The Perception of Affordances in Soccer

A Dissertation

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George S. Bailey

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Abstract

Affordances are opportunities for action that emerge from relations between properties of an animal (human or non-human) and properties of its environment (Gibson, 1979/1986; Stoffregen, 2003). An individual's ability detect affordances can change when a person acquires a high degree of skill in a particular sport (Higuchi et al., 2011; Seifert et al., 2018). In this dissertation, I extend research into affordances in sport, asking what soccer-specific affordances exist, and how they are detected and perceived. Chapter 1 serves as an introduction to the concept of affordances, explores context-specific affordances, and introduces higher- and lower-order affordances. In Chapter 2, I explore whether the type of kick (for power vs. for precision) affects youth soccer players' perception of affordances. Furthermore, the effect of experience on the ability to perceive kicking-related affordances is explored. Some previous research has examined task-specific affordances within a sport, and other research has examined the difference in sport-specific affordance perception between skilled athletes and persons without athletic experience. This chapter adds the novel element of soccer-task-specific affordances, as well as covarying manipulations of long- and short-term experience. Chapter 3 extends the research into affordance perception in soccer, investigating the perception of higher-order interpersonal affordances for kicking that emerge in soccer. This chapter explores how these higher-order interpersonal affordances differ from their constituent lower-order affordances on both a personal level (the distance of the kick) and at the interpersonal level (whether the ball would be kicked through a gap defined by teammates or opponents). Chapter 4 directly expands on Chapter 3, investigating the influence of additional interpersonal affordances revealing game-specific context clues.

In this Chapter, participants once again experienced the personal affordance of kick distance, as well as the interpersonal affordance of player role (team), though a third factor of whether they were facing away from each other (and, thus, facing away from the future path of the to-be-kicked ball), or facing toward each other (and, thus, facing toward the future path of to-be-kicked ball). Chapter 5 serves as a general discussion of the results of this research, as well as offering suggestions for future research into soccer- and sport-specific affordance research.

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Chapter 1: Introduction

Motivation

Affordances are opportunities for action which are available to a given animal in a given environment (Gibson, 1979/2014; Heras-Escribano, 2019; Stoffregen, 2003). A large empirical literature demonstrates that animals can perceive and act with respect to affordances; that is, animals make very precise choices about whether, when, and how to perform behaviors based on what actions are and are not available to them in particular situations. In the majority of this work, researchers have investigated the perception of affordances for behaviors, such as ascending stairs (Warren, 1984), reaching for an object (e.g., Mantel, Stoffregen, Campbell, & Bardy, 2015; Yonas & Hartman, 1993), crossing the street in traffic (Lee, Young, & McLaughlin, 1984), catching a fly ball (Fink et al., 2009), or scoring a free kick in soccer (Paterson et al., 2016). Affordances are sometimes contrasted with abilities (e.g., Tucker et al., 2016). Whether affordances are abilities would appear to depend upon the definition of *ability*. If ability is a context-independent thing (e.g., because an animal has lungs, it has the ability to breathe), then abilities differ from affordances. However, if ability is context-dependent (e.g., an animal's lungs give it the ability to breathe when it is surrounded by an atmosphere), then abilities and affordances are complementary and imply one another. A study of one (in a context that includes both) is necessarily a study of the other.

It has been suggested that internal, mental processes produce the awareness of these affordances. One such suggestion is that affordance perception occurs by combining an individual's knowledge of environmental properties, with wholly separate

knowledge about their own properties in order to yield awareness of the animal-environment relationships that are affordances (Norman, 1988). However, an alternative view of affordance perception – direct perception – claims that the animal-environment relations constituting affordances structure energy arrays in a manner that this structure is specific to these relations (e.g. Mantel et al., 2015; Turvey, 2019). This perspective suggests that animals perceive affordances via the detection of information pertaining to a particular animal-environment fit, with no need for additive perceptions of lower-order elements of that affordance (properties of the animal and/or the environment that do not relate to the specific affordance in question). That is to say, perceivers should have direct perceptual sensitivity to affordances as these emerging, higher-order relationships in an animal-environment system (Stoffregen, 2003). In this dissertation I utilize this direct perception perspective throughout.

In recent years, the concept of affordances has begun to gain currency in the domain of sports (e.g., Fajen, Riley, & Turvey, 2009). Several studies have investigated the perception of affordances in sport-specific contexts, such as ice hockey (e.g., Hove et al., 2006), and rugby (e.g., Correia et al., 2012). Only one study has addressed the perception of affordances in soccer. Paterson, van der Kamp, Bressan, and Savelsbergh (2016) examined relations between kicking performance, distance perception, and the perception of affordances for kicking in soccer. The study included perceptual reports of participants' ability to execute a free kick on the goal from a variety of distances. The results revealed that perception of the perception of affordances for kicking was more strongly related to actual kicking performance than was perception of linear distance.

Relative to my dissertation project, the study of Paterson et al., established that the perception of affordances could be investigated in the context of soccer, but gave only limited insight into the factors that influence affordance perception in soccer. I extended research on the perception of affordances in soccer to areas not addressed by Paterson et al.

The Effect of Experience on Affordances and affordance perception

Affordances in animals, human and non-human alike, can be influenced by long- and short-term changes in experience, or skill, occurring over weeks, months, or years. One of the clearest examples of this is the plethora of affordances that spring into existence when an infant first learns how to walk (Karasik et al., 2011). Novel affordances also emerge when a person acquires a higher degree of skill in a particular sport. For example, Peker and colleagues (2020) asked whether gymnastics experience might be associated with changes in the perception of gymnastics-related affordances. They compared sport- and non-sport-specific affordance judgements and performance in 8-year-olds with extensive gymnastics experience, and those without. Children judged affordances for a standing long jump (a behavior typically seen in gymnastics routine) and a vertical jump-and-reach (a behavior typical in other sports, but not common in gymnastics). Gymnasts performed better on both jumping tasks, though their judgments were only more accurate than non-gymnasts for the horizontal long jumping task. This suggests that experience can lead to improved sensitivity for sport-specific affordances.

While longer-term changes in affordances (and the perception of such affordances) can occur due to long-term changes in the animal, affordances (and affordance perception) can also change over smaller timescales. That is, rather than

months of practice, or years of experience, affordances can change over much shorter time scales, usually due to a short-term change in the animal itself. Research suggests that people can perceive short-term changes in affordances. An example of this is the ability to fine tune our perceptual sensitivity for judging affordances for sitting and climbing before, and after wearing 10cm blocks on their feet (Mark, 1987). The changes to the animal do not have to be due to long-term physiological changes, or short-term wearables to alter affordance perception. Fatigue is also a valid short-term change in the animal that can affect affordance perception. For example, a fly ball that was catchable in the first inning of a baseball game may not be catchable in the ninth inning due to fatigue preventing the player from moving in the correct manner (Fajen, Riley, & Turvey, 2009).

In Chapter 2, I directly address the effects of long- and short-term experience on affordance perception by examining the effect of experience mediated by age group (U16 and U18) and the effect of fatigue (before vs. after a match). While age group is not the perfect measure of long-term experience, soccer players in countries with high soccer participation rates anecdotally see a funneling effect as the age of participation rises. That is, it is unlikely that a novice will be playing on a competitive, near-adult U18 team. The effects of fatigue have been shown to reduce performance in sport, though limited literature discusses the effects of fatigue on *perception*. Contemporary research has attempted to illustrate the link between fatigue and affordance perception, yet has only observed quantitative differences in perception related to actual performance as opposed to fatigue itself (Piipers et al., 2007). Furthermore, the conditions of kicking for power versus kicking for precision add another layer to this variation. Precision kicking, that is

placing a ball with finesse to a specific player (or in this case, location) requires less physical effort than a power kick, such as the kick performed when trying to make a "clearance" (distancing the ball from opposing players around one's goal area). As such, Chapter 2 makes a novel contribution to the body of literature on affordance perception and performance, examining even the qualitative differences brought around by soccer match play.

Affordances: Lower- and Higher-Order

Everyday life is characterized by the presence of multiple affordances. In any given situation, numerous relationships between properties of the animal and properties of the environment yield numerous available behaviors. At any given time, many behaviors are always available to any given animal. The existence of multiple, simultaneous available behaviors raises questions as to how these available actions relate to one another.

Affordances may exist as unique, independent relations within the animal-environment system. For example, the affordance for jumping (i.e. lifting the body completely off the surface of support by generating force through extension of the legs) may exist independently from, but simultaneously with, an affordance for vertical reaching (i.e. raising the arm and hand above the head to touch or grasp an object). That is, the actor may independently perceive "I can jump" and "I can reach". However, it may be the case that such affordances do not exist independently, instead existing in relation to one another in a manner that has real, concrete consequences for action. That is, the *relation between two or more affordances* may lead to its own, separate affordance (Wagman, Cialdella, & Stoffregen, 2019). This affordance, constituted of two or more

affordances, would be of a higher order than the lower order affordances. Using the examples of jumping and reaching, a higher-order behavior that may be available is *reaching while jumping*. That is, simultaneously extending the legs so as to raise the body above the surface of support, while at the same time reaching vertically by raising the hand and arm above the head. This higher-order behavior of "reaching-while-jumping" affords novel behavior – making contact with, or grasping, objects that cannot be reached by jumping or vertical reaching alone. Prior literature has illustrated individuals' ability to perceive and exploit the higher-order affordance of reaching-while-jumping (Thomas, Hawkins, & Nalepka, 2018; Ramenzoni, Davis, Riley, & Shockley, 2010).

The perception of higher-order affordances, such as the aforementioned reaching-while-jumping may occur in numerous ways. Operating under the assumption that perceivers have direct perceptual sensitivity to affordances, it may be the case that lower-order affordances are directly perceived as individual, separate, affordances, with the awareness of higher-order affordances emerging from an internal, additive, mental process combining the individual lower-order affordances. To hark back to the example of reaching-while-jumping, this additive perception may appear as *affordances for reaching-while-jumping = f*(affordances for jumping, affordances for reaching). An alternative explanation for the perception of higher-order affordances is that they exist as real ontological entities awaiting to be perceived directly. That is, the affordance for reaching-while-jumping may exist in a manner that it could be specified in lawfully structured energy arrays, allowing direct perception. I endorse and adopt this latter view, consistent with the principles of direct perception.

Contemporary literature supports the claim that higher-order affordances are directly perceived as such, rather than being combined or computed from the perception of lower-order affordances. For example, Wagman & Stoffregen (2020) asked standing participants to give perceptual reports pertaining to their ability to reach an overhead object in two conditions – reaching with their arm alone, or reaching with a handheld tool. Perceptual reports about the participants arm length, shoulder height, and tool length were also given. Consistent with their predictions, it was shown that 1) the perceived maximum reaching height with the arm differed from the additive combination of perceived shoulder height and perceived arm length, 2) perceived maximum reaching height with the tool differed from the additive combination of perceived shoulder height and perceived arm-plus-tool height, and 3) perceived maximum reaching height with the tool differed from the additive combination of perceived maximum reaching height with the arm and perceived tool length. These findings suggest that the affordance for reaching with a handheld tool was perceived, directly, as such. That is, the affordance was perceived directly as a higher-order affordance, rather than an additive combination of the constituent lower-order affordances.

Higher-Order Affordances Emerging from Interpersonal Factors

While affordances often emerge from animal-environment relationships, affordances can also emerge from relationships between people. In other words, the animal-animal-environment relationship. These interpersonal affordances can be understood as higher-order affordances that depend upon (lower-order) affordances. Lower-order affordances that constitute higher-order affordances are available to individuals in the absence of a social context. However, when embedded in a social

context, these lower-order affordances differ from themselves as context-devoid affordances (Kimmel & Rogler, 2018).

Higher-order affordances are ever-present in team sports. One example of this would be throwing a ball to a teammate in baseball. Throwing to a teammate requires affordances to be present for both individuals; for the thrower, the affordance to throw the ball; for the receiver of the catch, the affordance to maneuver and catch the ball before it passes them or drops on the ground. However, these are not the only affordances necessary to complete the interpersonal throw-and-catch. This requires an affordance that cannot exist for any individual player – the interpersonal affordance for trading possession of the ball between players. In the introduction of Chapter 3, I discuss research exploring higher-order interpersonal affordances in sports in the context of rugby. However, as noted, these studies fail to co-variate the lower-order individual affordances constituent parts with the higher-order interpersonal affordances.

Competitive games, or matches in soccer, in team sports add another level to the interpersonal affordances observed during practice sessions. That is, during match play, soccer players interact both with their teammates, as well as members of the opposing team. Interacting with opponents differs distinctly from interacting with teammates in soccer as it does with any sport. If your team has the ball, the opposing team will be attempting to win back possession to prevent progress being made down field, and to stop any potential scoring opportunities; If the opposing team has the ball, the inverse is true. As such, one's ability to perceive affordances in team sports and to perform relevant behaviors requires an acute sensitivity to the simultaneous personal and interpersonal

constraints. In soccer, these constraints manifest on a personal level such as the individual's strength, stamina, kicking ability, and ball control; as well as on the interpersonal level, such as the positioning of teammates, their abilities, and the positioning and abilities of the opponents. Chapters 3-4 explore how these varying constraints contribute to the emergence of higher-order affordances in soccer, and how these affordances are perceived. Furthermore, I explore how varying the constraints, namely the roles of teammates and opponents, as well as the facing direction of said teammates or opponents further influences the emergence, detection, and perception of affordances in soccer.

A Collaborative Research Project

I began my journey at the University of Minnesota with the goal of studying perception-action in sports, spending my first semester tirelessly contacting football, rugby, and soccer teams in the local area, as well as boxing and mixed martial arts gyms for potential research opportunities and collaborations. After this unsuccessful attempt at forming collaborative research relationships in varying sport domains, the COVID-19 pandemic brought sporting and in-person research activity to a halt in the majority of the US, and pertinently the State of Minnesota. During this time, Dr. Alper Peker, a visiting scholar from Turkey, was working alongside Dr. Stoffregen in the Affordance Perception-Action Lab where I was pursuing my graduate studies, building his own research skills and understanding of perception-action as a theory. While discussing my desire to study perception-action in sport, it became known that Dr. Peker was a former professional soccer player in his home country of Turkey, and still had contacts in the

Turkish soccer system. After a brief period, the opportunity to collaborate with Dr. Veysel Böge, a youth soccer coach in Konya, Turkey, arose. Dr. Stoffregen and I collaborated with Dr. Jeffrey Wagman at Illinois State University to design a series of experiments examining the perception of affordances in youth soccer players. After designing the experiments, Dr. Peker served as the interlocuter between the US academics and Dr. Böge, conferring the experimental design and research plan. Data was collected by Dr. Böge in Konya, who subsequently sent Excel files of the data back. I analyzed all data for all three experiments, and solely contributed the methods and results sections of each of the following three chapters of this dissertation. As the sole expert on both perception-action and the sport of soccer, Dr. Peker and I collaborated on the sport-specific elements of each of the introduction and discussion sections of Chapters 2-4, while Dr. Stoffregen, Dr. Wagman, and I collaborated on the perception-action elements of each of the introduction and discussion sections. I was responsible for many of the suggested reviewer edits and all document formatting prior to publication. The research featured in this dissertation was also converted into my first conference presentation as first author at ISEPNA 2022 in Hattiesburg, MS.

Purpose of the Study

My purpose in this dissertation project was to further an understanding of the perception of affordances in sports, specifically soccer.

As discussed above and throughout this dissertation, a wide body of literature exists on the perception of affordance in sports, though limited research exists on soccer-specific affordance perception. Furthering the understanding of sport-specific affordances while also exploring and contributing to the growing body of literature on the perception

of higher-order affordances benefits athletes, coaches, and the greater scientific community alike. The research presented in Chapter 2 serves as a starting point for studying affordance perception in soccer. With limited soccer-specific research in existence at the time of writing this dissertation (see Paterson et al., 2016), it makes sense to begin with a baseline of how perception occurs specific to soccer. In addition to this, several training techniques and in-match situations in soccer rely on individual affordances and perceptual abilities, seemingly separate from the dynamic conditions of teammates, opponents, and field positioning of some in-match situations. However, as a dynamic game, soccer is an excellent candidate for the study of higher-order affordances. As such, following the completion of the first experiment (discussed in Chapter 2), armed with an understanding of affordance perception in soccer, I chose to advance the study of higher-order affordances utilizing soccer.

I first explored the perception of affordances in soccer for power kicking tasks, such as making a clearance downfield to prevent a goal scoring opportunity, versus precision kicking tasks, such as making a pass directly to a teammate. As seen in other research, sport-specific actions can also further be classified into various task-specific actions within the sport. Prior research has shown that athletes are capable of making sport-specific selections that benefit either power tasks or precision tasks in the context of ice hockey, with differences emerging depending on the athletes level of experience (Hove et al., 2006). As such, this study aimed to extend this body of research by comparing the perception of such affordances in relation to age-related differences in

soccer experience. That is, the effect of long-term experience on the perception and action of youth soccer players.

Furthermore, I examined the effect of short-term experience on youth soccer players' perceptual abilities by comparing perceptual judgments of kicking ability with actual kicking ability both before and after the participants played a regulation length soccer match. While prior literature has examined the effect of such short-term experience on perception and performance in sport, the co-variation of long-term experience (years of soccer experience) with short-term experience (before vs. after a soccer match) is a novel development. These manipulations allow the question of whether effects of short-term experience are modulated by variations in long-term experience.

This project later developed to examine the perception of higher-order affordances in soccer. Following a similar design of co-varying constraints at both the individual and interpersonal level, this study sought to provide evidence that higher-order interpersonal affordances emerge from such constraints in soccer, and are perceived as such. In this series of experiments, the target distance of the kick (personal level), and whether the ball would be kicked through a gap defined by teammates or opponents (interpersonal level) served as the constraints varied rather than the effects of long- and short-term experience.

Goals and Hypothesis

In this series of experiments, the goals of this project were to 1) explore the effect of long-term athletic experience on the perception and actualization of sport-task-specific affordances, 2) explore the effect of short-term athletic experience on the perception and

actualization of sport-task-specific affordances in relation to long-term experience, 3) investigate the detection and perception of higher-order affordances in soccer, and 4) examine the role of sport-specific context on the perception of higher-order affordances in soccer.

As noted throughout, while similar variables have been manipulated in existing literature, I am unaware of either observational or experimental research examining the effects of the co-variation of long- and short-term experience on the perception and actualization of affordances in soccer. Similarly, the examination of the detection, perception, and impact on performance of higher-order affordances in soccer is a novel contribution to the body of literature.

I designed the experiments to address the following hypotheses:

- H1: Actual kicking performance would be better for more experienced players; specifically that power kicks would be to a greater distance, and that precision kicks would be more accurate.
- H2: Perceptual judgments would have greater accuracy for the more experienced players. That is, the judged kicking distance would more closely correspond to actual kicking distance for more experienced players than for less experienced players. Furthermore, more experienced players would show more refined perceptual sensitivity to any present effects of short-term experience on actual kicking ability.

- H3: In the higher-order affordance experiments, there would be a statistically significant interaction between the Kick Distance and Team factors that differs qualitatively from either of the lower-order affordances.
- H4: In the second higher-order affordance experiment, there would be a statistically significant three-way interaction between the Kick Distance, Team, and Facing Direction factors that again differ qualitatively from their constituent lower-order parts.

Overview of the Remainder of this Dissertation

The research featured in Chapter 2 of this dissertation was published separately to the research featured in Chapters 3-4. The same participants operating under the same soccer coach featured in both of these publications, and as such there may be similarities between the Chapters. Regardless, each Chapter presents its own novel findings into the perception of affordances in soccer.

In this dissertation, Chapter 2 corresponds to Peker, Böge, Bailey, Wagman, & Stoffregen (2020), and Chapters 3-4 correspond to Peker, Böge, Bailey, Wagman, & Stoffregen (2023). Chapter 5 serves as a general discussion.

Chapter 2: Perception of Affordances in Soccer: Kicking for Power Versus Kicking for Precision

Introduction

Affordances are opportunities for action which are available to a given animal in a given environment (Gibson, 1979/2014; Heras-Escribano, 2019; Stoffregen, 2003). Human sensitivity to these affordances is demonstrated through years of experimental research. Examples include perception of one's ability to climb a staircase (Warren, 1984), to sit on a chair (e.g., Mark, 1987), to cross the street in traffic (Grechkin et al., 2013), to catch a fly ball (Fink et al., 2009), or to score using a free kick in soccer (Paterson et al., 2016). Affordances arise from various properties of the animal (as well as properties of the environment), and as such these affordances often change with changes in the animal. These changes may be physical (e.g., changes in height, weight, or strength), or in the case of the present study, changes in the animal's experience or skill level.

Prior research has sometimes contrasted affordances with abilities (e.g., Tucker et al., 2016). The relationship between affordances and abilities depends upon the operative definition of ability.. If ability is a context-independent thing (e.g., because an animal has lungs, it has the ability to breathe), then abilities differ from affordances. However, if ability is context-dependent (e.g., an animal's lungs give it the ability to breathe when it is surrounded by an atmosphere), then abilities and affordances are complementary and imply one another. When placed in a context inclusive of both affordances and abilities, a study of one is a study of the other.

Long-term Effects on Perception and Performance

Changes in experience, or skill, can influence affordances over a course of weeks, months, or even years. One such example of this is an infant learning to walk, and the

affordances that come into existence with this developmental change (e.g. Karasik et al., 2011). Another example is seen in reaching behavior. Ishak et al. (2014) studied perceived and actual ability to reach through small openings in infants (16, 22, and 34 months of age), children (5- and 7-year olds), and adults. Across age groups, judgments (reaching decisions) were consistent across trials. In spite of these consistent judgments, only 7-year-old children were capable of showing levels of judgement accuracy consistent with the adult participants. This suggests that the perception of the ability to reach through small openings develops over time, requiring experience over time.

When a person acquires a high degree of skill in a particular sport, affordances, and the athlete's perceptual sensitivity to said affordances can become refined (e.g., Higuchi et al., 2011; Seifert et al., 2018). For example, Higuchi et al. (2011) asked participants to walk or run between obstacles both with and without wearing the type of shoulder pads used in American football. Both the magnitude and timing of shoulder rotation that participants used to avoid the obstacles were measured. These parameters differed between participants with experience playing American football and participants whose athletic experience was limited to other sports when running between the obstacles. It was found that players with experience in American football made more efficient shoulder rotations while running through the aperture than those without American football experience. However, when walking between the obstacles, the groups did not differ in shoulder rotations. Similarly, Peker et al. (2020) compared 8-year-old children with versus without extensive training in gymnastics. In this study, children made affordance judgments for a standing long jump, and a vertical jump-and-reach. The

standing long jump is (more) typical of gymnastics events such as the floor exercise, and vault; whereas a vertical jump-and-reach is not typical of gymnastics events despite its relevance in other sports (e.g. basketball). The gymnasts exhibited better jumping ability than non- athletes for both jumping tasks. Gymnasts were also more accurate than the non-athletes in their perception of their jumping ability, but only for the horizontal jumping task. Both groups made comparable perceptual judgments of their jumping ability in the vertical jumping task. Peker and colleagues concluded that several years of gymnastics experience yielded improvements in sensitivity to sport-relevant affordances. Finally, Weast et al. (2011) asked both basketball players and non-players to judge other people's ability to perform sports-relevant actions (maximum standing-reach and jumping-reach) and non- sports-relevant actions (maximum sitting height). Basketball players were more accurate at perceiving another person's maximum jumping reach height than the non-players. However, both groups performed similarly when perceiving maximum standing-reach and maximum sitting height. These studies all reveal that affordance perception for sport-specific affordances differs between those with extensive sports experience versus those without experience in the chosen sport, though these differences are typically not observed when perceiving affordances baring little relevance to the specific sport.

Short-term Effects on Perception and Performance

In the prior section, I described how long-term changes in the animal (such as changes in strength or skill acquired through prolonged practice over time) can lead to changing affordances for the animal. To address this issue, in the present study I compared both actual and perceived kicking ability in groups of participants who differed

in years of competitive soccer experience. However, Affordances also can change over shorter timescales—hours, minutes, or even seconds (e.g., Malek & Wagman, 2008; Mark, 1987). In order to address the changes in affordances over these shorter timescales, I asked whether actual and perceived affordances for kicking might differ when assessed immediately before and after participants played a regulation soccer match. The effects, or experience, of match play may have a plethora of effects on both perceptual sensitivity to affordances, and on actual ability. For example, playing a match could fatigue players, so that their actual kicking ability would be reduced after the match, relative to before the match. Pijpers et al. (2007), studied the perception of affordances for rock climbing as participants who had no prior rock-climbing experience repeatedly climbed the same wall to fatigue. Fatigue was assessed using rating scales, while separate measures were used to assess perceived and actual maximum reachable distances. As expected, fatigue reduced actual maximum reaching ability. However, the changes observed to perceived reaching ability were more strongly related to changes in actual reaching ability, and less strongly related to independent ratings of fatigue. Match play could have other, even qualitatively different effects on perceptual sensitivity. For example, some studies have shown that immediate practice with performance of an action can increase perceptual sensitivity to the relevant affordance (e.g., Franchak & Adolph; Hove et al., 2006).

Power versus Precision in Sport Performance

The actions seen in sports are not only sport-specific,but can also be specific to a certain task within that sport. One such distinction within a given sport may be actions emphasizing power rather than precision, or vice versa. Hove and colleagues (2006) evaluated the distinction between sports actions that prioritize power versus precision by

studying affordance perception in the context of ice hockey. Two groups of participants, experienced and novice ice hockey players, were asked to choose ice hockey sticks that would be optimal for slapshots (an action that prioritizes powerful stick handling movements) versus receiving a passed puck (an action that prioritizes precision stick handling movements). They compared judgments made across the groups, and found that the experienced and novice players made different judgments for the power task, but not for the precision task. In soccer, kicking ability is related to many factors, including strength and skill. As in ice hockey, different types of kicks in soccer serve different purposes. For example, some kicks are intended to move the ball far downfield, while others are intended to pass the ball to a nearby player or to a specific destination. The former might fall into a category of "power kicks," while the latter two might fall into a category of "precision kicks." Inspired, in part, by the study of Hove et al., in the present study I evaluated participants' judgments of their ability to execute different kinds of soccer kicks; a power-based kick that emphasized moving the ball downfield as far as possible, and a precision-based kick that emphasized moving the ball to a specific destination.

The Present Study

In the present study, I examined the perception of affordances for power versus precision kicking, in the context of soccer. I was also interested in how age-related differences in soccer experience affected the players' perception of affordances for kicking. In addition, I asked whether both perception and actual ability might vary as a function of short-term experience. To address this issue, I compared perceptual

judgments of kicking ability and actual kicking performance immediately before and immediately after participants played a regulation soccer match.

In one form or another, each of the individual manipulations in the present study has been addressed in previous research (Higuchi et al., 2011; Hove et al., 2006; Peker et al., 2020; Pijpers et al., 2007; Seifert et al., 2018; Weast et al., 2011). With respect to the literature that I have reviewed, one aspect of my design is novel, making it possible for us to examine questions that have not been addressed in previous research. I co-varied a manipulation of long-term experience (i.e., years of soccer experience), and a manipulation of short-term experience (i.e., assessments made before and after playing a soccer match). The co-variation of these manipulations made it possible to ask whether effects of short-term experience might be modulated by variations in long-term experience.

Prior studies have typically compared a group of skilled athletes versus those without athletic experience (whether in general, or in the specific-sport). In the present study, I compared groups of athletes who differed in their quantity of experience in a particular sport, soccer. I predicted that actual kicking performance would be better for more experienced players; specifically, that they would be able to kick the ball further than less experienced players in the power kicking task, and that their precision kick would come to rest closer to the target line than for less experienced players. In line with Hove et al. (2006), I predicted that judgments for the power task would differ between players as a function of experience level, with more experienced participants making more accurate judgments better reflecting their actual kicking distance than less

experienced participants. Finally, I predicted that any effects of short-term experience on actual kicking ability would be more readily perceived by more experienced players. I conducted separate analyses of raw judgments, expressed in meters, and of judgments expressed as a proportion of achieved performance.

Author Contributions

For the research presented in this chapter, G. S. B., T. A. S., and A. P. conceived the presented idea. G. S. B., T. A. S., and J. B. W developed the methodology of the study, as well as the data analysis techniques to be used. Data was collected by V. B. in Konya, Turkey, and all formal data analysis was conducted by G. S. B. The introduction and discussion sections of this Chapter were first drafted by T. A. S. and J. B. W., with G. S. B. providing feedback and edits with A. P.'s contributions to the soccer-specific elements of the research. The methods and results sections were drafted in full by G. S. B. The final edits to the published manuscript were made by G. S. B., T. A. S., and J. B. W., and all authors approved of the final manuscript.

Method

Participants

The participants were 22 male players from a boy's youth soccer league in Konya, Turkey. Depending upon age, players gave their own informed consent, or participated with their parents' approval. Eleven players were recruited from a U16 team (mean age = 15.45 years, SD = 0.52 years; mean height = 171.64 cm, SD = 3.83 cm; mean weight = 58.55 kg, SD = 6.95 kg). The remaining 11 players were recruited from a U18 team (mean age = 17.55 years, SD = 0.52 years; mean height = 175.18 cm, SD = 3.16 cm; mean weight = 66.36 kg, SD = 7.32 kg). The two teams were coached by the same

person. The coach recruited starting players from the two teams. As league members, all participants engaged in a minimum of 7.5 hours of soccer training per week and, during soccer season, played in league matches each weekend. All participants had begun league participation at age 8 and had been playing age- appropriate league matches since the age of 10. Accordingly, participants in the U16 group had 6 years of experience in league matches, while participants in the U18 group had 8 years of experience in league matches. Each participant reported no history of medical or orthopedic disorders of balance.

Materials and Procedure

The experiment was conducted on a soccer field, which was 65 m × 100 m. The study used a size 5 FIFA match- approved ball. For data collection, all participants stood side-by-side on a line on the field, facing away from the experimenter. Participants were called to participate individually, at which point they would turn to face the experimenter. This method ensured that players could not observe each other's participation.

There were two judgment tasks, which are illustrated in Figure 2-1. In the power task condition, participants were asked to judge the maximum distance they could kick the ball in a free kick from the starting line. This was the distance the ball would travel in the air and did not include rolling after hitting the ground. In the precision task, the experimenter indicated a target line that was 10 m from the starting line, and the participant was asked to judge how close to the target line they could kick the ball using a single kick from the starting line. In this case, the participant was asked to judge the final position of the ball; that is, after any rolling.

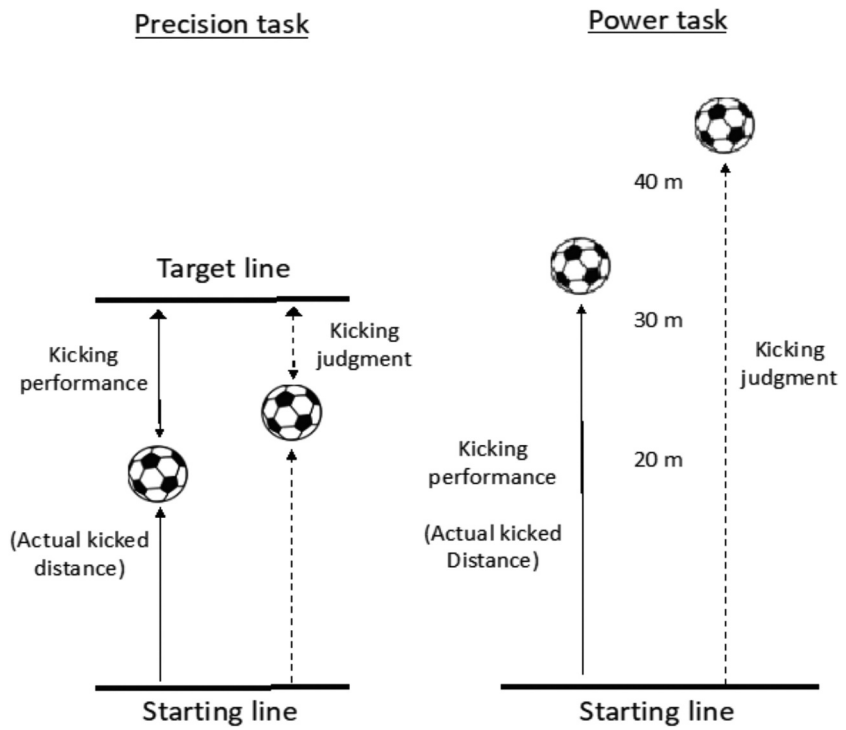

Figure 2-1: *The physical layout and measurement definitions for the judgment and performance tasks. The drawings are not to scale.*

Participants expressed their judgments using the method of adjustment (Walter et al., 2017). For each judgment, the experimenter stood directly in front of the participant, facing them, and placed the ball on the ground. The experimenter then gradually moved the ball away from the participant. When the participant judged the ball to be at their performance limit for that task, they asked the experimenter to stop. At this point, the participant turned their back, and the experimenter measured the judgment. Thus, participants received no feedback about the accuracy of their judgments. For the power task, the judgment was measured as the distance from the starting line to the ball. For the Precision task, the judgment was measured as the distance from the ball to the target line. Individual participants made judgments in succession; that is, all participants made their first judgment, after which all participants made their second judgments, and so on. For

each task, each participant gave six judgments, after which I evaluated actual kicking ability for that task. This process was repeated three times. As with the judgment task, participants performed kicking in succession; that is, all participants performed their first kick, after which all participants performed their second kicking, and so on.

For the power task, I measured kicking performance as the distance from the starting line to the point at which the ball hit the ground; that is, the point of initial impact, before any rolling. The field was marked at 20 m, 30 m, and 40 m from the starting line, with an experimenter standing at each mark. When the ball hit the ground, the nearest experimenter placed a marker at the point of impact. Actual kicked distance was measured as the distance from this marker to the starting line. For the precision task, kicking performance was measured as the shortest linear distance from the target line to the final position of the ball; that is after any rolling. Participants could see where the ball landed in each task, but did not receive any other feedback about their performance.

Data were collected before and after two matches between the U16 and U18 players, which were held 13 days apart. On each matchday, each participant from each team completed one of the judgment tasks and the associated performance task before playing in the match, which began immediately after the end of data collection. Immediately after completion of the match, post-match data collection began. On the first match day, U16 players performed the precision judgment and performance task before and after the match while U18 players performed the power judgment and performance tasks before and after the match. On the second day, U16 players performed power

judgment and performance tasks before and after the match while U18 players performed precision judgment and performance task before and after the match.

I separately analyzed the raw judgment data (that is, judgments expressed in metric units) and judgments expressed as a proportion of achieved performance. I analyzed performance data for the Power and Precision tasks separately, in each case using a 2 (Age: U16 vs. U18) × 2 (Time: Pre vs. Post) Analysis of Variance (ANOVA).

Results

To evaluate the likelihood of Type II errors, I conducted post hoc power analyses for all nonsignificant main effects and interactions on performance data, raw judgments, and proportions. Assuming a medium effect size, the G*Power program (Faul et al., 2007) estimated power to be between 0.78 and 0.95.

Performance Data

For the Power task, the main effect of age was significant, $F(1,20) = 14.98$, $p < .05$, partial $\eta 2 = 0.43$. Actual kicked distance was greater for the U18 group (mean = 34.27 m, SD = 5.23) than for the U16 group (mean = 27.36 m, SD = 3.84). There were no other significant effects.

For the Precision task, there were no significant effects.

Judgments

I analyzed judgment data for the Power and Precision tasks separately, in each case using a 2 (Age: U16 vs. U18) × 2 (Time: Pre vs. Post) ANOVA. For the Power task, the main effect of Time was not significant, but the main effect of Age was significant, $F(1, 20) = 26.01$, $p < .001$, partial $\eta 2 = 0.57$. In addition, the Age × Time interaction was significant, $F(1, 20) = 12.32$, $p < .05$, partial $\eta 2 = 0.38$ (Figure 2-2). The 95% confidence intervals revealed that judged kickable distance was shorter after playing than before

playing for the U16 group (Pre-match*M* = 35.12 m, 95% CI [31.95 m, 38.30 m], Post-match*M* = 30.82 m, 95% CI [29.06 m, 32.58 m]), but not for the U18 group (Pre-match*M* = 39.70 m, 95% CI [36.52 m, 42.88 m], Post-match*M* = 41.58 m, 95% CI [39.82 m, 43.34 m]).For the U18 group, the change in judgments before versus after the match was not significant. Consistent with the significant main effect of Age, pre-match judgments were greater for the U18 group (Mean = 39.70 m, 95% CI [36.52 m, 42.88 m]) than for the U16 group (Mean = 35.12 m, 95% CI [31.94 m, 38.30 m]). Similarly, post-match the judgments for the U18 group (Mean = 41.58 m, 95% CI [39.82 m, 43.34 m]) were greater than for the U16 group (Mean = 30.82 m, 95% CI [29.06 m, 32.58 m]).

For the Precision task, there were no significant effects.

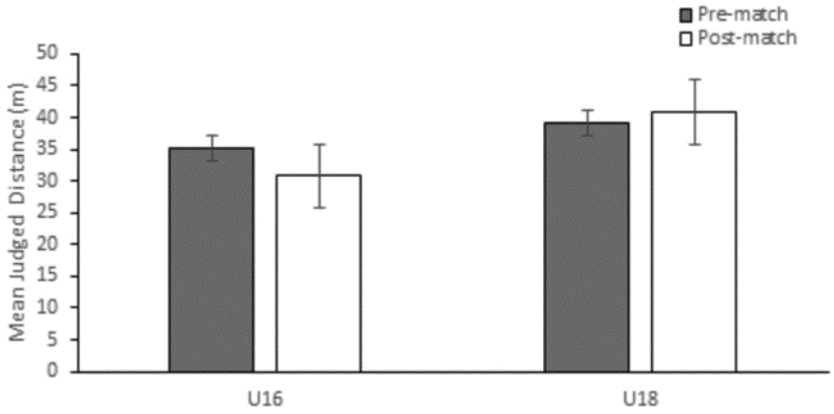

Figure 2-2: *Mean judged maximum kickable distance (Power Task), illustrating the statistically significant interaction between Age (U16, U18) and Time (Pre-match, Post-match), The error bars represent one standard error of the mean.*

Proportions

To assess the accuracy of perceived kicking distance, I divided mean perceived kicking distance by actual kicking distance for each participant for each task, creating proportions. For the Power task, the main effect of Age and the main effect of Time were not significant. However, the Age × Time interaction was significant, F (1, 20) = 7.83, p < .05, partial η2 = 0.28 (Figure 2-3). The 95% confidence intervals revealed that

perceived kickable distance better reflected actual kicking ability after the match than before the match for the U16 group (Before M = 1.309, 95% CI [1.168, 1.451], After M = 1.130, 95% CI [1.045, 1.215]) but not for the U18 group (Before M = 1.174, 95% CI [1.033, 1.316], After M =1.243, 95% CI [1.158, 1.328]). It has been shown that 95% confidence intervals can overlap while still producing statistically significant results (Austin & Hux, 2002). None of the other contrasts were significant.

For the Precision task, there were no significant effects.

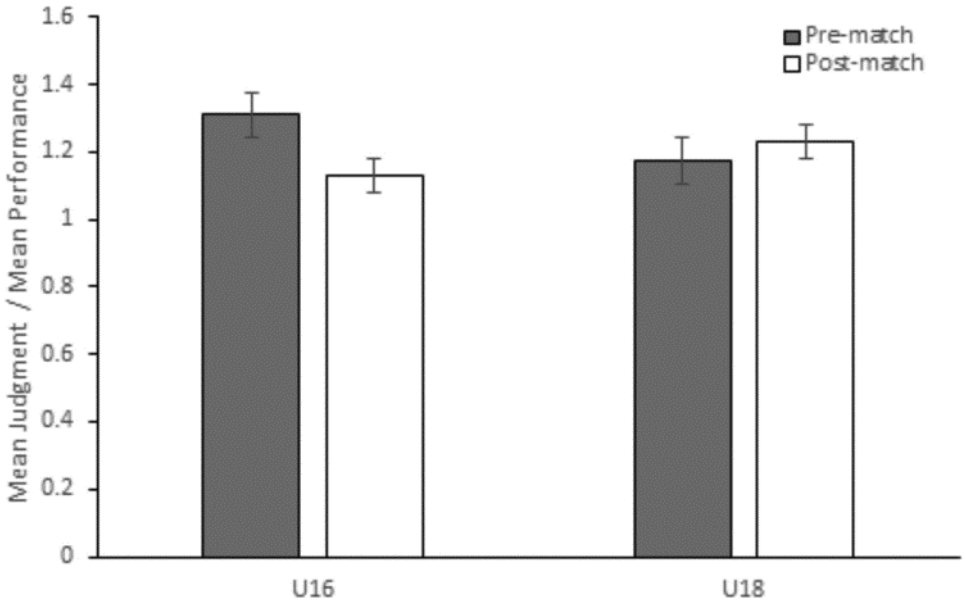

Figure 2-3: *Mean proportions (judgments / performance) for the Power task, illustrating the statistically significant interaction between age (U16, U18) and Time (Pre-match, Post-match). The error bars represent one standard error of the mean.*

Discussion

I evaluated the perception and actualization of affordances for two different kicking tasks (kicking for power vs. precision) among players in an organized youth soccer league. In the Precision task, I found no statistically significant effects on judgments of kicking ability or on performance. In the Power task older, more experienced players were able to kick the ball further than the younger, less experienced players, as was expected. An

interactive combination of age (U16 vs. U18) and the time of measurement (pre- vs. post-match) influenced the judgments of kicking ability in the Power task. These results are discussed below.

Kicking Performance

In the Power task, I found that older players could kick farther than younger players, confirming my prediction laid out in the introduction. However, my prediction concerning the effects of long-term experience on kicking ability in the Precision task was not confirmed: The U16 and U18 groups did not differ in their ability to kick the ball to the target line. Together, these effects are interpreted as indicating that age (serving as a proxy for soccer experience) was associated with an increase in kicking strength, or power, without necessarily being associated with kicking control, or precision. In contrast with my earlier prediction, performance after playing a match did not differ from performance before the match, for either task, or for either age group. That is, I found no evidence that performance abilities were affected by the immediate experience of match play, either in terms of fatigue, or in terms of match-based practice. This null result differs from Pijpers et al. (2007), who found that rock-climbing ability was reduced after climbing to fatigue. In the study of Pijpers et al., participants had no prior rock-climbing experience, whereas in the present study, all participants had been playing league soccer matches for at least 6 years. Soccer players are likely in better overall physical condition than a general population sample, and as such the effects of performance-related fatigue may be minimized compared to novices. It may also be the case that the effects of fatigue are sport or task-specific. Both of these are important topics for future research.

Perception of Kicking Ability

For the Precision task, I found no statistically significant effects on judgments. This null result was contrary to my prediction, and to the results of Pijpers et al. (2007), who found that judgments of rock-climbing ability after climbing to fatigue were reduced, relative to judgments made before fatigue. Given that I also found no significant effects on actual ability in the Precision task, these null results cannot be interpreted.

For the Power task, my prediction that judgments would differ between the experience groups was not confirmed. There was not a statistically significant effect of age (serving as a proxy for experience groups) for judgments in the Power task, either for the raw judgments or the proportions. This null result is in contrast with Hove et al. (2006), who assessed judgments of ice hockey sticks that would be optimal for executing a power shot (slap shot) and found statistically significant differences in these judgments between collegiate-level ice hockey players and participants who had no prior ice hockey experience. Similarly, my prediction that judgments in the Power task would differ before versus after playing a match was not confirmed; that is, the main effect of Time was not significant for raw judgments, or for proportions. As also discussed pertaining to the Precision task, this null result differs from the findings of Pijpers and colleagues (2007). It also differs from Hove et al. (2006), who found that novice hockey players showed changes in perceptual sensitivity to action-relevant properties of hockey sticks after practice performing the hockey tasks. As noted, participants in the study of Hove and colleagues did not have prior sport-specific experience. This shows that the brief experience provided during the study was sufficient to attune them to the action-relevant properties of hockey sticks. Conversely, the soccer players used in the present study were

likely sufficiently attuned their own kicking ability on account of their 6+ years in competitive soccer. As such, the additional experience of a single match was insufficient to bring about any further changes to their perception of their own kicking ability.

My design permitted the first test of whether the perception of sports-related affordances might differentially be influenced by co-variation in long-term versus short-term experience. For the Power task, my prediction was confirmed. For both raw judgments and judgments expressed as a proportion of actual kicking performance, match play influenced judgments among the less experienced, younger players (the U16 group) but had no effect on judgments among the more experienced, older players (the U18 group). Following match play, the U16 group judged that their kicking ability had decreased, relative to pre-match ability. When the judgments were expressed as a proportion of actual power kicking performance, the interaction revealed that for the U16 group, post-match judgments more closely reflected actual power kicking ability (were closer to 1.0) than pre-match judgments. No changes in proportions were observed for the U18 group.

As match play did not affect the actual kicking ability for either the U16 or U18 group, these results suggest that the two additional years of soccer experience stabilized sensitivity to power kicking ability. That is, the judgments by the U18 group were less affected by the short-term experience obtained during any given match than those of the U16 group. This short-term experience may come from the effects of fatigue after playing, or from the effects of the participant's kicking performance throughout the match. In the present study, whatever experiences affected the perception of the U16

group's power kicking ability had no such effect on the U18 group. Potential explanations for this phenomenon could be that U16 players learned more about their power kicking ability during the match than the U18 group. Another possible explanation is that the U16 players overestimated the effects of fatigue on their power kicking ability whereas the U18 group did not. Data on subjective fatigue levels of the participants was not collected from the participants (cf. Pijpers et al., 2007). As such, future research should aim to disentangle these possibilities, as discussed later in this dissertation.

One limitation of my design arises from the fact that age and experience were not able to be separated in this context (cf. Chang et al., 2008). Rather, I compared participants in a youth soccer league that differed in both age and experience.

In some ways, my study may resemble research inspired by action-specific concepts of perception. For example, Witt and Dorsch (2009) asked participants to estimate the size of American football field goal posts before after making a series of 10 attempts to kick the ball between the posts. After these attempts, estimates of goal post size were related to the number of successful kicks (i.e., that passed between the goal posts). Similarly, Paterson et al. (2016) presented soccer players with an on-field situation (an arrangement of ball position and dummy players) and required them to choose between making a free kick (i.e., attempt to score) versus a passing kick. In a separate task, participants attempted to reproduce a metric distance presented by the experimenter. The authors asked whether judgments of metric distance were related to performance in the kicking tasks. These studies did not feature separate age or experience

groups, and there was no manipulation of immediate experience (i.e., testing before vs. after a match).

The research of both Paterson et al. (2016) and Witt and Dorsch (2009) had the stated aim to investigate how performance accuracy might affect subsequent perception of affordances, as well as the perception of non-affordance properties of the environment, such as distance. One could argue that the results of my study could support the action-specific perception viewpoint, with game performance (between pretest and posttest) serving as an influence on posttest judgments. However, the results showed no changes in judgments before and after playing the match that were not intertwined with the age/experience groups of the participants. It is not clear how the action-specific view would account for such age-dependent effect of playing a match. More generally, the action-specific view has come under sustained criticism, suggesting that the empirical effects involved may be artifactual (e.g., Durgin et al., 2012; Firestone, 2013; Firestone & Scholl, 2016) or that changes in perception after performance in a task may arise due to factors unrelated to performance (Lee et al., 2012; cf. Witt, 2020).

Conclusions

In the research presented in this Chapter, members of a youth soccer league judged their ability in two soccer-related kicking tasks. I compared more experienced/older players versus less experienced/younger players. For each experience group, I assessed judged and actual kicking ability twice; Once immediately before and again immediately after participants played a regulation soccer match. I found that more experienced players could kick the ball farther than less experienced players, likely driven by age-related increases in size and strength. For the Power task, the actual and perceived kicking ability

of the more experienced players was not affected by playing in a regulation soccer. By contrast, match play significantly influenced the less experienced players' perception of (but not actual) kicking ability for the Power task. The interaction between long- and short-term soccer experience showed that any effects of long-term experience were not generalizable to all soccer abilities. Two additional years of playing experience did not lead to an overall improvement in the perception of kicking-related affordances. Instead, variation in long-term experience were associated with situation-specific changes in affordance perception being manifested after playing a soccer match, but not before.

These results have implications for both theoretical and practical issues. On the practical side, my results suggest that less experienced players might be more prone (than more experienced players) to misjudge their kicking ability early in a match, leading to power-based kicks that would yield negative outcomes (e.g., overshooting, or undershooting). This hypothesis could be evaluated by examining video recordings from matches, and comparing (across experience groups) the outcome of power-based kicks in (for example) the first half versus the second half of matches. My results might also suggest that less experienced players are more sensitive to kicking performance during a match and/or the effects of fatigue after playing.

On the theoretical side, the results in this Chapter give rise to the possibility of a general effect of experience leading to task-specific improvements in affordance perception within the human's area of expertise. This effect may be observed in other sporting contexts. For example, less experienced baseball players may be less accurate in judgments of their own throwing or hitting abilities in the early innings of a game,

relative to more experienced players. Similarly, a less experienced rugby player may make less accurate judgments pertaining to their ability to successfully pass the ball to their teammates or navigate through the gaps in their opponents defense than more experienced players.

What does this Chapter add to the Literature?

It is both well-documented and self-evident that athletic training leads to improved athletic performance. This Chapter shows that, beyond improvements in actual ability, youth soccer players' perception of their own kicking abilities was associated with additional soccer playing experience. However, this additional experience was not associated with general changes in affordance perception, as both groups exhibited stable affordance perception throughout the precision kicking task. On the contrary, younger, less experienced players were less sensitive to their power kicking abilities before rather than after playing a regulation soccer match, whereas the older, more experienced players were equally sensitive to their kicking abilities before and after match play. Younger, less experienced players appeared to be more dependent on the short-term experience of match play to refine their perceptual sensitivity to their power kicking ability. This was not observed in the older, more experienced players, who seemed to be aware that match play would not alter their ability to kick the ball to a maximum distance. These results raise questions for athletic training: Should younger, less experienced soccer players be given training that focuses specifically on how their abilities will change as they play individual matches? My results highlight the importance of athlete's perceptual sensitivity to their own athletic ability. This Chapter contributes to the limited scientific literature about relations between physical ability and perceptual sensitivity in athletics,

and specifically in youth soccer. The following Chapters will expand upon this, exploring the perception of higher-order affordances in soccer.

Chapter 3: Perception of Higher-Order Affordances for Kicking in Soccer: Distance and the Role of Players

Introduction

Affordances are opportunities for action that emerge from relations between properties of an animal (human or non-human) and properties of its environment (Gibson, 1979/1986; Stoffregen, 2003). Animals (including humans) perceive, and act with respect to, these affordances. In other words, animals choose whether, when, and how, to perform behaviors in accordance with the actions that are and are not available to them in a given situation. The majority of this work is concerned with the investigation o the perception of affordances for behaviors, such as ascending stairs (Warren, 1984), reaching for an object (e.g., Mantel, Stoffregen, Campbell, & Bardy, 2015; Yonas & Hartman, 1993), crossing the street in traffic (Lee, Young, & McLaughlin, 1984), or walking or leaping across gaps (e.g., Adolph & Young, 2021; Cole et al., 2013).

The awareness and perception of affordances may be produced through internal, mental processes. An example of this mental process would include an animal combining knowledge about its environmental properties with (separate) knowledge about its own properties to yield awareness of the animal-environment relations that constitute affordances. An alternative view has been proposed which claims that the animal-environment relations that constitute affordances lawfully structure energy arrays. These energy arrays are of a specific structure to each affordance (e.g., Mantel et al., 2015; Turvey, 2019). This perspective posits that affordances are perceived by animals detecting information specific to a particular animal environment fit without the need to

combine the perceptions of the lower-order constituents of the affordance (i.e., non-affordance properties of the animal or the environment). That is, affordances are directly perceived by perceivers with sensitivity to affordances as higher-order relationships in animal- environment systems (Stoffregen, 2003). The present study was developed from this direct perception perspective.

Affordances: Lower- and Higher-Order

It is often the case that research on affordances does not explicitly address the fact that everyday life is characterized by the presence of multiple affordances. In any given situation, relations between numerous properties of the animal and numerous properties of the environment yield numerous (perhaps, innumerable) available behaviors. At any given time, many behaviors are always available to any given animal in a given environment.

The existence of multiple, simultaneous available behaviors raises questions about how such available actions relate to one another. Each affordance may exist as a unique, independent relation within the animal-environment system. An example of this is the affordance for jumping (that is, lifting the body completely off the surface of support by generating force through extension of the legs). This affordance might exist independently from but simultaneously with an affordance for vertical reaching (that is, raising the arm and hand over the head to touch or grasp an object), such that an actor might independently perceive, “I can jump”, and “I can reach”. However, it might also be the case that affordances do not exist independently but rather in relation to one another in a way that has consequences for action. That is, there could be a behavior available to the animal that emerges out of a relation between two (or more) affordances

(Wagman, Cialdella & Stoffregen, 2019). The behavior, and the affordance for said behavior, would be of a higher order than the constituent affordances. In the case described, a higher-order behavior that might be available is reaching while jumping, that is, simultaneously extending the legs, so as to raise the body above the surface of support, while at the same time reaching vertically by raising the arm and hand above the head. The higher-order behavior of "reaching-while-jumping" affords the animal contact with (or the grasping of) objects that cannot be reached when jumping, or reaching. Research suggests that people are able to perceive and exploit the higher-order affordance of reaching-while-jumping (Thomas, Hawkins, & Nalepka, 2018; Ramenzoni, Davis, Riley, & Shockley, 2010).

One may wonder how people can perceive higher-order affordances for a behavior such as reaching-while-jumping. From the direct perception perspective, it may be that lower-order affordances (e.g., for jumping, and for reaching) are (directly) perceived as separate entities, and that awareness of higher-order affordances (i.e., reaching-while-jumping) is achieved through an additive, internal mental process that "combines" the lower-order affordances [affordances for reaching-while-jumping = f (affordances for jumping, affordances for reaching)]. Alternately, but still consistent with the direct perception perspective, the higher-order affordance for reaching-while-jumping might exist as a real ontological entity. That is, an affordance to be perceived, such that it could be specified in lawfully structured energy arrays and, therefore, perceived directly, without the need for any internal, non-perceptual process. I endorse this latter viewpoint.

Contemporary research supports the claim that higher-order affordances are directly perceived as such, rather than being "assembled" from perceptions of lower-level affordances. For example, Wagman and Stoffregen (2020) asked standing participants to give perceptual reports about their ability to reach an overhead object if they were to reach with their arm alone, or if they were to use a handheld tool. Perceptual reports about the length of their arm, the height of their shoulder above the floor, and the length of the tool were also provided by the participants. The authors made three predictions: 1) perceived maximum reaching height with the arm would differ from an additive combination of perceived shoulder height and perceived arm length, 2) perceived maximum reaching height with the tool would differ from an additive combination of perceived shoulder height and perceived arm-plus-tool length, and 3) perceived maximum reaching height with the tool would differ from an additive combination of perceived maximum reaching height with the arm and perceived tool length. The research confirmed each of these predictions. These results suggest that the affordance for reaching with a handheld tool was perceived as such, as a higher-order affordance and not as an additive combination of lower order affordances (see also Thomas & Riley 2014, 2015; Wagman, et al., 2018).

Higher-Order Personal and Interpersonal Affordances in Team Sports

Affordances can also be constituted by animal-animal-environment systems. That is, affordances can emerge from relations between people within an environment. These affordances are known as social affordances (e.g., Baggs, 2021; Van Acker & Valenti, 1989), interpersonal affordances (e.g., Richardson, Marsh, & Baron, 2007), or affordances for joint action (e.g., Davis, Riley, Shockley, & Cummins-Sebree, 2010;

Marsh, Johnston, Richarson, & Schmidt, 2009). In this Dissertation, I refer to them generally as interpersonal affordances. Interpersonal affordances can be understood as higher-order affordances that depend upon (lower-order) affordances that are available to individuals in the absence of a social context but which differ qualitatively from such lower-order affordances when embedded in a social context (cf. Kimmel & Rogler, 2018).

Team sports are an excellent medium for providing "real world" study opportunities on the perception of higher-order interpersonal affordances (Passos, Araújo, & Volssovitch, 2016). A straightforward example is passing a ball to a teammate in soccer. Passing the ball requires that certain affordances exist for individuals (e.g., for the player passing the ball, an affordance for kicking the ball, and for the player receiving the pass, an affordance for intercepting and receiving the moving ball). However, passing entails something that cannot exist for any individual: an interpersonal affordance for trading possession of the ball between players. In this Chapter, I investigated sensitivity to the simultaneous influence of personal and interpersonal affordances in soccer.

Some studies have assessed athletes' abilities to perceive sport-related personal affordances void of teammates or the wider social context of the given sport (e.g., Carello, Anderson, & Turvey, 1999; Chang, Wade, & Stoffregen 2008; Hove, Riley, & Shockley, 2007; Peker, Ermmen, et al., 2020; Peker, Böge, Bailey, Wagman, & Stoffregen, 2020). Other studies have investigated the ability to perceive sport-related interpersonal affordances which arise from the existence of and interaction with teammates and opponents. For example, researchers have used rugby as a vehicle to

study interpersonal affordances in sport (Correia, Araujo, Cummins, & Craig, 2012; Passos, Cordovil, Fernandes, & Barreiros, 2012). In those studies, players were exposed to realistic rugby situations involving a player choosing to run with the ball or pass the ball, depending on the position and movements of teammates and members of an opposing team (i.e., defenders). In a virtual environment, Correia et al., manipulated the actions of defenders who were running toward the participant and his teammates, and monitored whether and to whom the participant passed the ball. In a related study, Passos et al., examined passing decisions made by players in a "2 on 1" scenario acted out on a physical rugby field. Passos and colleagues examined player's passing choices as a function of the position and movement of an opposing defender relative to the boundary of the playing field. However, neither Correia et al., nor Passos et al., included systematic co-variation of lower-order individual and higher-order interpersonal affordances. In the present study, I ask whether participants could perceive higher-order interpersonal affordances in the context of a team sport (soccer) that emerged from constraints operating simultaneously at both personal and interpersonal levels.

Higher-Order Personal and Interpersonal Affordances in Soccer

In a soccer match, players interact both with members of their own team, and with members of the opposing team (e.g., Correia et al., 2012; Passos et al., 2012). These interpersonal interactions present in soccer give rise to affordances and behaviors that differ from those available when an individual interacts with inanimate objects, such as cones (Tomono, Makino, Furuyama, & Mishima, 2019). Therefore, an argument can be made that the perception and actualization of affordances in team sports requires a sensitivity to the simultaneous influence of constraints operating on both the personal and

interpersonal level. For example, interpersonal affordances, such as those relating to team possession of the ball, are influenced simultaneously by both individual characteristics, such as an individual's strength and control in kicking the ball and interpersonal relations, such as the relative positioning of teammates and opponents. In the present study, I ask whether youth soccer players might be sensitive to higher-order affordances that emerge from the simultaneous influence of personal and interpersonal constraints.

I expected to replicate the common finding that sport-specific personal affordances can be perceived (e.g., Hove et al., 2007; Kimmel & Rogler, 2018; Peker, Böge et al., 2020; Peker, Erkmen et al., 2020). I also expected to replicate the finding that sport-specific interpersonal affordances can be perceived in the context of team sports (e.g., Correia et al., 2012; Passos et al., 2012; Zheng, van der Kamp, Song, & Savelsburgh, 2022). My main novel predictions were related to my claim that higher-order interpersonal affordances emerging from constraints simultaneously operating at both personal and interpersonal levels can be perceived in the context of soccer, and that such affordances would be perceived as such, that is, not as additive combinations of lower-order affordances.

In two experiments (the second of which is discussed in Chapter 4), I co-varied constraints operating at the personal level (e.g., the distance that a soccer ball would be kicked) and at the interpersonal level (e.g., whether the ball would be kicked through a gap defined by teammates versus opponents). I predicted that perceived affordances for kicking the ball through the gap (i.e., perceived minimum kickable gap width) would be influenced by both such constraints, each as main effects. However, my central novel

prediction was that the combination of these personal and interpersonal constraints would yield a higher order interpersonal affordance that differed qualitatively from the constituent lower-order personal and interpersonal affordances. Specifically, I predicted that affordances for kicking the ball through the gap (i.e., perceived minimum kickable width) would be influenced by statistically significant interactions between these personal and interpersonal factors.

I used a convenience sample in which all of the participants were male (cf. Correia et al., 2012, and Passos et al., 2012, who did not report the sex of their participants). Recent research has documented sex differences in some aspects of affordance perception in soccer (Zheng et al., 2022). Accordingly, it cannot be assumed that the results of this experiment would generalize across genders.

The Present Study

In the experiment featured in this Chapter, players reported the minimum gap between two other players through which they could kick a ball. I varied a personal-level constraint—the distance that the ball was to be kicked to pass through the gap. I also varied a constraint operating at the interpersonal level—the role of the confederates who defined the gap. In one condition, the confederates were identified as teammates. In another condition, the confederates were identified as opponents. In actual game play, a kicking player's teammates would not try and interfere with the kicked ball, whereas opponents would attempt to interact with the kicked ball in an attempt to gain possession. The participant instructed the two confederates where to stand to define the minimum kickable gap width. That is, in each condition participants adjusted the distance between

the confederates to create a gap that they perceived to be the minimum width through which they could kick the ball.

I predicted that reported minimum kickable gap width would increase with the distance that the ball was to be kicked (a personal affordance). I also predicted that minimum kickable gap width would increase when confederates were regarded as opponents, rather than when they were regarded as teammates (an interpersonal affordance). My principal novel prediction was that the combination of the Kick Distance and Team factors would create (and be perceived as) a higher-order interpersonal affordance that differed qualitatively from either of the lower-order affordances. That is, I predicted that there would also be a statistically significant interaction between these factors, such that the difference in gaps between teammates and opponents would be greater for more distant gaps.

Author Contributions

The research presented in this chapter was conceptualized by G. S. B., T. A. S., J. B. W., and A. P. after completing data analysis on the research presented in Chapter 2. G. S. B., T. A. S., and J. B. W developed the methodology of the study, as well as the data analysis techniques to be used. Data was collected by V. B. in Konya, Turkey, and all formal data analysis was conducted by G. S. B. The introduction and discussion sections of this Chapter were first drafted by T. A. S. and J. B. W., again with G. S. B. providing feedback and edits with A. P.'s contributions to the soccer-specific elements of the research. The methods and results sections were drafted in full by G. S. B. The final edits to the published manuscript were made by G. S. B., T. A. S., and J. B. W., and all authors approved of the final manuscript.

Method

Participants

The participants in this study were 22 male players from a boy's youth soccer league in Konya, Turkey. Depending upon age, players gave their own informed consent, or participated with their parents' approval. All players were recruited from a U16 or a U18 team. At the time the study was conducted, mean age = 16.2 years, SD = 0.69 years; mean height = 172.11 cm, SD = 3.59 cm; mean weight = 62.3 kg, SD = 4.84 kg. The coach recruited starting players from the two teams. As league members, all participants engaged in a minimum of 7.5 hours of soccer training per week and, during soccer season, played in league matches each weekend. All participants had begun league participation at age 8 and had been playing age-appropriate league matches since the age of 10. Each participant reported no history of medical or orthopedic disorders of balance. In addition to the experimental participants, two other players from the same youth league served as experimental confederates, as described below. The research protocol was approved by Selçuk University (# E220048).

I conducted an a priori power analysis with the G*Power program (Faul, Erdfelder, Lang, & Buchner, 2007) using a large effect size ($f = 0.4$), estimated from comparable significant effects in Peker, Böge, et al. (2020). This analysis suggested that a minimum sample size of $n = 8$ would be required to detect significant effects in a repeated-measures, within factors ANOVA with statistical power of $p = .80$ and alpha set to 0.05.

Procedure

The experiment was conducted on a soccer pitch, which was 65 m×100 m. The data were collected November 2, 2020.

The method is illustrated in Figure 1. Two league players served as confederates to define the gaps. The confederates were naïve to the purpose and hypotheses of the experiment, and were unable to hear the instructions that were given to participants. The confederates always faced the participant (Figure 3-1). The left side of the figure portrays the trials beginning with the confederates shoulder-to-shoulder, and the right side of the figure shows trials beginning with the confederates apart.

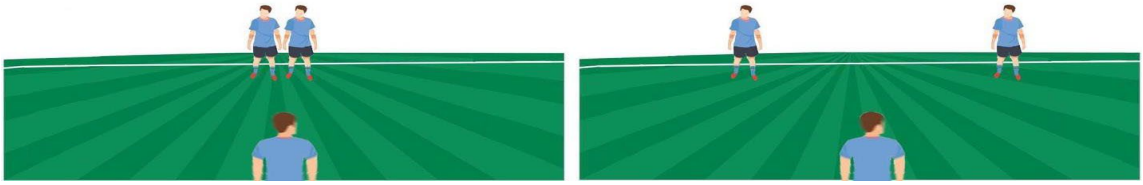

Figure 3-1: *Experimental setting of the study. The participant is shown in the middle with his back to the viewer. The confederates who defined the gaps are shown facing the participant (and the viewer).*

During data collection, all participants stood side-by-side on a line on the field, facing away from the experimenter (Peker, Böge et al., 2020). Participants were called to participate individually, at which point they would move to the appropriate position, facing the experimenter. This method ensured that participants could not observe each other's participation. To give their perceptual reports, participants used the method of adjustment. The participant instructed the confederates to move (apart or together) until he was satisfied that the gap between the confederates was the minimum gap through which he would be able to kick a ball in a given condition (i.e., combination of confederate roles and kick distance). Once the participant was satisfied with the gap width, an Experimenter measured the distance between confederates using a tape measure.

I used a 2-factor design, with factors Kick Distance and Team. Both factors were within-participants. For the Kick Distance factor, the gap was located at one of four distances from the participant: 10, 20, 30, or 40 m. Half of the trials began with the human confederates standing together (shoulder-to-shoulder; Figure 1, left), and the participant instructed them to move apart until they were at the appropriate distance from each other. The other half of trials began with the human confederates positioned standing apart (Figure 1, right), and the participant instructed them to move together until they were at the appropriate distance from each other. For trials in which the initial position of the confederates was standing apart, the initial distance between the confederates varied together with the four distances. Specifically, for Kick Distances of 10 m, 20m, 30m, and 40m the initial position of the confederates was 5 m, 10 m, 15 m, and 20 m apart, respectively. This was done, in part, to reduce the burden on participants and confederates, given that pilot data showed that participants did not position the confederates at extreme distances apart (e.g., 40 m) for relatively short kick distances (e.g., 5 m). I did not expect that this difference between the two types of trials would influence perceived maximum kicking distance.

The Team factor comprised variation in the nominal role of the confederates. Participants were told to “think of these players (the confederates) as your teammates”, in the Teammates condition and to “think of these players (the confederates) as your opponents”, in the Opponents conditions.

The Kick Distance and Team factors combined to yield a total of eight conditions. Participants gave four perceptual reports in each condition, for a total of 32 trials per

participant. In each condition, two trials began with the confederates positioned together (Figure 1, left), and two with the confederates positioned apart (Figure 1, right). Condition order was randomized across participants.

The data and study analytic codes will be available (pending at time of submission) in the Data Repository of the University of Minnesota (DRUM).

Results

The results are summarized in Figure 3-2. I analyzed perceptual reports using a 3-factor, repeated measures ANOVA, with factors of Kick Distance (10 m, 20 m, 30 m, 40 m from the participant), Team (Teammates vs. Opponents), and Trial Type (starting position of confederates: apart vs. together). Each factor was within-participants. Where the assumption of sphericity was violated, I used the Hyun-Feldt correction and, accordingly, sometimes report fractional degrees of freedom.

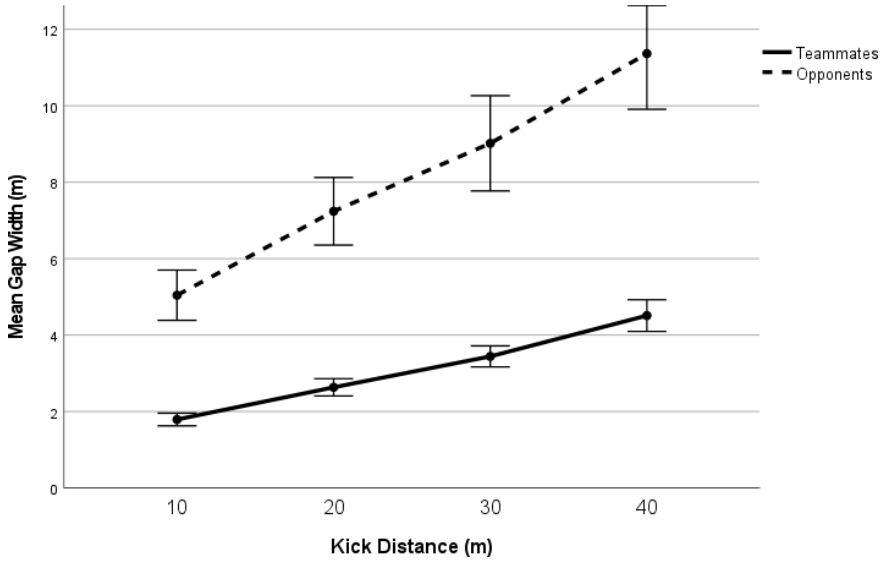

Figure 3-2: *Perceived minimum kickable gap width as a function of the egocentric distance of the gaps and the role of the confederates who defined the gaps, illustrating the statistically significant Kick Distance x Team interaction. The error bars illustrate the standard error of the mean.*

The main effect of Kick Distance was significant, $F(1.96,37.24) = 217.20$, $p < .0001$, partial $\eta 2 = 0.920$—overall, gap width increased as distance increased. The main effect of Team was significant, $F(1,19) = 101.45$, $p < .0001$, partial $\eta 2 = 0.842$—overall, chosen gap width was larger in the Opponent condition than in the Teammate condition. These effects were subsumed under a significant Kick Distance × Team interaction, $F(1.47,27.89) = 25.70$, $p < .0001$, partial $\eta 2 = 0.575$, which is illustrated in Figure 3-2. The Trial Type factor was not involved in any significant effects, either main effects or interactions.

To investigate the nature of the interaction, for each participant I calculated difference scores (i.e., mean reported gap width in the Opponents condition minus mean reported gap width in the Teammates condition) at each Kick Distance. I then compared mean difference scores at consecutive distances, using t-tests with Bonferroni corrections. These tests showed that the difference scores were larger when Kick Distance was 40 m than when it was 30 m, $t(19) = 9.00$, $p < .05$, were larger when Kick Distance was 30 m than when it was 20 m, $t(19)= 2.48$, $p < .05$, and were larger when Kick Distance was 20 m than when it was 10 m, $t(19) = 4.12$, $p <.05$.

Taken together, these results indicate that the difference between the perceived minimum kickable gap width in the Opponent and Teammate conditions was greater at larger kick distances.

Discussion

Participants positioned two confederates so that the distance between them was the minimum width through which the participant perceived that they could kick a soccer ball. I assessed how these perceptual reports might be influenced by simultaneous

variation of constraints operating at personal and interpersonal levels. To this end, I co-varied the distance that the ball would have to be kicked to pass through the gap between confederates (Kick Distance—10 m, 20 m, 30 m, or 40 m), and the nominal role of the confederates (Team— Teammates or Opponents).

Consistent with my predictions, participants created wider minimal kickable gaps (1) for more distant kicks, and (2) when the confederates were regarded as Opponents than when they were regarded as Teammates. Also consistent with my predictions, the creation of minimum kickable gaps was simultaneously, differentially, and interactively affected by the co-variation of the Kick Distance (personal) and Team (interpersonal) factors. Finally, I found no evidence that perceptual reports were influenced by the covariation of initial gap width and kick distance in trials that began with confederates standing apart but not in trials that began with confederates standing together.

The main effects of Kick Distance and Team, respectively, are consistent with the perception of (lower-order) affordances emerging from personal (distance) and interpersonal (team membership) factors, respectively. The interaction of Kick Distance and Team, such that differences between the Teammates and Opponents conditions were modulated by Kick Distance, is consistent with the perception of a higher-order affordance emerging from relations between personal and interpersonal factors. This interaction reveals that the higher-order affordance was not perceived as an additive sum of constituent lower-order affordances. Rather, it was perceived, as such—as differing qualitatively from either lower-order affordance. This finding is consistent with earlier studies demonstrating that lower-order and higher-order personal affordances are

perceived as such (e.g., Wagman & Stoffregen, 2020), and extends this effect to personal and interpersonal affordances in the domain of team sports.

Chapter 4: Perception of Higher-Order Affordances for Kicking in Soccer: The Role of Context

Introduction

The study discussed in Chapter 3 showed that in selecting a minimum kickable width through a gap defined by confederates, youth soccer players were sensitive to higher-order affordances that were simultaneously influenced by both personal (distance of the required kick) and interpersonal constraints (team of the confederates). Participants created wider gaps (1) for longer kick distances than for shorter kick distances, and (2) when kicking between two opponents than when kicking between two teammates. Presumably, the latter effect occurred because in the context of an actual game, opponents would be more likely than teammates to attempt to interfere with the kick. That is, minimum kickable gap width seemed to reflect, in part, the game-related goals of the people forming the gap to interfere with the kick.

In the experiment featured in this Chapter, I investigate whether participants were sensitive to an additional interpersonal factor that would be expected to influence the ability of other players to interfere with the kick—the facing direction of the confederates who defined the gaps (that is, whether participants were facing together, or away from each other). Previous research has shown that participants are sensitive to this factor when walking between two people. Tomono et al. (2019) found that participants rotated their shoulders more when walking between two people who were facing each other than when walking between two people who were facing away from each other. In this study, I expected that players would be similarly sensitive to this factor in determining the

minimal kickable gap width, such that gap width would be larger when the confederates faced together than when they faced apart. In addition, I expected that the facing direction factor would have a greater effect when the confederates were identified as Opponents than when they were identified as Teammates, for the same interference reasons laid out in the preceding chapter.

I expected to replicate the statistically significant effects shown in Chapter 3: The main effect of Distance, the main effect of Team, and the Distance × Team interaction. In addition, I predicted that there would be a statistically significant 3-way interaction among Distance, Team, and Facing Direction factors, such that the influence of the Team factor (as a function of Distance) would differ when confederates were facing away from each other (smaller predicted minimum kickable gap width) relative to when confederates were facing toward each other (larger predicted minimum kickable gap width). The analysis conducted in Chapter 3 did not indicate any influence on perceptual reports of manipulation of Trial Type (trials on which the human confederates began shoulder-to-shoulder vs. trials on which the confederates initially were separated). Accordingly, for this study, this factor was not included in my analyses.

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Author Contributions

The data in this Chapter was collected at the same time as the data presented in Chapter 3. As such, the research presented in this chapter was conceptualized by G. S. B., T. A. S., J. B. W., and A. P.. G. S. B., T. A. S., and J. B. W developed the methodology of the study, as well as the data analysis techniques to be used. Data was collected by V. B. in Konya, Turkey, and all formal data analysis was conducted by G. S. B. The introduction

and discussion sections of this Chapter were first drafted by T. A. S. and J. B. W., again with G. S. B. providing feedback and edits with A. P.'s contributions to the soccer-specific elements of the research. The methods and results sections were drafted in full by G. S. B. The final edits to the published manuscript were made by G. S. B., T. A. S., and J. B. W., and all authors approved of the final manuscript.

Method

Participants

The participants were the same 22 individuals who had taken part in the research discussed in the prior Chapter (22 male players from a boy's youth soccer league in Konya, Turkey). As in that study, depending upon age, players gave their own informed consent, or participated with their parents' approval. All players were recruited from a U16 or a U18 team. At the time that this study was conducted, (mean age = 16.3 years, SD = 0.86 years; updated information on height and weight was not collected). The coach recruited starting players from the two teams. As league members, all participants engaged in a minimum of 7.5 hours of soccer training per week and, during soccer season, played in league matches each weekend. All participants had begun league participation at age 8 and had been playing age-appropriate league matches since the age of 10. Each participant reported no history of medical or orthopedic disorders of balance. In addition to the experimental participants, two other players from the same youth league served as experimental confederates, as described below. The research protocol was approved by Selçuk University (# E220048).

I conducted an a priori power analysis with the G*Power program (Faul, Erdfelder, Lang, & Buchner, 2007) using a large effect size (f = 0.4), estimated from

comparable significant effects in Peker, Böge, et al. (2020). This analysis suggested that a minimum sample size of n = 8 would be required to detect significant effects in a repeated-measures, within factors ANOVA with statistical power of p = .80 and alpha set to 0.05.

Procedure

The data were collected June 15, 2021. I retained the Kick Distance and Team factors from Experiment 1, and added a third factor, Facing Direction. As shown in Figure 3, the confederates whose position defined the to-be-kicked-through gaps stood either facing away from each other (and, thus, facing away from the future path of the to-be-kicked ball); (Figure 4-1 A, B), or facing toward each other (and, thus, facing toward the future path of to-be-kicked ball) (Figure 4-1, C, D.) The Kick Distance, Team, and Facing Direction factors were co-varied to yield a total of 16 different experimental conditions. Each participant gave four perceptual reports in each of the 16 conditions, for a total of 64 perceptual reports for each participant. In each condition, two trials began with the confederates positioned together (Figure 4:1 A, C), and two with the confederates positioned apart (Figure 4:1 B, D).

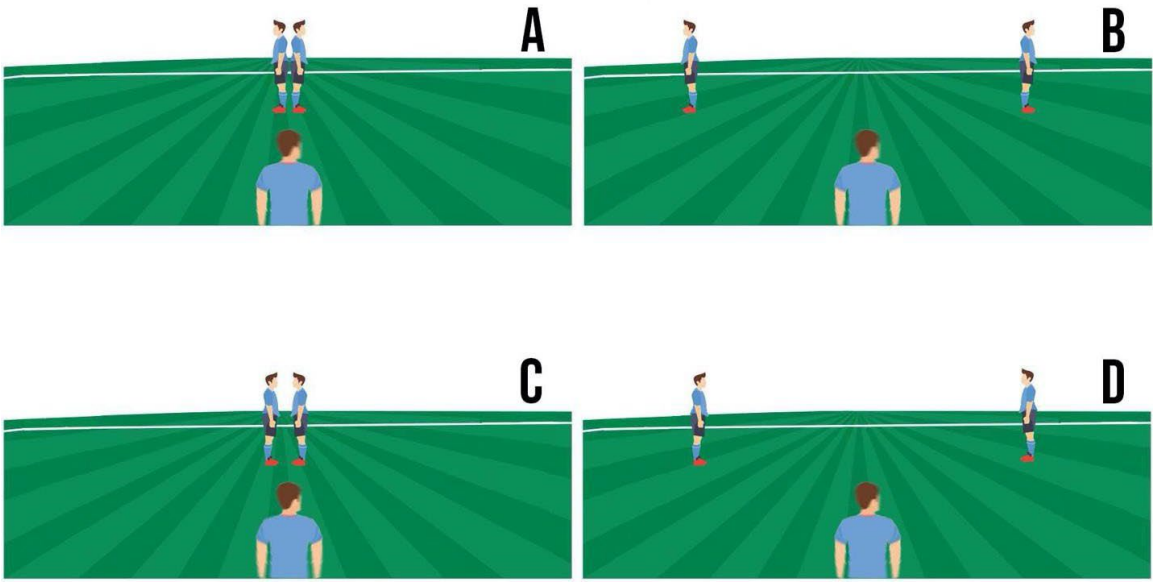

Figure 4-1: *Experimental setting of the study. The participant is shown in the middle with his back to the viewer. The confederates who defined the gaps are shown facing the participant (and the viewer).*

Results

The results are summarized in Figure 4-2. I conducted a 3-factor, repeated measures ANOVA on factors Kick Distance (10 m, 20 m, 30 m, 40 m), Team (Teammates vs. Opponents) and Facing Direction (Together vs. Away). Each factor was within-participants. Where the sphericity assumption was violated, I used the Huynh-Feldt correction, which can yield fractional degrees of freedom.

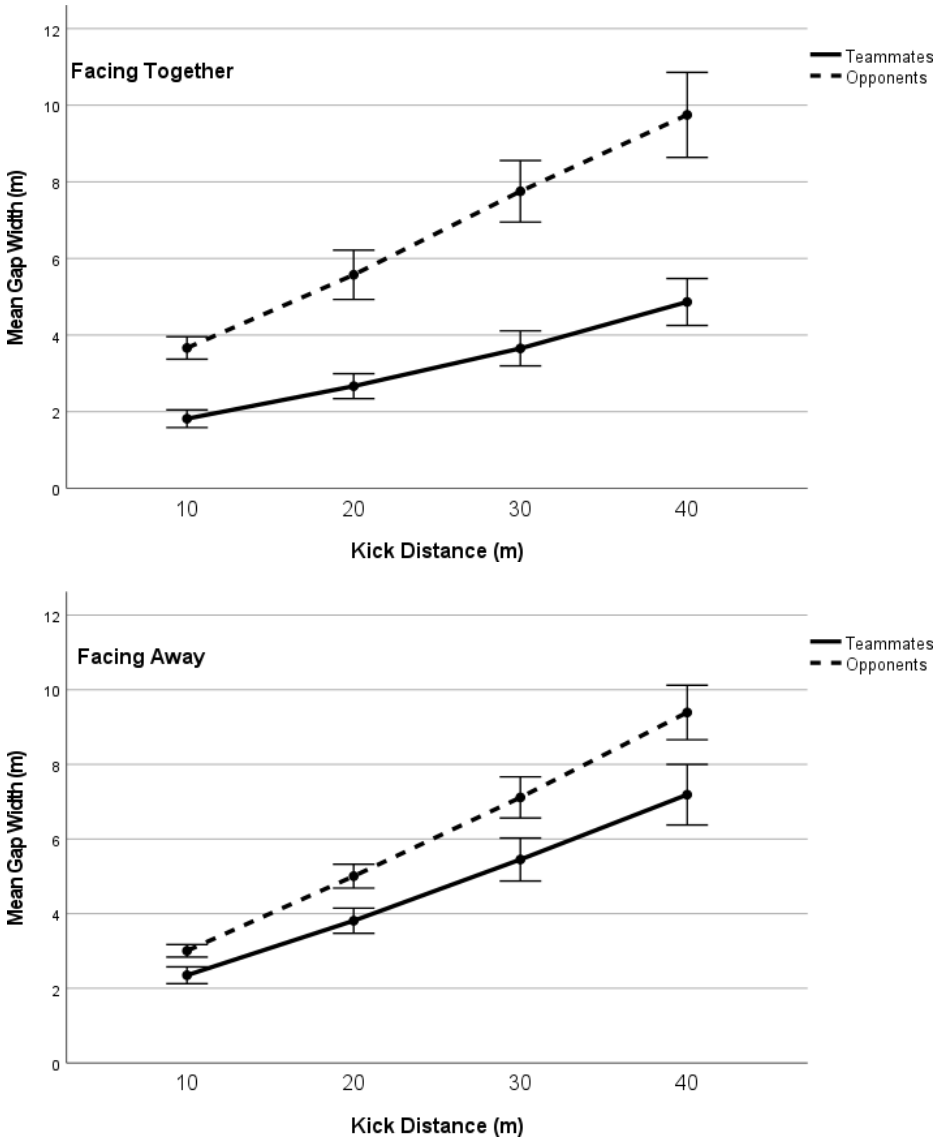

Figure 4-2: *Perceived minimum kickable gap width as a function of the egocentric distance of the gaps (Kick Distance: 10m, 20m, 30m, 40m), the role of confederates who defined the gaps (Team: Teammates vs. Opponents), and the Facing Direction of the confederates (Facing Together vs. Facing Away), illustrating the statistically significant Kick Distance x Team x Facing Direction interaction. The error bars illustrate the standard error of the mean.*

The main effect of Kick Distance was significant, $F(1.42,26.65) = 349.70$, $p <$ .0001, partial $\eta 2 = 0.948$—overall, participants created larger gaps between confederates at farther kick distances. The main effect of Team was significant, $F(1,19) = 133.19$, $p <$ .0001, partial $\eta 2 = 0.875$—overall, participants created larger gaps in the Teammates condition than in the Opponents condition. The main effect of Facing Direction was

significant, $F(1,19) = 4.75$, $p = .042$, partial $\eta 2 = 0.20$—overall, participants created larger gaps in the Facing Together condition than in the Facing Away condition.

The Kick Distance × Team interaction was significant, $F(1.63,31.03) = 41.69$, $p < .0001$, partial $\eta 2 = 0.687$. The Kick Distance × Facing Direction interaction was significant, $F(2.25,42.73) = 11.79$, $p < .0001$, partial $\eta 2 = 0.383$. In addition, the Team × Facing Direction interaction was significant, $F(1,19) = 34.13$, $p < .0001$, partial $\eta 2 = 0.642$. Each of these 2-way interactions was subsumed in a significant, 3-way interaction among the Kick Distance, Team, and Facing Direction factors, $F(1.93,36.58) = 5.13$, $p = .012$, partial $\eta 2 = 0.213$.

To investigate the nature of the 3-way interaction, I conducted two separate 2-factor, repeated measures ANOVAs on factors Kick Distance (10 m, 20 m, 30 m, 40 m) and Team (Teammates vs. Opponents)— one ANOVA in the Facing Together condition and the other in the Facing Away condition. In the Facing Together condition (Figure 4-2), the main effects of Kick Distance, $F(3,57) = 239.07$, $p < .001$, partial $\eta 2 = 0.926$, and Team, $F(1,19) = 28.58$, $p < .001$, partial $\eta 2 = 0.601$, were significant, as was the Kick Distance × Team interaction, $F(3,57) = 18.51$, $p < .001$, partial $\eta 2 = 0.493$. In the Facing Away condition (Figure 4-2), the main effects of Kick Distance, $F(3,57) = 264.553$, $p < .001$, partial $\eta 2 = 0.933$, and Team, $F(1,19) = 4.43$, $p < .05$, partial $\eta 2 = 0.189$, were significant, but the Kick Distance × Team interaction was not significant. That is, in the Facing Away condition, the difference in gap size between the Teammates condition and the Opponents condition remained constant across the four Kick Distances, whereas in

the Facing Together condition the difference in gap sizes between the Teammates and the Opponents conditions increased across the four Kick Distances.

Discussion

I replicated the three significant effects seen in Chapter 3—i.e., the main effect of Kick Distance, the main effect of Team, and the Kick Distance × Team interaction. As in the results discussed in the last Chapter, participants created wider minimal kickable gaps for more distant kicks that for less distant kicks, and created wider minimal kickable gaps when the confederates were regarded as Opponents than when they were regarded as Teammates. In addition, the significant main effect of Facing Direction revealed that participants created wider minimal kickable gap widths when confederates were facing toward each other (and toward the path of the impending kick) than when they were facing away from each other (and away from the path of the impending kick). Of greatest importance, in this Chapter the creation of minimum kickable gap width was simultaneously, differentially, and interactively affected by the co-variation among a personal factor (Kick Distance) and two interpersonal factors (Team, and Facing Direction). As with the 2-way interaction in Experiment 1, this 3-way interaction is consistent with the proposal that participants perceived a higher-order affordance emerging from relations between and among personal and interpersonal factors and that they perceived this higher-order affordance as such, and not as sums of constituent affordances.

Chapter 5: General Discussion

In this dissertation, I examined the perception of soccer-specific affordances, both lower- and higher-order. In the introductory Chapter, four goals and four hypotheses were noted and discussed, which were intended to be answered through three experiments. The following subsections address each of the goals and hypotheses, before discussing the general significance and applications of this research.

Goal 1

My first goal was to explore the effect of long-term athletic experience on the perception and actualization of sport-task-specific affordances in soccer. Two hypotheses were associated with this goal. 1) Actual kicking performance would be better for more experienced players; specifically, that power kicks would be to a greater distance, and that precision kicks would come to rest closer to the target line. 2) Perceptual judgments would have greater accuracy for the more experienced players. That is, the judged kicking distance would more closely correspond to actual kicking distance for more experienced players than for less experienced players.

This hypothesis is supported by the results of the power task discussed in Chapter 2, which showed older, more experienced players were more accurate in their perceptual judgments, and older players could kick the ball further than their younger, less experienced counterparts. However, for the precision task, there were no significant effects of age alone for either perceptual judgments, or actual kicking performance. As discussed later in this discussion section, age was used as a proxy for experience, and experience was used as a proxy for skill level, due to the near-inseparable nature of these qualities in organized sport. I would expect these results to be consistent had there been a

way to accurately measure the actual skill-level of players within an experience, or age, group. Had lesser experienced players formed the entire data set, proxied by age once again (e.g. U14 vs. U16; U12 vs. U16, etc.), I would expect a replication of these results. That is, more experienced (skilled) players would consistently display more accurate perceptual judgments, while also kicking the ball a greater distance in power-based tasks. In order to assess this, future research must be conducted.

As such, the hypothesis is only partially supported by the findings of this research, showing that experience does have an effect on both perception and action for youth soccer players, though only in relation to kicking for power versus kicking for precision. This result illustrates that soccer experience was associated with an increase in kicking strength or power, but not in kicking control or precision.

Goal 2

The second goal of this research was an extension of the first goal, looking to explore the effects of short-term athletic experience on the perception and actualization of sport-task-specific affordances in relation to long-term experience. The second of two hypotheses used to test the first goal was used to test this goal, with additional context. To address this goal, the same 22 participants completed both the power and precision kicking tasks after the short-term experience of playing a soccer match. It was predicted that perceptual judgments would have greater accuracy for the more experienced players post-match. That is, more experienced players would show more refined perceptual sensitivity to any present effects of short-term experience on actual kicking ability, whether for power kicks, or precision kicks. In this experiment, experience (albeit short- rather than long-term) was the primary variable, and with the nature of short-term

experience it was not necessary to experience as a proxy for skill, via age. However, for the comparison across the two groups, age was again used as a proxy for overall, long-term experience.

When looking exclusively at pre- versus post-match comparisons, neither the power nor precision task yielded a significant main effect of time. However, for the power kicks, there was a significant interaction between age (U16 or U18) and time (pre- and post-match). The judged kickable distance was shorter after playing the match than before playing for the U16 group, but not for the U18 group. That is, the change in judgments for the U18 was not significant. When creating proportions to assess the accuracy of perceived kicking distance, there was once again a significant interaction between age and time for the power task. For the U16 group, the perceived kickable distance better reflected the participants' actual kicking ability after the match than before the match. These effects were not seen for the U18 group. Neither raw judgments or proportions for precision kicks showed such effects.

As shown above and in Chapter 2, match play did not affect the actual kicking ability for either group. As such, these results suggest that the two additional years of soccer experience for the U18 group served to stabilize perceptual sensitivity to power kicking judgments. That is, the U18 group were less affected by the short-term experience of any given match than those in the U16 group. Therefore, similar to the findings pertaining to goal 1, the hypothesis is only partially supported by the findings of this research. Short-term experience does have an effect on the perceptual sensitivity of youth soccer players when kicking for power, not when kicking for precision. Those in

the U18 group were less sensitive to whatever altered the U16 group's perception, which may have been gaining a better understanding of their abilities following a match (that is, the U18 group were more consistent in their awareness of their abilities than the U16 group), or an overestimation of the effects of fatigue on kicking ability in the U16 group.

Goal 3

My third goal was to investigate the detection and perception of higher-order affordances in soccer, with the associated hypothesis being as follows: there would be a statistically significant interaction between the Kick Distance and Team factors in the higher-order affordance experiments that differs qualitatively from either of the lower-order affordances. As with all goals and hypotheses in this dissertation, the same 22 male participants from a youth soccer league in Turkey completed a task in which they reported the minimum gap width between two other players through which they could kick a ball. At a personal level, the distance that the ball would be kicked to pass through the gap was varied; and at an interpersonal level, the role of the confederates defining the gap was varied.

There were significant main effects of Kick Distance, and of Team. That is, the gap between confederates was wider as the distance of the kick grew longer, and when the confederates defining the gap were opponents rather than teammates. A significant Kick Distance x Team interaction was also observed. Difference scores were calculated, and the mean difference scores were compared at consecutive distances using *t*-tests with Bonferroni corrections. These tests revealed that difference scores were larger as distance increased (Figure 3-2).

The main effects of Kick Distance and Team are consistent with the literature suggesting that the perception of lower-order affordances emerges from both personal and interpersonal factors, respectively (e.g. Baggs, 2021). The interaction between Kick Distance and Team illustrates that the differences between the two interpersonal conditions (Teammates vs. Opponents) was modulated by Kick Distance and emerges due to the relations between personal and interpersonal factors. Rather than this higher-order affordance being perceived as an additive sum of the constituent lower-order affordances, the interaction shows that the higher-order affordance was perceived as such, differing from either lower-order affordance alone. This result is consistent with prior research (Wagman & Stoffregen, 2020), and confirms the hypothesis noted above.

The comparison of long-term experience groups was not used for this experiment. However, based on the results of Experiment 1 discussed in Goal 1 & 2 above, I would expect less-experienced, less-skilled, and/or younger players to have wider gaps between the confederates at all kick distances. Considering the results of Experiment 1, the refined perceptual ability of more experienced players may lead to a greater accuracy of judgments for the Team condition than players with less experience. On the contrary, if the gap-defining confederates were to be experience-, skill-, or age-matched to the participants, there may be consistency in the difference between gap sizes for Teammates vs. Opponents across the experience groups. That is, the difference in the gap size judged by a less-experienced player when defined by less-experienced Teammates and less-experienced Opponents may be statistically similar to the difference in gap size judged by a more-experienced player defined by more-experienced Teammates and more-

experienced opponents, on account of the judged comparative nature of the abilities of the confederates. Further research examining the effects of experience on the perception of higher-order affordances is required in order to resolve these open questions.

Goal 4

My fourth and final goal in this dissertation was to examine the role of sport-specific context on the perception of higher-order affordances in soccer. The same 22 participants were used to assess this goal. The hypothesis for this goal posed that there would be a statistically significant three-way interaction between the Kick Distance, Team, and Facing Direction factors in the second higher-order affordance experiment that again differ qualitatively from their constituent lower-order parts. The Kick Distance and Team factors remained from Goal 3, with the addition of varying the direction in which the confederates were facing for the trials.

Consistent with the findings of Goal 3, there were significant main effects of Kick Distance and Team, with the additional main effect of Facing Direction. That is, the gap between the confederates was smaller when they were facing away from each other than when they were facing together. The significant interaction of Kick Distance x Team was repeated, with additional significant interactions between Kick Distance and Facing Direction, and between Team and Facing Direction. Furthermore, there was a significant 3-way interaction between the Kick Distance, Team, and Facing Direction factors. Two separate 2-factor repeated measures ANOVAs were conducted on Kick Distance and Team, one for each Facing Direction condition. The main effects of Kick Distance and Team were significant in both ANOVAs, though the Kick Distance x Team interaction was only significant in the Facing Together condition. That is, the difference in gap size

between the two Team conditions remained constant across the Kick Distance conditions in the Facing Away condition, with the difference in gap size increasing across the distances in the Facing Together condition.

In addition to building upon the findings discussed in the prior goal, the emergence of the 3-way interaction between Kick Distance, Team, and Facing Direction supports this hypothesis. That is, participants perceived a higher-order affordance that emerged from relations both between *and among* personal and interpersonal factors. Once again, this higher-order affordance was perceived as such, rather than an additive sum of its constituent affordances.

As with Experiment 2 discussed in Goal 3, long-term experience did not serve as a variable in this research. Consistent with the reasoning described in the above section, I would expect less-experienced, less-skilled, and/or younger players to have wider gaps between the confederates at each kick distance. Similarly, I would expect one of the two described outcomes to occur for the Team variable. Using the same reasoning, the Facing Direction variable may yield more accurate perceptual judgments for more-experienced players. However, if the gap-defining confederates were to be experience-, skill-, or age-matched to the participants, there may be consistency in the difference between gap sizes for each Facing Direction condition across the experience groups. That is, the difference in the gap size judged by a less-experienced player when defined by less-experienced confederates facing each other and less-experienced confederates facing away from one another may be statistically similar to the difference in gap size judged by a more-experienced player defined by more-experienced confederates facing each other and

more-experienced confederates facing away from one another, on account of the judged comparative nature of the abilities of the confederates. Once again, further research examining the effects of experience on the perception of higher-order affordances is required in order to resolve these open questions

Significance

The experiments in this dissertation, to my knowledge, were the first to investigate the perception of affordances for non-free kicks in soccer players, and the first to investigate the existence and perception of higher-order affordances in soccer. As such, this research was also the first to provide evidence for the direct perception of higher-order affordances in soccer, contributing to the ever-growing body of literature examining the perception of such affordances.

Along with being self-evident, it is well documented that athletic training improves athletic performance. However, in Chapter 2 of this dissertation, I expanded the literature and illustrated that beyond improvements in actual athletic ability, the experience of actually playing a soccer match was associated with changes in the ability to perceive their own kicking ability. While additional experience wasn't associated with general changes in affordance perception (that is, the perception of precision kicking was observed to be stable across age groups); the older, more experienced players were equally sensitive to their kicking abilities both before and after playing a soccer match, whereas younger, less experienced players were found to be less sensitive to their own kicking abilities before rather than after match play. Older players were knowledgeable enough about their kicking ability to understand that match play wouldn't alter their ability to kick the ball to a maximum distance, and younger players relied on short-term

experience to refine their perceptual sensitivity to their power kicking ability. This research offers a contribution to the lacking scientific literature about relations between perceptual sensitivity and physical ability in athletics, and specifically in youth soccer.

The statistically significant interactions I observed in Chapters 3 and 4 indicate the existence of a higher-order relationship between (or among) the interactive factors. That is, in Chapter 3, the egocentric gap distance was regulated by the simultaneous influence of social roles, and vice versa; and in Chapter 4, each of the three factors (gap distance, social role, and direction of attention) were simultaneously influenced by each other. The effect of the whole in each of these experiments was different from the sum of the effects of the parts. The interactions in the aforementioned Chapters were not trivial, as shown by the existence of other studies on the perception of affordances in which manipulations of multiple factors constituent of an affordance have failed to yield such statistically significant interactions (e.g. Wagman et al., 2019). Not every study examining the combination of non-affordance properties and/or lower-order affordances constituent of a given affordance yield the higher-order affordances observed in this dissertation. In addition to this, prior literature has predicted the absence of such statistically significant interactions. For example, researchers predicted and subsequently found that mass and rotational inertia would influence the perception of affordances for manipulating an object as main effects, independently, with no interaction between the two variables (Shockley, Grocki, Carello, & Turvey, 2001; Turvey, Shockley, & Carello, 1999). These results further illustrate that the statistically significant interactions observed in my research presented in Chapters 3 and 4 should be taken at face value.

That is, these results should be taken as an insight into the perception of higher-order affordances that differed qualitatively from their lower-order constituent parts. My results are relatively novel for the field of affordance perception, specifically the perception of affordances in athletics, and youth soccer.

A Field Analysis of Kicking in Soccer

The study of higher-order affordances for kicking in soccer is significant, especially when understanding them in relation to the "field of safe travel" (Figure 5-1) developed by Gibson and Crooks (1938) in their analysis of driving (see also Delucia & Jones, 2017; Marti, Morice, & Montagne, 2015). The "field of safe travel" was described as the areas of the road that drivers perceive as available for safe driving. That is, the field of possible paths which the car may take, unimpeded by obstacles, both static and other vehicles. The results I illustrated in Chapters 3 & 4 allow the proposition of an analogous concept within the domain of soccer, suggesting a "field of safe kicking".

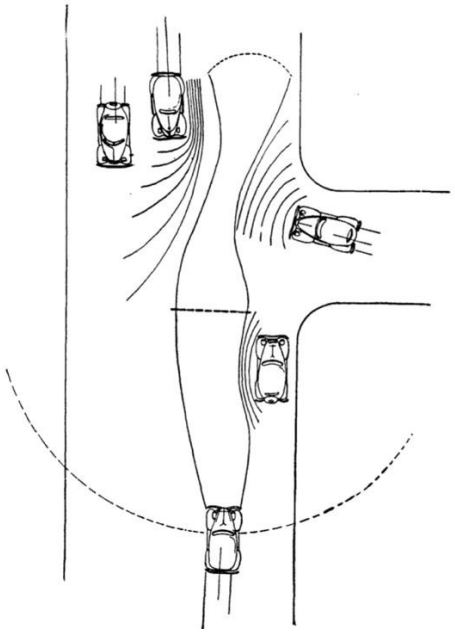

Figure 5-1: *The field of safe travel, reproduced from Gibson & Crooks (1938).*

` The "field of safe kicking" can be defined as the path the ball may take after being kicked by the participant without being impeded by other players. Specifically, from the results of Chapters 3 & 4, it can be argued that the reported that the minimum kickable gap widths at each egocentric distance (given the identity and facing direction of the people who defined the gaps) determined a field of safe kicking. Figure 5-2 below shows a composite of the data from Chapter 3. The figure presents the data from the four distance conditions simultaneously, thereby illustrating a field of safe kicking that was not actually present, but which was implicit in the perceptual reports.

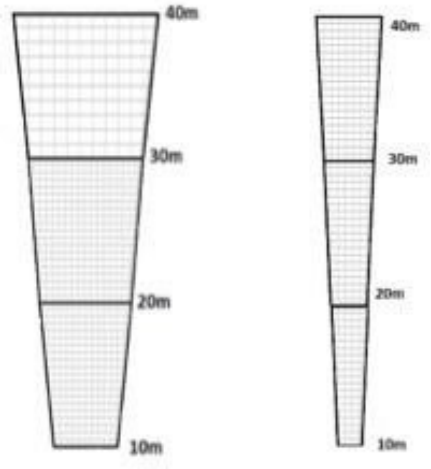

Figure 5-2: *The results from Chapter 3, re-drawn to illustrate the field of safe kicking as a function of Team. Left. Opponents. Right. Teammates. The figure shows an overhead perspective, with the participant standing at the bottom.*

For Gibson and Crooks (1938), the field of safe travel was both multidimensional and dynamic – they saw it as the consequence of many interacting components, changing in size and shape with the movements of the driver, as well as those of other drivers and pedestrians. In the research presented in this dissertation, the field of safe kicking was multidimensional – it was the consequence of multiple interacting components, but it was relatively static – it did not change in size or shape because neither the participant nor the

confederates could move freely. In this respect, this research contracts with real soccer games, in which the field of safe kicking will change in size and shape with the movements of players, including the player in possession of the ball, as well as their opponents and teammates (whom compress and stretch the field, respectively), and with several other variations and active changes in playing conditions. In Figure 5-3, a hypothetical field of safe kicking for a soccer game is presented, illustrating the dynamic nature of the field under game conditions.

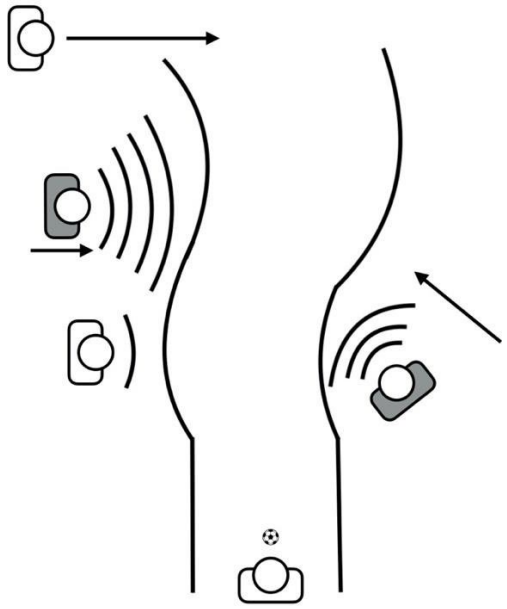

Figure 5-3: *Hypothetical field of safe kicking in a soccer game, illustrating the bulging, irregularly shaped field influenced by a realistic arrangement of players. White uniforms: Teammates. Dark Uniforms: Opponents.*

The field of safe travel proposed by Gibson and Crooks (1938) can, and should, be understood as a higher-order affordance and thus, the perception of the field of safe travel is the perception of a higher-order affordance (see Figure 5 from Delucia & Jones, 2017). Similarly, the field of safe kicking is a higher-order affordance, and the results of Chapters 3 & 4 demonstrate perception of this higher-order affordance as such (Figures

3-2, 4-2). The statistically significant interactions observed in these Chapters are consistent with the hypothesis that the field of safe kicking is a real feature of game play, and that players in actual game situations may be able to perceive it in all its dynamic elasticity. Learning to perceive this field of safe kicking directly as the higher-order affordance it is may be a critical component in the acquisition of soccer playing skill. The concept of affordances being defined, at least in part, by skills has been advocated in prior literature (e.g. Bruineberg, Chemero, & Rietveld, 2019). This has been supported by studies of human perceptual-motor development documenting the role of skill in defining affordances (e.g. Adolph & Hock, 2019).

Application

This dissertation provides insight into the perception of affordances in sports, specifically soccer, both as lower- and higher-order affordances and across experience levels. The effects of short-term experience on less-experienced soccer players could have implications for the development of novel coaching techniques, aimed at combatting the effects of fatigue after playing a match in younger players and/or at assisting younger players in better understanding the limitations of their own abilities. Real-world applications of these findings could be vital in the development of youth soccer players, as there are true consequences of misjudgments of power kicking ability in soccer match play. From a defensive play, a player attempting a "clearance" kick – one that relies on power to kick the ball as far away from the kicking player's own goal area to prevent the advancement of the opposing team – who is incapable of accurately judging their own maximum kicking distance could potentially turn over possession to the other team, leaving the kicking player's team at a disadvantage compared to their playing position

prior to the kick itself. A less-experienced player's inability to accurately judge their maximum kicking distance may also have consequences during offensive play. A player who cannot accurately judge their kicking distance may attempt a through-ball – that is passing a ball to a player making an off-ball run behind the opponents last line of defense - not kick the ball far enough to reach the teammate. This may lead to possession of the ball being overturned to the opponents, and/or a goalscoring opportunity never fully materializing. Another offensive consequence may be the player failing to attempt a pass that their kicking ability would allow on account of the individual misjudging their own kicking ability. With similar consequences to the failed through-ball, this failure to make the pass may lead to the player denying their own team a goal-scoring opportunity,

Approaching the findings from a different angle, the results of my dissertation could help guide youth soccer players away from attempting such kicking methods, instead opting for a series of precision kicks to advance the ball downfield and away from the danger of their own goal. That is, younger and less experienced soccer players may fair better if coaches prioritize short-distance, more precision focused passing, rather than long-distance power kicks. This could be applied in a variety of playing situations. For example, rather than attempting to reduce the opposing team's chances on goal via "clearance" kicks that require powerful kicks with accurate distance judgments, players may be better suited to repositioning to allow short, precision focused passes to retain possession and reduce the other team's attack. Furthermore, it may be beneficial for coaches to discourage longer-distance passes between players, instead opting for tactics that allow players to make multiple shorter passes to cover the same distance.

My results pertaining to the perception of higher-order affordances could also be utilized in future soccer training techniques. One such example of this may be attempts to attune youth players to the aforementioned field of safe kicking when training them how to respond to varying situations on the soccer pitch. This may be implemented by coaches setting up varying fields of safe kicking during training sessions, similar to the one shown in Figure 5-3. Coaches could attempt to teach players the point at which each field no longer is "safe". That is, through a series of exercises, players would be able to fine tune their perceptual abilities in order to determine the specific points at which each field of safe passing becomes unsafe. One such method of achieving this could be through varying the locations of teammates and confederates acting as opponents marking the field of safe kicking, and having players continually judge when the field is safe versus unsafe. While the dynamic nature of the field of safe kicking makes it impossible for trainers and players alike to account for every possible situation, the mere exposure to and experience of the field of safe kicking could yield finer perceptual abilities for perceiving the everchanging situations arising from match-play soccer.

Future Research

My dissertation research spark raises further questions on the perception of affordances in soccer, both due to the limitations of the study designs as well as the results of the research conducted. One limitation of my research that is present across Chapters 2-4 arises from the inability to separate age from experience (as shown in Chang, et al., 2008). Instead, participants from a youth soccer league that differed in both age and experience were compared. Typically, in countries where soccer is the dominant sport (i.e. Turkey) at the ages of the participants used in this research (U16, U18),

experience and age will align. That is, players usually begin playing soccer at a young age, and continue playing through young adulthood. Professional soccer academies often have teams representing the U13 level, three age groups below the youngest participants used. In professional soccer academies, different characteristics are of differing levels of importance depending on the age range of the players, with speed and technical skills taking priority in U13 and U14 age groups and cardiorespiratory endurance being more valuable in U15 and U16 age groups (Vaeyens, et al., 2006). The value of these skills goes to illustrate the issue of separating age from experience, especially with the popularity of sports such as soccer. As such, future research may be better suited to examining a broader range of age groups, with the ideal participant pool being drawn from a soccer club with age groups from U13-U18 at minimum. This may be extended by including U21 teams (the last pre-senior age group in semi- and full-professional soccer clubs), and senior teams for a broader comparison.

Developmental differences also create further issues when trying to separate age, experience, and skill in sporting domains. For example, even by using a broader sample of age-grouped soccer teams, researchers could not be sure that experience or skill was being examined over naturalistic developmental differences between ages. One such example of this is the increase in quadricep strength, especially for boys, which accelerates between the ages of 13-17 (Jones & Round, 2008). Pertaining to this dissertation, one may assume that an increase in muscle strength would also translate to an increase in kicking power, and as such, sport-specific experience (or skill) may be mediated by this increase. Changes in anaerobic performance have also been shown as

being linearly correlated to age in adolescents (Falk & Bar-Or, 1993), illustrating further difficulties separating developmental changes from age-mediated experience differences in youths. Furthermore, one can not guarantee that all players on the more junior team are less skilled than those on the more senior team. That is, it is conceivable that the U16 team may have had one or two standout players that were of a higher sport-specific skill level than some players on the U18 team. Anecdotally, many youth soccer leagues across the world accommodate for this by allowing players younger than the team's nominal age to "move up" and play for a more senior team, often allowing up players to play above their age by up to two years. This is true in Turkish youth soccer leagues, though it was not seen in our research. To counter these difficulties, future research should include quantitative measures of the youth soccer players' physical abilities, in terms of strength and endurance, as well as soccer-specific skills. Furthermore, in research examining a broader range of youth soccer teams in an attempt to mediate the age and experience confounds, a combine-style event should be held by all coaches prior to separating the players into skill-related groupings of "teams".

Specific to Chapter 2, a limitation of the design was the choice to not include a measure of fatigue. Piipers et al. (2007) examined the perception of affordances in climbers with no prior experience who repeatedly climbed the same wall to fatigue, with fatigue being assessed using ratings scales. It was found that fatigue reduced actual maximum reaching ability for climbing, though changes in perceived reaching ability was more related to changes in actual reaching ability than fatigue ratings. However, considering the lack of fatigue measurements included in this dissertation research, it is

unknown if the effects of fatigue are sport- or task-specific. In Chapter 2, I did not observe any effects of match play on actual kicking ability, which may signify that soccer players are better physically conditioned, such that fatigue effects may be less than those seen in novices. That said, considering the effects of match play on the perception of power kicking abilities in younger players, I suggest that future research considers taking measures of fatigue to assess any potential effects on perception, specifically in youth soccer.

The results of my research presented in Chapters 3-4 motivate future research on the perception of higher-order affordances in soccer and other sports. Such research may build on the concept of affordances being defined by skill by extending the variation of skill level (or as discussed earlier in this section, age) to include that of the confederates defining the gaps. That is, examining how participants perceive the "field of safe kicking" when younger, less experienced players serve as the gap-defining confederates; versus when older, more experienced players are defining the gaps through which the ball is intended to be kicked through. This research would be especially pertinent should the researcher extend the age groups used in the study. It could be hypothesized that, the younger and less experienced the confederate, the smaller the gap through which the ball could be kicked, across the age ranges of participants. Furthermore, this research may be extended to other team sports while still utilizing a similar methodology. Sports such as hockey (both ice hockey and field hockey), basketball, lacrosse, water polo, and others, all utilize passing techniques to advance the game ball (or puck) between players of the same team while opponents attempt to intercept said passes. By applying the

methodology shown in Chapters 3-4, it can be examined whether or not similar “fields of safe passing” are present in these sports.

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