's attention on specific events or behaviors, eliciting more detailed and contextually grounded responses (van Meurs et al., 2022). This is especially valuable, as coaches often rely on tacit, experience-based knowledge that is difficult to articulate without visual cues (Raya-Castellano et al., 2020). In this study's context, video sequences helped ensure that discussions remained anchored in observable phenomena, reducing the risk of responses drifting into abstraction or generalization, a common limitation of interviews conducted without supporting material (Nicholas et al., 2018). By presenting sequences depicting real elite youth players, the study encouraged coaches to draw upon their practical expertise and focus on concrete examples of player behavior. This method allowed for deeper insights into how specific PCSs—such as anticipation, decision-making, and switching—are recognized and assessed in real-world scenarios.

Moreover, this approach enhances ecological validity by simulating situations that closely resemble the environments in which coaches typically make evaluative judgments, such as during games or training sessions (Lawlor et al., 2021). Unlike traditional interviews, which often separate theoretical discussions from practical realities, integrating real-life video stimuli aligns the research setting with the practical contexts that coaches encounter daily (Lawlor et al., 2021). Further, this approach enables an exploration of PCSs within their natural environment, emphasizing the critical role of contextual information as outlined in the framework of embodied cognition (e.g., Araújo et al., 2019). Embodied cognition posits that cognitive processes are deeply rooted in the physical interactions of an individual within their environment rather than functioning in isolation (e.g., Musculus et al., 2021). This method captures the interplay between perception, cognition action, and the surrounding context by incorporating real-life scenarios through video stimuli. It is essential for understanding PCSs

as they occur dynamically in soccer (Roca et al., 2013). Additionally, using video material drawn from an elite youth soccer population ensures that the findings directly apply to this critical developmental stage in soccer. This population-specific focus enables the results to inform targeted procedures in both assessment and training.

Behavior-based perceptual-cognitive skills descriptions

Using behavior-based descriptions rather than abstract scientific terms, such as pattern recognition or spatial awareness, represents an additional methodological advancement in research on domain-specific PCSs. This approach aligns closely with the increasing need for observation-based methods in player evaluation, which have proven highly effective in capturing performance-relevant behaviors (Ortega-Toro et al., 2019). Observation-based methods mirror the reality of how coaches and scouts evaluate players in real-world settings (Lawlor et al., 2021). One of the primary goals of using behavior-based descriptions is to standardize subjective assessments. While valuable for their flexibility and nuanced insights, subjective evaluations are often criticized for their lack of consistency and susceptibility to individual biases (Jokuschies et al., 2017). By grounding assessments in clearly defined behavioral indicators, this methodology fosters a more systematic approach that aligns with established scientific quality criteria, such as reliability, objectivity, and validity (Lethole et al., 2024a; Musculus & Lobinger, 2018). For example, instead of broadly referencing spatial awareness, the evaluator was presented with a description (i.e., the player positions himself in open spaces [i.e., with appropriate distance from the opponent] and plays balls into open space [e.g., into the movement of a teammate]) that was derived from the previous qualitative interviews (Article 1).

Moreover, behavior-based descriptions promote comparability across different evaluators and settings, increasing objectivity and reliability (Musculus & Lobinger, 2018). Coaches and scouts often operate within diverse organizational cultures, leading to varying

interpretations of abstract concepts (Flatgård et al., 2020). Providing a shared framework of observable behaviors reduces ambiguity and ensures that all assessors operate from a unified understanding of critical concepts. This improves inter-rater reliability and facilitates better communication among coaches, scouts, and researchers (Roberts et al., 2019). Behavior-based descriptions also contribute to the transferability and applicability of research findings. Scientific studies on cognitive skills in sports often employ abstract terminology that may not resonate with practitioners. Converting these terms into behavior-focused indicators helps establish a common language, enhancing communication and collaboration between scientists and practitioners (Lautenbach et al., 2022).

8.4. Applied contributions

Standardization of subjective assessment

The applied value of this dissertation was one of its foundational motivations. While the practical contributions have already been emphasized in previous subchapters, within this section, the subjective assessment and the transfer of knowledge will be addressed in more detail. Additionally, this dissertation contributes by outlining future directions for both applied research and the continued transfer of knowledge into practice, extending its impact beyond the scope of this work (see Chapter 10). The insights gained from this study provide practitioners with a comprehensive overview of domain-specific PCSs, their behavior-based descriptions, and a quantitative understanding of their importance in player assessment. This information can be directly applied to support systematizing the subjective evaluation of players in real-world settings (Musculus & Lobinger, 2018). As extensively detailed in the third article, these results should always be adapted to the specific context in which they are applied, considering the club's philosophy, the demands of particular player profiles, and the available resources for implementing assessments (Flatgård et al., 2020). This research was deliberately defined as

usage-inspired basic research (Hassmén et al., 2016), designed to serve as a starting point for further studies and the development of practically relevant methodologies.

Interestingly, in-match situations involving direct ball possession account for only a tiny fraction of a player's activity, approximately 2% (van Maarseveen et al., 2018). This underscores the importance of understanding skills that influence the game positively, even off the ball. These include a range of domain-specific PCSs such as preparedness, activity, positioning, and many more. By focusing on these skills, the present study brought attention to these often-overlooked skills and placed them on the radar for future research and practical applications. Further, the practical value of this work lies in its ability to directly support coaches, scouts, and other stakeholders in developing systematic approaches to player evaluation. By providing behavior-based descriptions, this research offers a common language for assessing and discussing key PCSs, reducing the variability and subjectivity traditionally associated with player evaluations (Bergkamp et al., 2022a; Christensen, 2009). By shedding light on the importance of domain-specific PCSs beyond ball-related activities, this dissertation opens new avenues for research and practice. It highlights the need for understanding the multidimensional cognitive requirement profile to inform the holistic player's assessment and talent identification (Mota et al., 2023). Yet only the most common PCSs have received attention in these procedures, without considering the broad range. While a main applied contribution is to enhance the quality of the subjective observational assessment by coaches and scouts, the presented results can also inform objective assessment procedures. As previously stated, this sport-specific knowledge can also optimize objective, lab-based procedures by better aligning the selection of stimuli and responses with real-world conditions.

A framework of evidence-based knowledge transfer from science to practice

Transferring the knowledge into practice has been one of the primary aims of this dissertation, thereby helping to close an existing research-practice gap (Norman, 2010). A gap between both a scientific call for domain-specific PCSs investigations and a practical request to inform coaches about how to identify and assess PCSs. As presented in the third article, recommendations on evidence-based knowledge transfer from science to practice have been provided. Within this discussion, I want to build upon Lautenbach et al. (2022), who discussed the integration of cognitive psychology in soccer, emphasizing the collaboration between research and practice. A framework was developed based on the transfer of knowledge on domain-specific PCSs from science to practice (see Figure 8.1), but it applies to the transfer in general.

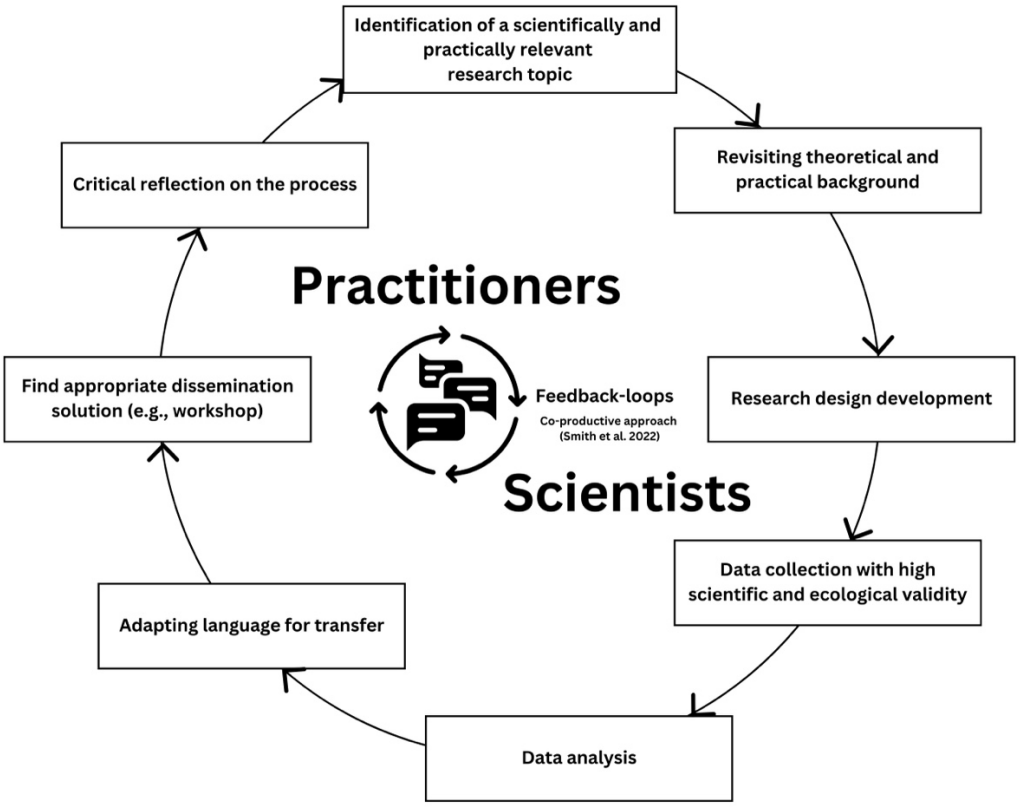

Figure 8.1 *Transfer of knowledge on domain-specific PCSs from science to practice.*

This framework is grounded in adopting a co-productive approach (Smith et al., 2022), which actively involves key stakeholders from the field in collaboration with scientists. The process begins with formulating a research question that holds both theoretical and practical relevance, motivated by a practical phenomenon (e.g., players in different positions require specific PCSs; what are the cognitive requirement profiles for various positions?). In alignment with standard scientific practices, the next step involves a comprehensive review of existing literature to establish the theoretical background and identify the current state of research. However, the framework emphasizes building on both theoretical and practical foundations. The practical background incorporates contextual factors, including identifying the relevant stakeholders (e.g., player-coaches who define position requirements), understanding the existing knowledge base (e.g., implicit knowledge of PCSs), and considering potential applications of the findings (e.g., informing player assessments and training method development). After establishing the background, data collection is conducted using appropriate methods. It is crucial to adhere to scientific quality criteria, such as reliability, objectivity, and validity, while ensuring ecological validity (Musculus & Lobinger, 2018). A practical background is instrumental in this phase, as it provides contextual insights (e.g., players are often assigned positions early in their development) and anticipates future applications (e.g., assessment protocols and training strategies). This phase also fosters effective communication between scientists and practitioners by facilitating a shared understanding through exchanging perspectives. Practitioners should be involved whenever feasible during the data analysis phase, mainly when qualitative data is being analyzed. The co-productive approach (Smith et al., 2022) enhances scientific rigor by incorporating diverse perspectives. Once data has been collected and analyzed, a regular feedback loop should be established to review the findings and integrate insights from both scientific and practical viewpoints. Following analysis, the knowledge must be prepared for dissemination. A critical prerequisite for successful knowledge transfer is accessible and

contextually appropriate language. Ideally, this consideration is embedded throughout the research process, minimizing the need for adjustments during the dissemination phase. If necessary, practitioners should review the materials before dissemination to ensure the vocabulary aligns with practical usage. The framework then recommends determining the most effective method for communicating the findings. Practical constraints and workflows in the field should guide this choice. For contexts with many full-time coaches working at training facilities, workshops or lectures may be appropriate. Independent materials, such as recorded video presentations, brochures (e.g., Eckardt & Lobinger, 2024), or training guidelines, may be more suitable in other settings.

While this proposed framework is exemplified through research on PCSs, it is adaptable to other topics. Ultimately, the transferred knowledge should meet four critical criteria: it must be (1) scientifically and practically relevant, (2) evidence-based, (3) ecologically valid, and (4) feedback-driven, leveraging collaboration between scientists and practitioners.

9. Limitations

While this dissertation has made significant contributions, it is equally important to critically evaluate its methodological and theoretical limitations to guide future studies. Although the close connection between the articles strengthened the coherence and quality of the project components, it also introduced specific challenges. For example, the analysis of qualitative data, given the extensive volume of material, required multiple rounds of review and refinement (Braun & Clarke, 2023). The questionnaire development used in the second study was based on a two-round comprehensive analysis that identified 35 PCSs (see Appendix Table 14.1). In another subsequent analysis, this list was reduced to 26 PCSs, mainly because of the involvement of an additional expert from the field and the pilot testing of the first draft of the evaluation form. This additional discussion and practical testing resulted in the decision to further cluster PCSs (e.g., speculation and anticipation, estimation and timing, spatial awareness and positioning). In this discussion, it became evident that merging these skills more closely reflects their conceptualization in actual gameplay, further supporting the intertwined nature of different PCSs in soccer and highlighting the added value of a practical perspective. Importantly, since coaches evaluated the extensive list, they thoroughly examined all skills included in the final list.

However, the behavior-based descriptions were slightly adjusted, as the descriptions of the merged PCSs were modified to better align with their integrated nature. These differences are transparently documented in Table 14.1 (see Appendix) to allow for the tracking of adjustments made throughout the process. One potential solution to address this discrepancy could have been a second round of data collection on evaluations. However, the highly practice-oriented target group proved difficult to engage, even during the initial data collection phase, a common problem in soccer (Hecksteden et al., 2022). Various sampling strategies were employed, including distributing a link via social media, engaging with coordinators of soccer

academies, and leveraging personal contacts. Despite these efforts, the response rate was low, as feedback from participants revealed challenges such as the length of the study and the time constraints faced by individuals working in professional soccer.

Given that the collected sample already included many highly experienced coaches whose expertise was critical for answering the research questions, a cost-benefit analysis led to the decision to accept the discrepancies in the PCSs' findings and address them critically within the study discussion. Another critical issue arose from the sensitivity of coaches to language and labeling in PCSs' descriptions. Subtle differences in wording had a significant impact on how items were interpreted. For example, the term "quickly" was often associated with "speed of action," even in contexts where this skill was not the primary focus of the item (e.g., "The player quickly finds solutions to problems on the field [e.g., freeing himself from opponents or space pressure]). Hence, these adjectives have been removed from the final list of 26 PCSs (Article 1) to ensure clarity in labels. This sensitivity highlights the need for precise and consistent language to ensure practitioners correctly interpret and apply the evaluated concepts. These findings suggest that the influence of terminology on practitioner understanding warrants further investigation to minimize misinterpretations and enhance evaluation consistency. Another limitation concerning language lies in the varying specificity of the behavior-based descriptions. While some PCSs are described with precise behavioral indicators (e.g., activity: "The player is constantly moving, such as making runs and creating passing options"), the description of decision-making is significantly less detailed (e.g., "The player makes decisions"). Although most PCSs include clear behavioral indicators, others lack clear behavioral anchors. However, coaches showed no difficulties inferring decision-making from their observation, mainly focusing on outcomes of actions (e.g., an executed pass). Given a generally strong focus on these PCSs and detailed elaborations of coaches, it is unlikely that more coaches need further information to consistently evaluate them. Nevertheless, an in-depth

analysis and further exploration of the broad range of behavioral indicators could be a valuable avenue for future research.

Furthermore, the fact that the data analysis was primarily conducted by myself introduces certain scientific limitations. Specifically, my affiliation with the same club as the participants in the first study presents both advantages and challenges for the interpretation and analysis of the data. On the one hand, this shared background fosters a foundation of mutual understanding, common knowledge, and practical experience, which can enrich the depth and contextual relevance of the analysis. This familiarity may have also facilitated trust and openness during data collection, potentially enhancing the authenticity of participant responses. However, it also raises concerns about potential bias. The overlap in knowledge and shared experiences could unconsciously shape the interpretation of findings, introducing confirmation bias or reducing the ability to critically interrogate implicit assumptions. Furthermore, this shared context may limit the generalizability of the results, as conclusions drawn from this study could be overly specific to the club environment. Despite implementing strategies such as external critical reviews of data analysis and incorporating diverse perspectives from scientists and applied stakeholders to mitigate these biases, the inherent subjectivity of qualitative research must be acknowledged. These limitations should be carefully considered when evaluating the transferability of the findings to other contexts. To enhance the generalizability and robustness of the conclusions, further research with participants from varied environments is necessary.

Another limitation of this project lies in the exclusively male sample, which restricts the generalizability of findings to female players. This reflects a broader issue of underrepresenting female samples in research on PCSs in soccer, although some exceptions exist (e.g., Beavan et al., 2022). Male game footage was deliberately chosen as stimuli to align with the coaches' experiences, given their involvement in male youth academies. While this approach ensured

ecological validity for the current sample, it highlights the need for further research involving female athletes to explore potential gender-related differences and similarities in domain-specific PCSs. Despite this limitation, evidence from prior studies indicates comparable cognitive performance between male and female samples, both within and beyond sports contexts (e.g., Beavan et al., 2022; Huizinga et al., 2006). This highlights the potential applicability of the present findings to female players, which requires validation in future studies. Additionally, gender-specific trajectories of cognitive growth should be cautiously investigated to account for differences in pubertal development. Incorporating these considerations can help future research better elucidate the role of puberty in shaping cognitive development across genders (Bramen et al., 2011). On the coaches' level, while there were no explicit restrictions on including female coaches, none of the applicants met the inclusion criteria. This gender imbalance underscores the need for future research to include female players and coaches to ensure broader applicability and investigate potential gender-related differences in PCSs evaluation and development. Expanding the sample to include diverse populations would enhance the relevance and inclusivity of study findings (Nygaard et al., 2022).

Another limitation of the present research project pertains to language. The data was collected from a German sample, using culturally and context-sensitive language grounded in practice. This language was later translated into English for academic purposes, which may have introduced subtle shifts in meaning. While the translation and back-translation processes adhered to scientific standards (e.g., Bennett, 2022) and were reviewed by an English-speaking practitioner with domain knowledge as well as a native speaker, it is possible that essential nuances in the conceptualization were lost during this process. Additionally, the use of academic language, its technical terms, and the reliance on English make it challenging for practitioners to fully engage with and apply the findings (Bansal et al., 2012). This issue

conflicts with one of the project's primary aims, namely, to deliver practical value. The original German-language data are available upon request to address this limitation, ensuring transparency and accessibility. Furthermore, a key future direction involves the development of practice-oriented contributions in German to promote the dissemination of findings within German-speaking contexts following the completion of the dissertation. These limitations underline the challenges and complexities of bridging scientific inquiry and practical application. They also offer valuable opportunities for refinement and expansion. By addressing these issues, future research can build on the foundational insights of this study, advancing the understanding and application of PCSs assessment in elite sports while fostering a more inclusive and comprehensive approach.

10. Future directions

The dissertation was conducted as usage-inspired basic research (Hassmén et al., 2016), hence aimed at building a solid foundation for further investigations and transferring knowledge into practical application on soccer-specific PCSs. In the following, future directions are presented with their primary focus on scientific or applied aspects, as outlined in Table 10.1. The scientific future directions outlined in this project focus on expanding theoretical knowledge and refining research methodologies related to domain-specific PCSs. These include investigations into the relationship between domain-general and domain-specific PCSs, longitudinal studies tracking developmental trajectories, and exploring differences across positions, age groups, and genders. Theoretical underpinnings such as a developmental embodied cognition perspective and the expert performance approach form the basis for many of these directions, aiming to deepen the understanding of how PCSs develop and operate within elite soccer contexts. Proposed scientific future directions are centered on investigating both the broad range of PCSs and the in-detail research of single PCSs. Additionally, it is recommended that this research be used as a foundation for informing classical expertise-study designs and research programs on talent identification and development in perception and cognition.

After completing this doctoral project, the applied future directions will be the focus, emphasizing the translation of scientific insights into practical tools and strategies that benefit practitioners. These directions address several pressing needs in soccer practice. This will be preceded by consultation with the university's transfer office to ensure that the knowledge is accessible and practiced most effectively and sustainably.

Table 10.1 Overview of future directions derived from this dissertation

Scientific future directions				
Theory	**Research aim**	**Method**	**Sample**	**Contribution**
Developmental embodied cognition (e.g., Musculus & Raab 2022)	In-depth investigation of the intertwined nature of PCSs	Qualitative video-stimulated (age-groups U14-U16) semi-structured interviews	Elite soccer coaches and scouts	Development of a structural PCSs model in elite soccer, displaying relationships of individual PCSs
Expert performance approach (Ericsson et al., 1993)	Expertise study on differences in soccer-specific PCSs	Quantitative Cross-sectional	Elite youth soccer players (U14-U16) and Amateur youth soccer players (U14-U16)	Informing talent identification and expertise research by analyzing differences between elite and non-elite samples (e.g., Huijgen et al., 2015).
Developmental embodied cognition (e.g., Musculus & Raab 2022)	Development of key domain-specific PCSs in young soccer players	Quantitative Longitudinal Two assessments yearly (5yrs.)	Elite youth soccer players (U11-U15)	Identifying developmental trajectories of key soccer-specific PCSs (e.g., Musculus, 2018)
Developmental embodied cognition (e.g., Musculus & Raab 2022)	Age differences in soccer-specific PCSs	Qualitative Video-stimulated (age-groups U11-U19) semi-structured interviews	Elite soccer coaches and scouts	Expanding the knowledge of the current project in terms of age-differences (e.g., Article 1)
Position-specific perceptual-cognitive expertise (e.g., Schumacher et al., 2018)	Position differences in soccer-specific PCSs	Qualitative Video-stimulated (age-groups U11-U19) semi-structured interviews	Elite soccer coaches and scouts	Expanding the knowledge of the current project in terms of position-differences (e.g., Article 1)
Coach's eye (e.g., Christensen, 2009) Talent identification (e.g., Williams et al., 2020)	Comparing subjective and objective measures of soccer-specific PCSs' assessment	Quantitative Longitudinal Two assessments yearly (7 yrs.)	Elite youth soccer players (U12-U19)	Prognostic validity of assessment procedures, informing talent identification and development (e.g., Höner et al., 2021)
Expert performance approach (Ericsson et al., 1993) & cognitive component skill approach (Nougier et al., 1991)	Investigating the relationship of domain-general PCFs and soccer-specific PCSs	Quantitative Cross-sectional	Elite youth soccer players (U14-U16)	Learning about the involvement of domain-general PCFs in soccer-specific cognition; Investigating underlying mechanisms (e.g., Heisler et al., 2023)

Gender Similarities Hypothesis (Hyde, 2005)	Replication of the current project in female soccer players	Qualitative video-stimulated (age-groups U14-U16) semi-structured interviews	Elite soccer coaches and scouts	Adding insights into gender differences of domain-specific PCSs in soccer (e.g., Beavan et al., 2021)
Developmental embodied cognition (e.g., Musculus & Raab 2022)	Replication of the current project in other youth academies	Qualitative video-stimulated (age-groups U14-U16) semi-structured interviews	Elite soccer coaches and scouts	Enhancing the generalizability of study findings

Applied future directions

Practical Issue	**Aim**	**Involved stakeholders**	**Action plan**
Unsystematic and subjective scouting reports	Creating scouting report guidelines	Co-productive approach with coaches and scouts	Providing an information sheet with a general structure for displaying PCSs within scouting reports. Provide background information on the conceptualizations of PCSs.
Unvalidated assessment procedures	Validation of a soccer-specific PCSs assessment tool	Co-productive approach with coaches and scouts	Validation of the evaluation form addresses both construct and ecological validity.
Unsystematic and subjective player assessment	Informing clubs about standardized observational assessment	Clubs' representatives and coaches	Exchange with club representatives to inform them about the project and to transfer solutions tied to their structures (e.g., workshops, brochures, video presentations).
Mostly digital documentation of observations	Developing an online version of an evaluation form	Pilot-testing by coaches and scouts	Developing an online version for practical use; Providing digital items for clubs to set up their version based on their technical resources.
Lack of accessible scientific (German) knowledge of diagnostics	German applied article on PCSs assessment	Co-author with expertise in coaching	Writing an applied-oriented article in "Fußballtraining" (Philippka) on the main results of the research project, focusing on the observational assessment of domain-specific PCSs.
No or unsystematic training of PCSs	Development of training method to train PCSs systematically	Co-productive approach with coaches	Develop training methods on domain-specific PCSs and provide recommendations on the periodization of these exercises.
Lack of accessible scientific (German) knowledge of PCSs training methods	German applied article on PCSs development	Co-author with expertise in coaching	Writing an applied-oriented article in "Fußballtraining" (Philippka) on training methods for soccer-specific PCSs developed in co-production with elite youth soccer coaches.

Guidelines will be co-produced with practitioners to tackle the issue of unsystematic and subjective scouting reports, offering a structured approach to integrate PCSs evaluations into scouting processes. These will include informational sheets detailing PCSs' conceptualizations and practical frameworks. This will be one of the first steps, given scouting activity for the next season will intensify in the upcoming months. One of the primary aims was to provide clubs with actionable knowledge directly. Yet, it needs to be prepared for the transfer into applied settings. The goal is to introduce standardized observational assessments developed from this project through workshops, brochures, and video presentations. It is essential to align these procedures with existing systems, available resources, and overarching philosophies. This phase emphasizes fostering increased exchange and communication with stakeholders in the field to ensure effective implementation.

Another practical need that motivated the start of this project was the demand from coaches for training methods. While many clubs and coaches are open to adopting new approaches—and numerous recommendations already exist through online platforms, books, and articles—this project focuses on closely collaborating with coaches to develop evidence-based training methods derived from the current research. This approach aims to give the extracted knowledge from coaches a meaningful return path into the system, with their continued involvement playing a central role. Such a collaborative process is expected to enhance the acceptance of these methods while ensuring they are firmly grounded in experiential and evidence-based knowledge. To inform a broader audience in German practice, the scientific results will be prepared for publication in practice-oriented journals (e.g., "Fußballtraining", Philippka).

11. Conclusion

This dissertation explored and evaluated domain-specific PCSs in elite youth soccer players from a professional coach's perspective, adopting a developmental embodied cognition framework (Lux et al., 2021). By utilizing a co-productive approach, the study accessed practitioners' experience-based, rich knowledge while applying scientifically rigorous methods. The research identified a comprehensive list of 26 PCSs categorized into four overarching domains, underscoring the involvement of a diverse array of PCSs necessary for acting in the dynamic and complex game of soccer. Furthermore, the intertwined nature of these skills was emphasized through the descriptions provided by coaches, illustrating that every soccer action requires the interaction of skills across all four domains. Switching, preorientation, and spatial awareness have been rated as highly relevant, frequently used during play, and best to observe, indicating their specific significance for youth players' PCSs assessment. The dissertation also highlighted notable differences between scientific and practical conceptualizations and language of soccer-specific PCSs, offering valuable insights for developing and refining sport-specific measurement and training methods. By exploring the cognitive profile of players aged 13 to 16, the findings follow the advocated shift towards dynamic, age-specific evaluation of players rooted in a developmental embodied cognition perspective. This approach emphasizes behavior-based observations that account for the evolving nature of PCSs during critical developmental stages. Ultimately, the research findings were utilized to develop an evaluation form for the observational assessment of PCSs during actual gameplay conducted by coaches and scouts. By providing foundational knowledge, this work lays the groundwork for the continuation of critical research pathways to generate robust and actionable insights. The dissertation recommends a systematic framework for integrating scientific evidence-based knowledge into practice, ensuring that research findings are theoretical and practically beneficial.

12. Postface

Even after nearly four years of this doctoral journey, my passion for soccer research and practice remains undiminished—quite the opposite: this journey has deepened it. The intensive engagement with a topic that holds theoretical importance, and significant practical relevance has opened new perspectives. This work does not conclude with a sense of "arrival" but rather a renewed desire to refuel and continue the journey. It began to contribute to the description, explanation, prediction, and optimization of performance. With this dissertation, I have primarily provided empirical contributions to the description and explanation of PCSs in youth players while also laying a conceptual foundation for future predictions and optimizations. To borrow a phrase from the applied field, a talent has been identified—one that must now be systematically supported to develop fully and realize its potential. While my personal goal is to continue this work and contribute to nurturing this potential, I also hope to inspire other researchers and practitioners to join this journey. It is encouraging to see that the first steps have already been taken, with initial media attention around this research project helping to make science more accessible to a broader audience beyond the confines of the academic playing field. I hope to expand this exchange further, to view PCSs through the eyes of many “coaches,” and to incorporate diverse perspectives—for the benefit of both science and practice alike.

13. References

Note: The below listed references refer to citations in chapters 1 to 4 as well as 8 to 12 of this dissertation. References for each of the included articles are listed separately within the respective chapters.

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14. Appendix

Appendix A

Table 14.1 Overview of differences between PCS-lists used within Study 1 and 2

Origin	**Scientific label**	**Behavioral description of perceptual-cognitive skill** (items of the online questionnaire)
Article 2	Cognitive flexibility	The player reacts flexibly to situational factors (e.g., after a position change or player substitution).
Article 2	Switching	The player switches quickly between two game situations (e.g., from offense to defense; after a mistake).
Article 1	*Switching*	*The player switches between two game situations (e.g., from offense to defense; after a mistake).*
Article 2	Sustained attention	The player remains attentive throughout various game actions and stays "engaged" in the play.
Article 2	Activity	The player is constantly moving (e.g., by making runs and creating passing options).
Article 1	*Activity*	*The player is active and remains attentive through various actions. He stays "online" during a set of actions.*
Article 2	Speculation	The player acts before gathering all the necessary information. showing a willingness to take risks.
Article 2	Anticipation	The player can think ahead in several situational stages. He initiates actions before the outcome of the previous situation is clear, based on key information from others.
Article 1	*Anticipation*	*The player anticipates or speculates about a situation and thinks several moves ahead.*
Article 2	Estimation	The player correctly estimates distances, times, and speeds of the ball, as well as of teammates and opponents.
Article 2	Timing	The player adjusts the speed of the pass or his own movement so that the ball or player reaches the target at the right time.
Article 1	*Timing*	*The player times his actions so that the ball or he arrives at the destination at the right moment.*
Article 2	Option generation	The player positions himself in ways that give him multiple advantageous action options.
Article 2	Decision making	The player makes correct decisions for the game situation.
Article 1	*Decision making*	*The player makes decisions.*
Article 2	Goal-directed action	The player acts purposefully and does not deviate from his plan during the action, making it seem as if he is following a set action plan.
Article 2	Imagination	The player gives the impression that his actions are driven by an underlying idea.
Article 1	*Imagination*	*The player has or follows ideas.*

Origin	**Scientific label**	**Behavioral description of perceptual-cognitive skill** (items of the online questionnaire)
Article 2	Interpersonal coordination	The player adapts his actions to those of teammates and opponents, involving them in his play (e.g., initiating a one-two pass or pushing the opponent wide).
Article 2	Perspective taking	The player puts himself in the shoes of his teammates or opponents, using that information to adjust his own behavior (e.g., predicting the next action from body posture).
Article 1	*Interpersonal coordination*	*The player engages in joint actions with teammates or opponents. Through his actions, he involves them (e.g., by initiating a joint action such as a one-two pass; closing off the inside channel and forcing the opponent outward).*
Article 2	Motor control	The player is able to control his motor skills and use his abilities appropriately for the situation.
Article 2	Procedural knowledge	The player shows appropriate movement patterns for the situation. He knows how to move.

Note: Red highlighted perceptual-cognitive skills (PCSs) indicate the PCS that was deleted from the extensive list of 35 PCSs to the reduced list of 26 PCSs. Italic labels and descriptions indicate the merged PCSs. Two PCSs were not merged with a specific other PCS but instead implied in other descriptions.

Appendix B: Video-based semi-structured interview guide (Study 1)

POTENTIAL 1.0 – Ablauf	
Setting: Besprechungsraum mit Bildschirm (Panasonic, 50 Zoll) Videos werden abgespielt mit VLC Media Player auf Dell Laptop Tonaufzeichnung mit Laptop à Abspeichern auf Passwortgeschütztem USB-Stick	**Materialien:** Laptop, Raum
Videomaterial: Alle Videoszenen stammen aus den Aufzeichnungen des NLZ des Hamburger Sportvereins. Die Szenen zeigen Spiele der U14-U16 Mannschaften, wobei der Beobachtungsfokus auf den gegnerischen Spielern liegt, um Bewertungseinflüsse durch Erfahrungswerte zu den Spielern durch die Trainer zu minimieren. Insgesamt werden 14 Szenen gezeigt. Randomisierte Reihenfolge der Szenenpräsentation.	Videoszenen OneDrive
Ablauf: 1. Begrüßung 2. Ausfüllen der Einverständniserklärung (inklusive Zusatz für Einzelfallnutzung) 3. Instruktion: *„Danke, dass Du dich bereiterklärt hast an der Studie „POTENTIAL“, die ich im Rahmen meiner Doktorarbeit durchführe, teilzunehmen. Ich beschäftige mich in meiner Arbeit mit perzeptuell-kognitiven Fertigkeiten im Jugendfußball. Das heißt es geht um alle Fertigkeiten, die die Wahrnehmung und Informationsverarbeitung des zu beobachtenden Spielers betreffen. Nachfolgend werde ich dir insgesamt 14 Videoszenen aus Spielen der U14-U16 zeigen. Die Videoszene beginnt mit einem Standbild, bei dem ein Spieler (immer aus dem gegnerischen Team) durch einen gelben Kreis markiert ist. Ich zeige dir die Szene 5-mal, danach kannst du sie dir nach Bedarf weitere Male ansehen. Anschließend werde ich dir zu der Szene Fragen stellen. Ich werde dich erst bitten die Szene neutral zu beschreiben und erst in einem nächsten Schritt zu bewerten. Es wird eine Probeszene geben, anhand derer wir den Ablauf testen können und du gegebenenfalls Nachfragen stellen kannst. Unser Gespräch möchte ich, dein Einverständnis vorausgesetzt, mitschneiden, da ich deine Antworten für die Datenauswertung benötige. Wenn du jetzt keine weiteren Fragen hast, kann es losgehen.“*	
Hauptteil: **Allgemeines Vorgehen:** 1. Szene wird gezeigt: Erst 5-Mal ohne Kommentar, dann wird sie weiter präsentiert während Trainer eine Einschätzung vornehmen 2. Ich mache es an einem Beispiel vor „Der Spieler orientiert sich im Raum, das erkenne ich daran, dass er mit seinem Kopf die Umgebung scannt und sein Dribbling verlangsamt. Danach zieht er das Tempo an und trifft eine Entscheidung. Vor der Entscheidung zeigt er eine Vororientierung“ 3. Nächste Szene wird gezeigt	Nur für Probeszene
Fragen:	

• Bitte **beschreibe das Verhalten** des Spielers in der gezeigten Szene. Bitte konzentriere dich auf jedes Verhalten, das für dich in dem Zusammenhang mit Wahrnehmung und Informationsverarbeitung steht. Nachfragen: • Woran machst du das fest? • Wie erkennst du das? • Was erkennst du in Bezug auf seine Wahrnehmung? • Wann hat sich etwas an seinem Verhalten verändert und was glaubst du wieso? • Bitte **bewerte nun das von dir eben beschriebene Verhalten** des Spielersauf einer Skala von 1-5, wobei 1 sehr schlecht, 2 eher schlecht, 3 mittelmäßig, 4 eher gut und 5 sehr gut bedeutet. • Was wäre für dich eine 5? Was eine 1? • Worauf stützt du deine Bewertung? • Fällt dir darüber hinaus noch etwas auf? 5. **Verabschiedung:** „Vielen Dank für deine Teilnahme. Die Daten werden ausgewertet und in anonymisierter Form aufbereitet.“ 6. **Im Nachgang: Soziodemografischer Fragebogen (online)**	

Appendix C: German translation of PCSs

Table 14.2. Overview of the perceptual-cognitive skill labels and their behavioral descriptions in German

Domäne	Konstrukt	Beschreibung
VP	Raumwahrnehmung	Der Spieler zeigt sich in freien Räumen (d.h. mit angemessenem Abstand zum Gegenspieler und spielt Bälle in den freien Raum (z.B. in die Bewegung des Mitspielers).
VP	Daueraufmerksamkeit	Der Spieler bleibt über verschiedene Spielaktionen aufmerksam und bleibt in Spielaktionen "drin".
VP	Aktivität	Der Spieler ist ständig in Bewegung (z.B. durch ein Freilaufverhalten und das Schaffen von Angeboten).
VP	Antizipation	Der Spieler ist in der Lage mehrere situative Stationen vorauszudenken. Er initiiert eine Handlung bereits bevor der Ausgang der vorangegangenen Situation klar ist, in dem er entscheidende Informationen des Mit- oder Gegenspieler wahrnimmt.
VP	Spekulation	Der Spieler lauert und handelt, bevor er sich alle Informationen für den Ausgang der Situation eingeholt hat. Sein Handeln ist geprägt von Risikofreudigkeit.
VP	Vorbereitet sein	Der Spieler bereitet seine Handlungen gut vor (z.B. durch einen zielgerichteten ersten Kontakt, das Durchlaufen lassen des Balles oder das Absetzen vom Gegenspieler).
VP	Schätzungen	Der Spieler schätzt Distanzen, Zeiten und Geschwindigkeiten des Balles sowie von Mit- und Gegenspielern richtig ein.
VP	Arbeitsgedächtnis	Der Spieler greift auf abgespeichertes Wissen zurück, das er kurz zuvor wahrgenommen hat und nutzt es für seine nächste Aktion (z.B. Pässe mit dem ersten Kontakt oder No-Look-Pässe).
VP	Mustererkennung	Der Spieler erkennt wiederkehrende Spielsituationen schnell und wendet bekannte Lösungen an (z.B. Gegenspieler schießt immer mit links, Abwehrspieler lenkt ihn daher auf den rechten Fuß).
VP	Optionsgenerierung	Der Spieler bringt sich in Spielpositionen, in denen er mehrere vorteilhafte Handlungsoptionen hat.
VP	Entscheidungen treffen	Der Spieler trifft für die Spielsituation richtige Entscheidungen.
VP	Positionierung	Der Spieler passt seine Positionierung vorteilhaft an. Er wählt Abstände zu Mit- und Gegenspielern sinnvoll, so dass er immerzu einen positiven Einfluss auf das Spiel nimmt.
VP	Timing	Der Spieler dosiert die Passschärfe oder sein eigenes Tempo so, dass Ball bzw. er zum richtigen Zeitpunkt beim Zielort ankommen.

VP	Fantasie	Der Spieler erweckt den Eindruck, dass sein Handeln eine Idee verfolgt.
IA	Blickführung	Der Spieler steuert seinen Blick in Richtung relevanter Informationen (z.B. Ball, Gegenspieler).
IA	Periphere Wahrnehmung	Der Spieler nimmt Informationen in seinem peripheren Blickfeld (d.h. im Augenwinkel) wahr, ohne direkt hinzusehen.
IA	Multimodale Wahrnehmung	Der Spieler bezieht in seine Wahrnehmung verschiedene Sinne ein (z.B. Sehen, Hören, Körperkontakt).
IA	Vororientierung	Der Spieler scannt sein Umfeld (bestmöglich 360°) regelmäßig. Dieses Verhalten nimmt kurz vor seiner Aktion zu (z.B. durch Schulterblicke).
IA	Selektive Aufmerksamkeit	Der Spieler fokussiert seine Aufmerksamkeit und konzentriert sich nur auf einen Reiz (z.B. bei einem Standard nur auf einen bestimmten Gegenspieler).
HA	Reaktionsfähigkeit	Der Spieler reagiert auf situative Faktoren (z.B. Verhalten von Mit- oder Gegenspielern, Kommandos, Situationswechsel) in höchstem Tempo.
HA	Handlungsschnelligkeit	Der Spieler führt seine Aktionen im höchsten Tempo aus (z.B. bei Ballan- und mitnahme + Pass).
HA	Deklaratives Wissen	Der Spieler agiert taktisch. Erkennbar ist es beispielsweise an einstudierten Handlungsabläufen oder taktischem Positionsspiel.
HA	Prozedurales Wisses	Der Spieler zeigt der Situation angemessene Bewegungsmuster. Er weiß, *wie* er sich bewegen muss.
HA	Zielgerichtets Handeln	Der Spieler agiert zielgerichtet und weicht von seiner Handlung im zeitlichen Verlauf der Aktion nicht ab. Es wirkt als führe er einen Handlungsplan aus.
HA	Fintieren	Der Spieler setzt Finten und Täuschungen gezielt ein, sie wirken automatisiert.
HA	Interpersonale Abstimmung	Der Spieler passt seine Handlungen seinen Mit- und Gegenspielern an. Durch sein Handeln bezieht er diese mit ein (z.B. durch Initiierung einer gemeinsamen Handlung wie einen Doppelpass; Innenbahn schließen und Spieler nach außen drängen).
HA	Perspektivübernahme	Der Spieler versetzt sich in seine Mit- oder Gegenspieler hinein in dem er sich Information für eine eigene Verhaltensanpassung zu nutzen macht (z.B. anhand der Körperhaltung nächste Aktion vorausschauen).
HA	Problemlösen	Der Spieler findet für Probleme auf dem Feld schnell eine Lösung (z.B. befreit sich aus Gegner- oder Raumdruck).

HA	Kreativität	Der Spieler zeigt für die Situation überraschende, teilweise risikoreiche Lösungen.
HA	Intuition	Der Spieler handelt spontan und automatisch, ohne Sicherheitsblicke zur Kontrolle seiner Handlungen.
HA	Motorische Kontrolle	Der Spieler ist in der Lage seine Motorik zu kontrollieren und seine Fähigkeiten situationsangemessen einzusetzen.
HAP	Umschalten	Der Spieler schaltet zwischen zwei Spielsituationen schnell um (z.B. von Offensive zu Defensive; nach Fehlern).
HAP	Kognitive Flexibilität	Der Spieler reagiert flexibel auf situative Faktoren (z.B. nach Positionswechsel, Spielerwechsel).
HAP	Inhibition	Der Spieler bricht, wenn notwendig, eine einmal gestartete Handlung ab (z.B. Pass, Torschuss, Laufweg).
HAP	Korrekturverhalten	Der Spieler handelt spontan und automatisch, ohne Sicherheitsblicke zur Kontrolle seiner Handlungen.

Appendix D: German versions of the evaluation form

Perzeptuell-kognitive Fertigkeiten **POTENTIAL**

Name (Nr.): **Gegner:** **Datum:** **Beurteilt von:**

Bitte gib die Qualität der Leistung in Bezug auf die folgenden Fertigkeiten an (von 1 = niedrige Qualität bis 5 = hohe Qualität; N = unsicher/keine Angabe). Bitte bewerten Sie die Qualität unter Berücksichtigung der positionsspezifischen Anforderungen und der Altersgruppe.

Qualität

	Niedrig				Hoch	N
Informationssuche						
Der Spieler nimmt Informationen in seinem peripheren Blickfeld wahr (z.B. Mit - oder Gegenspieler).	1	2	3	4	5	N
Der Spieler orientiert sich auf dem Feld (z.B. durch scanning oder Schulterblick).	1	2	3	4	5	N
Der Spieler ist darauf fokussiert, gezielt nach wichtigen Informationen auf dem Spielfeld zu suchen (z. B. freie Räume).	1	2	3	4	5	N
Verarbeitung und Planung						
Der Spieler erkennt freie Räume (z. B. spielt den Ball in einen freien Raum oder positioniert sich selbst in freien Räumen).	1	2	3	4	5	N
Der Spieler erkennt wiederkehrenden Spielsituationen oder Handlungsmuster.	1	2	3	4	5	N
Der Spieler greift auf abgespeichertes Wissen zurück, das er kurz zuvor wahrgenommen hat.	1	2	3	4	5	N
Ein Spieler antizipiert oder spekuliert auf eine Situation und denkt mehrere Stationen voraus.	1	2	3	4	5	N
Der Spieler ist aktiv und bleibt über verschiedene Aktionen aufmerksam. Er bleibt in der Aktion oder Situation „drin“.	1	2	3	4	5	N
Der Spieler positioniert sich vorteilhaft.	1	2	3	4	5	N
Der Spieler timt sein Handeln so, dass Ball bzw. er zum richtigen Zeitpunkt beim Zielort ankommen.	1	2	3	4	5	N
Der Spieler bereitet seine eigene Handlung vor, beispielsweise durch eine bestimmte Positionierung oder ein Freilaufen.	1	2	3	4	5	N
Der Spieler trifft vorteilhafte Entscheidungen in Bezug auf die Spielsituation.	1	2	3	4	5	N

Sinikka Heisler, Deustche Sporthochschule Köln

Figure 14.1. *Long evaluation form including 23 perceptual-cognitive skills in four domains (German version)*

Perzeptuell-kognitive Fertigkeiten POTENTIAL

Name (Nr.): **Gegner:** **Datum:** **Beurteilt von:**

Bitte gib die Qualität der Leistung in Bezug auf die folgenden Fertigkeiten an (von 1 = niedrige Qualität bis 5 = hohe Qualität; N = unsicher/keine Angabe). Bitte bewerten Sie die Qualität unter Berücksichtigung der positionsspezifischen Anforderungen und der Altersgruppe.

Qualität

	Niedrig				Hoch	N
Handlungsauführung						
Der Spieler beteiligt sich an gemeinsamen Aktionen mit Mitspielern oder Gegenspielern. Durch sein Handeln bezieht er sie mit ein (z. B. durch das Einleiten einer gemeinsamen Aktion wie einem Doppelpass oder das Schließen des Zentrums, um den Gegner nach außen zu lenken).	1	2	3	4	5	N
Der Spieler reagiert schnell auf situative Faktoren (z.B. Verhalten von Mit- oder Gegenspielern, Kommandos, Situationswechsel).	1	2	3	4	5	N
Der Spieler führt eine Folge von Aktionen im höchsten Tempo aus (z.B. bei Ballan- und mitnahme + Pass).	1	2	3	4	5	N
Der Spieler setzt Finten und Täuschungen gezielt ein.	1	2	3	4	5	N
Der Spieler agiert taktisch. Erkennbar ist es beispielsweise an einstudierten Handlungsabläufen oder taktischem Positionsspiel.	1	2	3	4	5	N
Der Spieler zeigt für die Situation kreatives und überraschendes Verhalten.	1	2	3	4	5	N
Der Spieler handelt intuitiv, das heißt spontan und automatisch.	1	2	3	4	5	N
Der Spieler findet für Probleme auf dem Feld eine Lösung (z.B. befreit sich aus Gegner- oder Raumdruck).	1	2	3	4	5	N
Handlungsanpassung						
Der Spieler schaltet zwischen zwei Spielsituationen um (z.B. von Offensive zu Defensive; Nach Fehler)	1	2	3	4	5	N
Der Spieler bricht, wenn notwendig, eine einmal gestartete Handlung ab (z.B. Pass, Torschuss, Laufweg).	1	2	3	4	5	N
Der Spieler korrigiert, wenn nötig, seine Handlungen (z.B. durch Tempoveränderung oder angepasste Positionierung).	1	2	3	4	5	N

Zusätzliche Notizen:

Sinikka Heisler, Deustche Sporthochschule Köln

Perzeptuell-kognitive Fertigkeiten POTENTIAL

Name (Nr.): **Gegner:** **Datum:** **Beurteilt von:**

Bitte gib die Qualität der Leistung in Bezug auf die folgenden Fertigkeiten an (von 1 = niedrige Qualität bis 5 = hohe Qualität; N = unsicher/keine Angabe). Bitte bewerten Sie die Qualität unter Berücksichtigung der positionsspezifischen Anforderungen und der Altersgruppe.

	Qualität					
	low				high	N
Der Spieler orientiert sich auf dem Feld (z.B. durch scanning oder Schulterblick).	1	2	3	4	5	N
Der Spieler erkennt freie Räume (z. B. spielt den Ball in einen freien Raum oder positioniert sich selbst in freien Räumen).	1	2	3	4	5	N
Der Spieler timt sein Handeln so, dass Ball bzw. er zum richtigen Zeitpunkt beim Zielort ankommen.	1	2	3	4	5	N
Der Spieler bereitet seine eigene Handlung vor, beispielsweise durch eine bestimmte Positionierung oder ein Freilaufen.	1	2	3	4	5	N
Der Spieler trifft vorteilhafte Entscheidungen in Bezug auf die Spielsituation.	1	2	3	4	5	N
Der Spieler führt eine Folge von Aktionen im höchsten Tempo aus (z.B. bei Ballan- und mitnahme + Pass). when receiving and passing the ball).	1	2	3	4	5	N
Der Spieler findet für Probleme auf dem Feld eine Lösung (z.B. befreit sich aus Gegner- oder Raumdruck).	1	2	3	4	5	N
Der Spieler schaltet zwischen zwei Spielsituationen um (z.B. von Offensive zu Defensive; Nach Fehler)	1	2	3	4	5	N
Zusätzliche Notizen:						

Hinweis: Farben beziehen sich auf die Kategorie (**blaue** = Informationssuche, **gründ** = Verarbeitung und Planung, **braun** = Handlungsausführung, **orange** = Handlungsanpassung)

Sinikka Heisler, German Sport University Cologne

Figure 14.2. *Short evaluation form including 8 perceptual-cognitive skills (German version)*

Appendix E: Ethics approval

Deutsche
Sporthochschule Köln
German Sport University Cologne

Institut für Pädagogik und Philosophie
Institute of Pedagogy and Philosophy

Prof. Dr. Dr. h.c. Eckhard Meinberg
Vorsitzender der Ethikkommission

Am Sportpark Müngersdorf 6
50933 Köln · Deutschland
Telefon +49(0)221 4982-4520
meinberg@dshs-koeln.de
www.dshs-koeln.de

Deutsche Sporthochschule Köln · 50927 Köln

Psychologisches Institut
Abt. Leistungspsychologie

Frau Sinikka Heisler

Köln, den 04.05.2021

Ethikantrag Nr. 072/2021

POTNTIAL – Perzeptuell-Kognitive Talentkriterien im Fußball; Entwicklung und Erprobung eines Leistungsmodells zur Talentidentifikation in Nachwuchsleistungszentren

Sehr geehrte Frau Heisler,

hiermit darf ich Ihnen mitteilen, dass die Ethikkommission gegenüber Ihrem geplanten Forschungsvorhaben keinerlei Bedenken erhebt.

Hinweis: Die Ethikkommission beurteilt nicht die Einhaltung gängiger Datenschutz-Vorschriften!

Ich wünsche Ihnen für die Durchführung viel Erfolg!

Mit besten Grüßen

E. L

Prof. Dr. Dr. h.c. E. Meinberg