UNIVERSITY OF TURKU

ABSTRACT

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Many ice hockey players and experts intuitively acknowledge that some players are better at in-game anticipation than others. Currently there are no explanations for the supposed differences between players with equal expertise. This may be because our understanding of anticipation in invasion team sports like ice hockey is undermined by the challenge of measuring it; as a systemic and emergent phenomenon, anticipation requires holistic approaches beyond traditional sports science.

This thesis investigates the relationship between professional ice hockey players' in-game performance metrics and anticipatory capacities, measured using the Futures Consciousness Scale (FC Scale). Forty-seven professional ice hockey players playing in the Finnish National Hockey League during the 2022/23 season were tested with the FC Scale, and several of their in-game performance metrics were gathered. Data was analysed by means of correlation analysis.

Initial analysis of FC scores and in-game performance metrics revealed no significant correlations at a population level. Subgroup analysis showed distinct patterns for different player roles. Defenders with higher FC levels, especially in two of the five dimensions: Agency Beliefs and Concern for Others, performed better in all in-game metrics, including goals, assists, points, and skating distance. Conversely, forwards generally exhibited weak negative correlations between FC and their performance metrics. Further item-level analysis supported these trends.

The findings of this study emphasize the importance of comprehensive approaches, integrating cognitive functions and decision-making processes, to understanding anticipation in invasion team sports. Additionally, the study highlights the necessity for specialized research methods tailored to invasion team sports to investigate players' individual anticipatory capacities. Further research is also needed to explore how player roles and other in-game dynamics impact anticipation in ice hockey and similar sports.

Key words	Futures Consciousness, anticipation, anticipatory capacities, expert anticipation, decision-making, ice hockey, invasion team sports

UNIVERSITY OF TURKU
Turku School of Economics

HOW IS PLAYERS' FUTURES CONSCIOUSNESS ASSOCIATED WITH ANTICIPATION IN ICE HOCKEY?

Master's thesis
in Futures Studies

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1 INTRODUCTION

The greatest ice hockey player of all time – Wayne Gretzky – has said that "*Good players play where the puck is, great players play where the puck is going to be*". This statement has since been repeated numerous times in many different contexts ranging from sports to strategic management. Like the man himself, many of his quotes have become so famous that one simply cannot write a thesis on anticipation and ice hockey without quoting the Great One.

Gretzky's quote serves a double purpose in this thesis. First, as an introduction to the importance of anticipation in ice hockey and second, as the primary catalyst for undertaking this research. Gretzky's proficiency in anticipation was arguably a significant factor in his unparalleled success in ice hockey. Many ice hockey players and coaches also intuitively recognize that some players are better at thinking and playing ahead in the game than others. However, there seems to be no consensus on why this is. This fact calls for more interest towards understanding why certain individuals excel in anticipation.

1.1 Anticipation in Sports Science

So far anticipation research in sports science has focused on the expertise-anticipation relationship as well as the perceptual-cognitive mechanisms of anticipation (Williams & Jackson, 2019). The research conducted by de Groot (1946) as well as Simon and Chase (1973) establish the theoretical background for this thesis, as their studies explain the perceptual mechanisms and knowledge structures on which both expertise and anticipation in any sport relies upon. The bulk of our understanding on anticipation in sports also comes from similar studies that contrast novice and expert players, rather than comparisons of professional players with their peers (Williams & Jackson, 2019). It has been well established that the heightened anticipation capability of experts within their sport comes from their large amounts of sport-specific expertise acquired through sustained periods of domain specific play and practice (Loffing & Cañal-Bruland, 2017). The experts' proficiency enables them to focus on crucial elements and discern key signals through their senses, a capability less experienced novices lack, making experts more proficient in anticipating movements and patterns within their domain.

Concerning the literature on anticipation in sports science, a more accurate version of the ”Gretzky quote” would then be: a novice player goes where the puck is, an expert player goes where the puck is going to be. However, it is evident that the anticipation discussed in sports science cannot be equated with the phenomenon Gretzky referred to. He specifically spoke about himself and his fellow National Hockey League (NHL) players, who were the crème de la crème of ice hockey, each being an expert. In other words, Gretzky's quote acknowledges that there are differences in anticipation even between experts that the current understanding of anticipation in sports science does not explain.

Initially, this seemed like a too challenging puzzle to work out, considering my background as a former junior ice hockey player and current master's student—I lack expertise in both studying anticipation and professional ice hockey. However, it suddenly hit me that the puzzle was missing a piece. What if instead of diving deeper into the details what is needed is a broader view on anticipation in sports? To find out what could explain the individual differences in anticipation, we should look beyond traditional sports science to understand how ice hockey players as anticipatory systems interact within complex systems.

1.2 Ice Hockey as a Complex and Dynamic System

In the field of sports science, much of the current research on anticipation originates from sports like tennis or volleyball (Williams & Jackson, 2019). These are sports which have altogether different dynamics from invasion team sports such as ice hockey. This raises questions on how well the findings from one context can be applied to another.

Modern sports science views ice hockey together with other invasion team sports (e.g. football, basketball, rugby) as complex and dynamic systems (McGarry et al., 2002; Travassos et al, 2013). These are sports where two opposing teams aim to invade each other's territory to score points, while adapting and responding to rapidly changing contextual conditions. In invasion team sports, the competition and cooperation between individual players create an interconnected network, where player movements display self-organization (McGarry et al., 2002). This self-organization, rooted in interpersonal interaction and information exchange (Travassos et al., 2013), makes invasion team sports inherently unpredictable. This means that specific outcomes of player interactions are often impossible to predict in advance, as even small changes can lead to completely different results. (Passos, Araujo & Davids, 2013, 3.)

According to Pol et al. (2020) traditional sports science, dominated by reductionism, struggles to approach invasion team sports as complex and dynamic systems. The reductionist perspective predominantly focuses on isolating and studying specific physical attributes or quantifiable cognitive abilities (like IQ), in the process often treating athletes as “human machines” (Nadin, 2015). By simplifying complex processes through reductionism, as well as by breaking down systems into smaller, more manageable components for analysis traditional sports science is neglecting the holistic and emergent nature of complex and dynamic systems where the whole is more than the sum of its parts. The reductionist approach is especially ill-suited for studying anticipation because anticipation is systemic in nature, encompassing various interconnected aspects of cognition and perception (Nadin, 2015).

1.3 Human Anticipatory Capacities

In response to these challenges, this thesis proposes Rosen's (1985) anticipatory systems theory as a holistic alternative for understanding anticipation in invasion team sports. According to Rosen every living organism has a predictive model of itself and is anticipatory by its nature. The work by Poli (2010; 2014), Ahvenharju, Minkkinen, and Lalot (2018), and Ahvenharju (2022) connects Rosen’s anticipatory systems theory to anticipation engaged by individuals and groups of people. Anticipation, as per Rosen requires various functions from organisms which he calls anticipatory capacities. Like other biological systems, we humans have our own anticipatory capacities, which include functions enabling us to process, reflect, and evaluate information needed for anticipatory actions. Ahvenharju et al. (2018) recognize that human anticipatory capacities consist of interplay of cognitive functions and inherent qualities. These capacities, unique to everyone, are formed by cognitive functions like perception and memory, along with other central qualities such as habits and the people we interact with.

Ahvenharju et al. (2018) have developed the five-dimensional concept of Futures Consciousness based on what they identified as essential qualities for this capacity. Futures Consciousness consists of five dimensions: 1) Time Perspective, 2) Agency Beliefs, 3) Openness to Alternatives, 4) Systems Perception, and 5) Concern for Others. According to Ahvenharju et al. differences in Futures Consciousness can explain variations in individuals' abilities to understand, anticipate, prepare for, and embrace the future. Lalot et al. (2019; 2021) have operationalized Futures Consciousness into a

Futures Consciousness Scale, a psychometric instrument used to measure individual differences in anticipatory capacities.

In summary, through Rosen's framework players can be approached as dynamic wholes emphasizing the interconnectedness of various aspects of anticipation. This holistic approach considers not only physical attributes but also cognitive functions and other central qualities, thus providing a more nuanced understanding of sport performance dynamics. Ice hockey players, as anticipatory systems are viewed as integrated entities where the whole is more than the sum of its parts. Futures Consciousness offers a framework and method to examine individual differences in anticipation, enabling the exploration of the cognitive aspects of anticipation (Figure 1).

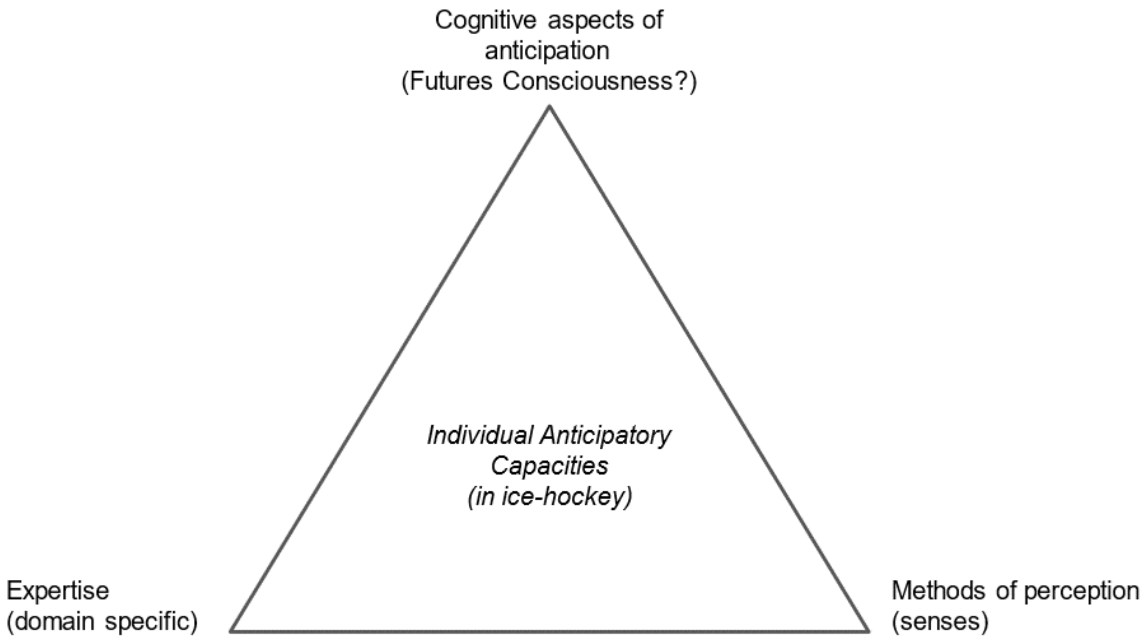

Figure 1. The missing piece?

1.4 Research Question and Structure of the Thesis

This thesis attempts to build a bridge between the field of sports science, dominated by reductionist tendencies, and the holistic view of anticipation found in Rosen's anticipatory systems theory. Its aim is to explore if individual differences in anticipation in ice hockey could be explained by the differences in players' anticipatory capacities. Additionally, the thesis attempts to understand how these unique anticipatory capacities influence players' in-game performance metrics.

The game of ice hockey was chosen as the research topic, because of ice hockey's complex and dynamic nature as an invasion team sport which requires both simple and complex anticipation. Even among other invasion team sports ice hockey is characterized by its fast-paced skating, rapid changes of speed and direction well as overall physicality (Vigh-Larsen & Mohr, 2024). Both speed of play and physicality of ice hockey create clear situational demands for anticipation, as players must anticipate player movements to keep up with the game while also protecting themselves. Studying ice hockey also provided access to a large variety of in-game statistics as well as enabled comparisons among fully professional players.

This thesis aims to answer the following research question:

- To which extent Futures Consciousness is associated with the differences in in-game anticipation between expert ice hockey players?

To answer the research question, this thesis lays the theoretical groundwork connecting a wide range of subjects related to anticipation and ice hockey. The theoretical framework (illustrated in Figure 2) presents anticipation as a broad phenomenon before narrowing down to anticipation in invasion team sports and ice hockey. The last two parts of the theoretical framework examine possible reasons and explanations for individual differences in expert anticipation. The final part introduces the concept of Futures Consciousness as a potential explanation for individual differences in anticipation, along with the Futures Consciousness Scale as a tool for assessing and comparing individual anticipatory capacities.

Following the theoretical framework, the Futures Consciousness Scale was employed to measure the individual Futures Consciousness levels of a group of professional ice hockey players from four different teams. Furthermore, a variety of the players' in-game performance statistics (goals, assists, points, plus-minus score, time on ice, and skating distance) during the regular season of 2022/23 were gathered. Data was analysed by means of correlation analysis.

The results section displays the outcomes of correlation analyses between the ice hockey players' in-game performance variables and Futures Consciousness. The results are analysed across all players and separately for forwards and defenders.

In the discussion section, the main findings of the study are outlined and discussed. The section explores the implications of the study's main findings, highlights theoretical and methodological limitations in the research process, and considers opportunities for further research.

2 ANTICIPATION

There has been a steadily growing interest in anticipation within sports science (Williams & Jackson, 2019). It is essential for sports researchers and practitioners to understand that anticipation as a phenomenon is not limited to sports, nor is it confined to human sciences. Although this thesis focuses on anticipation in sports, it also aims to connect the broader body of research on anticipation with the specific research conducted in sports science. Building this connection is especially important in this chapter, which seeks to understand the complex phenomenon of anticipation from the perspective of ice hockey.

This chapter presents the theoretical background for this thesis. It begins with an introduction to anticipatory studies, spanning from biology to sports. It then explores the expertise-anticipation relationship and the perceptual-cognitive functions supporting anticipation in sports. The next three sections delve into the importance of anticipation in sports, particularly in invasion team sports like ice hockey, and assess possible explanations for individual differences in anticipation. The final section introduces the concept of Futures Consciousness as the human anticipatory capacity and a potential explanation for differences in players' in-game anticipation.

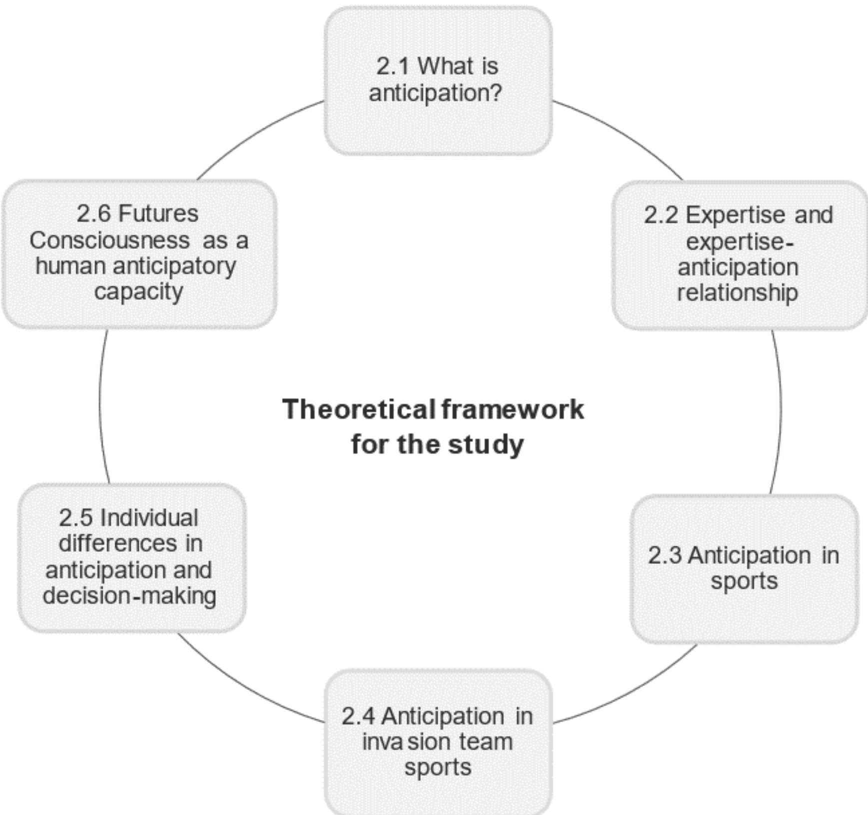

Figure 2. The theoretical framework for the study.

2.1 What is Anticipation?

To study anticipation, one must first understand anticipation, which translated from Latin means "to see forward". Anticipation is at the intersection of ideas on time, perception, change, causality, and free will, all ideas that have been at the centre of philosophical discussions since people started having them (Ernst, 1955, as cited in Froeyman, 2010). Throughout history, being able to anticipate something with a high degree of accuracy has been regarded as a supernatural act in cultures around the world. Regardless of the mystery and obscurity surrounding anticipation, it is a very real phenomenon, and essential for surviving and thriving. Modern findings in neuroscience have argued that the human brain is inherently proactive and continuously generates predictions that guide our actions and thinking (Bar, 2007). These predictions are formed by combining information from our environment with our previous experiences and knowledge stored in memory through anticipatory processes.

Anticipation is present in everything we do. It affects the way we see, think of, and act in the world. Attempting to understand what anticipation is, how and why it happens, and how anticipation can be developed for practical purposes has produced a plethora of research across multiple disciplines. Thus far, anticipation has been studied in array of fields including but not limited to physics (Whitehead, 1929; Feynman, 1982; Dubois, 2000), economics (King, 1938; Klir, 2002a, 2002b), computer science (Svoboda, 1960; Feynman, 1982), biology (Rosen, 1985), psychology (Huron, 2008), neuroscience (Bubic et al., 2010), futures studies (Poli, 2010; Ahvenharju, 2022), and sports science (Jones & Miles, 1978; Williams & Jackson, 2019). The definition and significance given to anticipation varies from something that has practical value (e.g., in computer science and sports science) to being the key feature that distinguishes the living from non-living (Rosen, 1985).

This fragmentation of anticipation research makes it difficult to see anticipation as one clearly defined phenomenon and has led one of the most prominent anticipation researchers Mihai Nadin (2010, 35) to state that anticipation research has become too specialized and more generalized approaches are needed. According to Nadin, theoretic and applied research in anticipation has produced an impressive body of knowledge, but because the scope and focus of researchers has often been limited within their own disciplines and there has not been enough exchange across disciplines, anticipation research has developed into a field that is data-rich but theory-poor. Miller brings up a similar observation pointing the lack of collected data and systematic comparison of results between different disciplines (2018, 53).

A more general approach to anticipation research can be found within the field of futures studies. One general definition for anticipation is given by a futurist Roberto Poli, who writes that anticipation can be understood as the use of future in the present (2010). To put it in other words, we start with the end in mind and alter our behaviour based on the expectations we have. Anticipation, according to Poli, is a result of variety of processes, which appear to us as autonomous, and often lead to increased performance (like avoiding possible dangers or seizing opportunities). This means that our expectations of the potential future events guide actions and decision-making in the present. Like when deciding whether to pack an umbrella for a weekend trip depends on if you anticipate rain or not (see De Jouvenel, 1967, 86–87). "Anticipation really is about the impact of a prediction or expectation on current behaviour", as stated by Nahodil, and Vitků (2012, 5). Although not included in Poli's or Nahdodil and Vitků's definitions of anticipation, the definitions also hint that we not only use the future in the present but the past as well. When deciding to pack the umbrella you might consider your previous experiences of the usefulness of an umbrella and information concerning the likelihood of rain based on the time of the year.

According to Robert Rosen (1985) a pioneer of anticipation studies, not just us humans but all life by its nature is anticipatory and anticipation is not something we do, but rather something we are. Rosen describes all living organisms as beings always on the move through time and hovering in the present moment, while having one foot in the past and the other in the future. It is important though, as Miller (2019) states, to draw a distinction between the fundamentally different non-conscious anticipatory systems of bacteria and plants and the conscious and learned human anticipation. Possibly because of his approach as a theoretical biologist Rosen did not make this distinction as clearly, but to make things easy for the reader henceforth in the text anticipation will only refer to human anticipation. According to Rosen all anticipation relies on the anticipator having some kind of model of what they expect will happen in the future. The models are built on information from earlier experiences of the anticipator on themselves and of the environment around them. Rosen defines an anticipatory system as any system – whether biological, social or artificial – that contains an internal predictive model of itself and of its environment. This capacity allows the system to change its state in anticipation based on the model's predictions regarding future states (Rosen, 1985, 341).

Through the anticipatory processes it becomes possible for life to be proactive rather than only being reactive (Nadin, 2012). An anticipatory system is based on a feedforward mechanism as opposed to feedback mechanism. This means that anticipatory systems can act proactively and will not have to rely on external pressure to react. Anticipation is not limited to human behaviour, but we humans have highly developed anticipatory capacities that allow us to act proactively. Although uncertainty is an inherent part of life and our world, there exists many causal regularities in our living environments. We use these environmental causal regularities to direct our behaviour. In other words, our actions and decisions in the present are affected by both our past experiences as well as expectations of the future. For example, in ice hockey when goalies and defenders anticipate if a forward controlling the puck is going to shoot, pass or dribble, they use their knowledge from similar past situations to evaluate the likelihood of possible options. (Louie, 2010.)

We automatically assigning probabilities to the patterns and regularities we encounter (Sanborn & Chater, 2016). When learning that certain actions or sequences are likely to lead to certain outcomes, we have created an internal predictive model to use in anticipation of the future. Some factors are thought to be more consistent and therefore we consider them as more reliable. We assign probability and reliability values for different factors, which are considered in construction of predictive models. If an internal model of your own capabilities and environmental factors is accurate, you are likely to reach an anticipated state in the future, conversely if you fail to take some situational factors into account you might not be able to fully realize the anticipated outcome. (Louie, 2010.)

The success of an anticipatory system is tied in its ability to model itself and its environment. The information used in creation of the anticipatory models derives from past experiences and acquired knowledge as well as through senses in the present (Bar, 2007). When identifying cues of familiar patterns in its environment an anticipatory system can act according to its predictive models and respond appropriately in advance. The predictive models are only as good as the information that is used in construction of the models. Because we experience the world through our senses and interpret what we experience through previous experiences and emotions, the information used in construction of the models can be biased and / or limited. Interpretation errors happen especially in ambiguous situations (Schoth & Liossi, 2017). New information and experiences will test the models based on how accurate they prove to be, and confirmation leads to higher confidence in the prediction while failure should lead to lesser confidence and therefore also possible changes in the model (Louie, 2010).

It is important to recognize that failure is an integral part of anticipatory systems, and an error does not mean that anticipation is not taking place. Errors in anticipatory systems happen all the time because the models of anticipatory systems are not perfect representations of themselves or the environment. In fact, a model of any real system is incomplete since the systems are more than their models. Apart from inaccurate modelling failure in an anticipatory system can also result from the system using defective effectors. Effectors are the parts of the system that respond to detected stimulus according to the instructions they have. For example, in sports, the athlete's brain plans and orchestrates vital effectors such as the athlete's hands, feet and eyes (Gallivan et al., 2011). An effector is defective when it does not have the appropriate effect to the anticipatory system, or it fails to react accordingly to the information from internal models (Louie, 2010). Anticipatory systems can sometimes produce unintended side effects, which can result from people using incomplete models and/ or defective effectors. One example of such is the well-known left-handed advantage in interactive sports, which originates from the fact that most athletes are right-handed and therefore athletes are also more accustomed to play against right-handed athletes (Hagemann, 2009).

Another way to understand anticipation is provided by Klein, Snowden, and Pin (2011) through anticipatory thinking. They describe anticipatory thinking as "critical macrocognitive function for individuals and teams" (2011, 1). According to Klein et al. the function of anticipatory thinking is preparing for the future, not only attempting to predict it, though it is somewhat overlapped with making predictions and forecasts. While predictions and forecasts are attempts to estimate certain future states, anticipatory thinking is concerned about how to make sense of and to prepare for the sometimes-overwhelming inherent ambiguities and uncertainties of future in the present. Because anticipatory thinking considers the potential events, not just the most likely ones, it helps us to recognize and prepare for also the possible unknown future challenges.

Anticipatory thinking depends on cognitive functions which include attention, memory, executive function, situation awareness, and domain expertise (Koziol et al., 2012; Mullally and Maguire, 2014). Klein et al. (2011) also include active attention management into their definition of anticipatory thinking, because of its role in focusing on the sources of information that are likely to be important. Learning where to search and focus to gain information about probable future developments is a key part of anticipation. In dynamic and complex environments, not every source of information is important and misplacing one's attention can sometimes be futile or misleading. According to Klein et al. (2011, 1) anticipatory thinking should not be regarded as attempting to predict what is going to happen. Rather it is about gambling with our attention to monitor some events we expect are important while risking ignoring or downplaying others. We do this by using our own experience as well as acquired knowledge to find patterns and meaning in our environment to approach the future, and to evaluate what we think is important and what is less important.

The are two basic theories on how people deal with excess information and integration of multiple information sources: simple heuristics model and Bayesian integration model. Simple heuristics, commonly known as rules of thumb, are decision tools / strategies which are proven to work in the past to a satisfactory degree. Simple heuristics are used to make fast and accurate decisions within challenging informational environments in ways that deliberately ignore parts of the available information. According to Raab (2012) athletes use simple heuristics such as the 'take the first' (option) in complex situations to respond faster and more accurately. Tversky and Kahneman (1974) famously argued that although simple heuristics are useful, relying on them sometimes produces unintended biases in decision-making. Recently the simple heuristics model has also been criticized for being unable to explain the integration of information necessary for anticipation (Helm et al., 2020).

Bayesian decision theory suggests that people weigh the influence of the information sources based on their experience of the credibility or certainty of that information. People frequently update their level of trust in different information sources as more information and evidence becomes available. Research on perception and sensorimotor learning demonstrates that in many circumstances people are able to act in ways that are consistent with and ideal Bayesian decision maker (Vilares & Kording, 2011). Gredin, Bishop, et al., (2023) have recently studied contextual priors and their importance on anticipation in sports and advocate for a wider adaption of the Bayesian framework in sports and sports science.

The amount of experience one has within a domain is linked with the ability to anticipate and make decisions to a higher degree of accuracy within the domain (Ericsson, 2018). This is especially true in sports, where the ability to anticipate opponent's or teammate's actions is strongly related to the amount of expertise one has within the sport (Gredin, Broadbent, et al., 2023). In the field of sports science, the relationship between perceptual-cognitive expertise and anticipation is well established. The mechanisms behind perceptual-cognitive expertise and the extent to which domain expertise can explain the individual differences in anticipatory capacity are less well understood. Before we can attempt to further our understanding on how anticipatory capacities can vary among experts, we need to understand how expertise affects anticipation. This is the topic of the next chapter which will be a wide-ranging look at the research conducted on expertise as well as on expertise-anticipation relationship.

2.2 Expertise and Expertise-anticipation Relationship

"Expertise is a prime example of how various cognitive processes, such as memory, attention, and perception, come together to enable a truly magnificent performance."

(Bilalić & Campitelli 2018, 233.)

The modern research on expert performance originates from de Groot's now famous (1946;1978) studies on how people with different levels of expertise approach the same problems in chess. Before de Groot it was assumed that chess experts prevailed through their superior intellectual capacity to analyse possible moves in both greater quantity and depth. Through his studies De Groot was able to demonstrate that chess experts had a fundamentally different approach to information gathering and decision-making (seeing and thinking) than novices in chess. What differentiates expert players from novices was their ability to generate high quality solutions with the first glance, not the depth of their subsequent analysis. The remarkable thing in de Groot's findings is that later work by other researchers which has shown that the expert-novice differences de Groot found are not restricted to chess.

In his first research de Groot (1946) studied the performance differences between two groups of high-level chess players: grand masters (the most skilled players) and candidate masters (very good players). De Groot found that although the grand masters on average found better moves and found them faster, there was little difference between how the grand masters and candidate masters approached finding the moves. In his later 1978 study de Groot asked chess-players from experts to novices to recall different positions on a chessboard after only seeing the position briefly (for 2–17 sec). De Groot found that master level chess players were able to reconstruct a chess position on the board almost perfectly while players below master level did much worse in the task. He also concluded that the performance was directly related to the amount of skill the players had, higher ranked players did better than medium ranked players who in turn did better than players with lower rankings. De Groot's findings suggested that world-class chess players were able to perceive the best chess moves based on their initial perception of the position rather than through an extensive search of possible options like was thought before.

Later work on expert memory structures in chess by Chase and Simon (1973) give more insight to de Groot's findings. Chase and Simon asked chess players ranging from experts to novices to reproduce chess positions they were shown briefly. In the first round the players were shown meaningful chess positions, ones that could be from an actual game of chess, and the expert players outperformed the novice players in the reproduction task by a wide margin. Later in the second round of the study, players were shown another chess position, this time a meaningless position where the pieces were assigned randomly. This time the expert players showed only a slight advantage over the novice players in reproducing the position.

Chase and Simon deduced that because the experts did significantly better with the meaningful positions but not with the meaningless positions the expert advantage was not due to them having a better general memory ability. Instead, they hypothesized that expert chess players' advantage derived from their ability to perceive structure in meaningful positions and to encode them in chunks. Rather than recalling a group of unconnected chess pieces like the novice players did, expert players recalled chunks of four to five pieces bound by their roles and relations (the patterns) with each other and then organized the chunks into a single relational structure with a remarkable accuracy. They were able to do this because, as Chase and Simon argued, through many years of deliberate chess practice, the expert players had developed enormous amounts of chess specific knowledge (50,000 to 100,000 chunks) and the ability to perform pattern-based retrievals from their memory. The reason why expert players performed worse when the pieces were assigned randomly, was because they struggled to recognize any familiar patterns from unfamiliar positions. Based on the results of their studies, Chase and Simon hypothesized that individual differences in the level of expertise can be explained by the number of chunks individuals hold in their long-term memory.

Since de Groot, Chase, and Simon the research on expert performance has expanded beyond chess to cover many different fields, often focusing on the differences between experts and novices. The expert's ability to effectively chunk information has been widely established in such diverse domains as e.g., music (Sloboda, 1976), the Chinese board game GO (Reitman, 1976), basketball (Allard, Graham & Paarsalu, 1980), ice hockey (Mulligan, McCracken, & Hodges, 2012), as well as many others. Simon and Chase (1973) were the first to propose that developing domain specific knowledge and the ability to perform pattern-based withdrawal through many years of practice was the prerequisite for expertise in chess. Nearly 50 years later, Ericsson et al. (2018) echoed this by stating that the domain-specific memory which is acquired through deliberate practice and exposure within a domain of specialization is at the core of all types of expertise.

Gobet and Simon (1996) updated Chase and Simon's chunking theory by introducing the template theory of expertise. They proposed that experts evolve their chunks of knowledge into larger memory structures they called templates, which unlike chunks are stored in long-term memory. Templates consist of reoccurring environmental patterns that develop into complex data structures. Templates are open structures that have slots which additional information could be added in, such as smaller configurations (i.e., chunks) or conceptual knowledge (i.e., general strategies). According to Campitelli (2015), remembering knowledge is an active process where new knowledge is built into the existing knowledge structures. Before receiving the incoming information, the relevant knowledge structures in the brain are activated in anticipation of the to-be-remembered information. In this process, new information is being perceived and analysed through the existing knowledge and the new information is either disregarded or used in updating the knowledge structures in long-term memory.

Ericsson, Krampe and Tesch-Römer (1993) argued that for anyone to achieve the highest level of human performance in any domain at least ten years of daily deliberate practice activities is required. According to Ericsson et al. ten years of daily practice does not guarantee expertise in any specific domain, but it seems to be the minimal requirement for anyone to compete successfully on an international level. The findings of Ericsson and Lehman (1996) later seemed to confirm the 10-Year Rule in multiple different domains such as sports, chess, medicine, auditing, computer programming, bridge, physics, typing, juggling, dance, and music.

Later research by Côté (1999) somewhat questioned the importance of deliberate practice in developing expertise in sports. According to Côté, deliberate practice is needed to develop expertise, but the role of other sports related activities, such as engaging in deliberate play, organized games and doing other sports, are equally if not more important. In their study (2003), Soberlak and Côté estimated that elite level ice hockey players accumulated, on average, three thousand hours of deliberate practice and over three thousand hours of deliberate play from the age of 6 to 20. Additionally, they spent over two thousand hours in organized games and one thousand hours in various other sports activities. Their findings raise questions about Ericsson, Krampe, and Tesch-Romer's 10-Year Rule and the predominant role of deliberate practice in expertise development when considering the total hours across all sports-related activities.

Subsequent studies have also shown that engaging in deliberate play is beneficial for improving tactical performance in team sports (Greco, Memmert & Morales, 2010) and that high engagement in sport specific play activities during childhood is essential for developing anticipation and decision-making skills (Roca, Williams & Ford, 2012). Furthermore, variable, and multidisciplinary engagement in sports during childhood is important for development of excellence, while too early single-sport specialization together with specialized practice can compromise the sustainability of an athlete's long-term development (Güllich, Macnamara & Hambrick, 2022).

Neuroimaging studies of experts and non-experts reveal that acquiring expertise leads to measurable physical changes in the expert's brain (Debarnot et al., 2014). This is due to neuroplasticity: the brain's ability to form and reorganize its structure, functions, and connections in response to learning through experience or after suffering an injury. Similarly, to the experts themselves the expert's brain also specializes through sustained experience within a specific domain. When performing domain specific tasks experts' brains show decreased overall activity but increased activity in the specific brain areas. This is because the expert's brain activity is focused more on the areas responsible for performing the task. Through sustained practice the experts' brains develop more to become more efficient in domain specific tasks and the execution of tasks requires fewer active neurons (Krings et al., 2000) or simply less attention (Floyer-Lea & Matthews, 2004).

According to Brams et al. (2019), individuals use their perceptual-cognitive skills to gain information from the environment and combine that information with their prior knowledge to evaluate the situation, process stimuli, and execute appropriate responses on complex tasks. The perceptual-cognitive skills are at the heart of expertise and have been linked to superior performance in domains that involve actions in complex and dynamic environments like sports (Mann, Williams, Ward & Janelle, 2007) and aviation (Schriver, Morrow, Wickens & Talleur, 2008). Although the role of perceptual-cognitive skills for performing in complex environments is well recognized, it is often presented without the acknowledgment of how past experiences shape how we view and analyse our environments.

The work of Stokes et al. (2012) demonstrates that people use statistical regularities of the environment drawn from their experiences stored in long-term memory to not just guide anticipatory attention and actions, but to also interpret the present. The links between memory attention, behaviour and perception do not just exist, but they are all integrated processes. We place attention on things we find important based on our previous experiences, act in ways that have worked for us in the past in similar situations and experience the reality through our learned experiences.

Experts can draw predictive information from their vast amounts of domain information stored in long-term memory to guide their attention and optimize perception (Stokes et al., 2012, 360). Knowing ahead where to look for likely relevant information allows experts to focus on the most important information sources in advance and to ignore irrelevant stimuli. Because human working memory is limited, drawing from long-term memory to direct attention allows experts to be more efficient in complex environments where there is an overabundance of information (Rosen, Stern & Somers, 2014). Meta-analyses of eye-tracking research from various sports by Mann et al. (2007) and Gegenfurtner, Lehtinen and Säljö (2011) have also included physical differences between experts and novice athletes in search strategies, visual gaze-behaviour and processing speed when encountering domain specific situations, to explain visual expertise and anticipation.

People engage in and rely on anticipation especially in situations where the temporal demands for action are high. Anticipation not only manifests in the superior performance of experts, but also plays integral part along with expertise in complex and dynamic behaviour such as engaging in ball games or operating vehicles. In his 2014 article "Anticipation – The Underlying Science of Sport" Mihai Nadin states that the capacity to anticipate is what separates professionals from other sport practitioners.

It has been well established within sports science that expert athletes are superior in their anticipation skills to non-experts. There exists a great body of evidence on how experienced athletes are more effective at picking up and analysing the visual information than their less experienced counterparts (Van der Kamp et al.; Williams, North & Hope, 2012). Expertise and anticipation relationship has been shown not only in striking sports like tennis and baseball but also in open field play sports like football, basketball, and ice hockey. The capacity to anticipate opponent's and teammates actions is widely seen as a critical factor in sport performance and has been thought of a way to distinguish experts from non-experts (e.g., Williams, Ford, Eccles & Ward, 2011; Morris-Binelli & Müller, 2017).

Therefore, sports provide perhaps an ideal field to study the intricacies of the expertise-anticipation relationship and expert anticipation differences (Abernethy, Farrow & Mann, 2018, 690). Although it could be seen as quite separate from anticipatory studies, sports science as a field has a lot to offer for the general understanding of anticipation. This is especially true for the plethora of research conducted in sports science on the expert – novice differences in anticipation, as we shall see in the next chapter.

2.3 Anticipation in Sports

In sports, expert performance demands perceptual-cognitive and motor skills that almost always include the need for fast decisions and precise motor responses (Ericsson and Lehman, 1996). When watching expert athletes perform in their sport, we can see that even with virtually no time to react, the best athletes always manage to produce brilliant responses. Witnessing this our perception might tell us the athletes must possess super-human reaction speeds to be able to hit the ball in baseball or make the save in ice hockey.

But perhaps somewhat surprisingly, research tells us that the differences in the overall reaction speed between the very best athletes and the people watching from home is not remarkably high (Helsen & Stark, 1999, 22). The top athletes have a less than 15 percent advantage in their overall reaction speed compared to average people, not nearly enough to explain how for example, the best tennis players can routinely return tennis serves going over 200 km/h. Put simply, expert performance in sport cannot be based by reaction speed alone, because the extreme speeds of objects in play often leave too little time for even the very best athletes to react.

What then explains expert athlete's 'super-human' like reaction speed? This may not come as a surprise to the reader, but according to research, the answer lies in anticipation. Expert athletes rely on anticipation, to guide their visual attention and prepare their body to respond quickly (Shim et al., 2005). Having access to advance information gives expert athletes the time needed to analyse, react, and respond. Borysiuk and Sadowski (2007) showed that when the stimulus is anticipated not only is athlete's reaction time shorter, but the execution of motor responses also becomes faster, both these factors likely contributing to the idea of the super-human reaction speed. Many studies have also confirmed that people react significantly faster to any general stimulus they know to expect (Poulton, 1950; Walter et al., 1964; Helsen & Stark, 1999). Using early cues of their opponent's future movements, athletes can respond in advance, and this way the reaction time can be zero or negative (Conrad, 1955). Beside speed, relying on advance information also affects the athlete's choice of movement strategy. Without access to any advance information the athlete is forced to rely on their reaction time and / or default responses but knowing what to expect allows the athlete to prepare their possible responses in advance (Gutierrez-Davila et al., 2011).

The amount of time pressure as well as the need for precision vary across different sports and different levels of competition. As the level of competition increases with the growing skill, speed, and strength of the athletes, the amount of time available for actions and reactions decreases. In many sports the temporal requirements reach a level where in many situations it may not be humanly possible for the athletes to rely on their reaction and movement speed alone, and to produce responses some level of anticipation is needed. Buszard (2022) shows through multiple studies conducted in different sports that while people have the capacity to anticipate very early on this capacity is not developed unless the sport the engage in requires anticipation. In other words, like deliberate practice and play is needed to develop expertise, time pressure seems to be necessary to elicit anticipatory behaviour (Triolet, Benguigui, Le Runigo & Williams, 2013).

For example, in tennis the threshold for anticipatory behaviour is thought to exist somewhere between 12- and 15-year-olds, as skilled 15-year-old tennis players can detect patterns on service direction that skilled 12-year-old players generally cannot (Farrow & Reid, 2012). Invasion sports like football and ice hockey, evoke high temporal demands for also younger players and are likely to elicit and develop players' anticipation capacity considerably earlier. The temporal pressure that attackers and defenders apply on each other during the matches, especially in small-sided games (Kermarrec, 2015), is theorized to be the reason why skilled football players elicit anticipatory behaviour from as early as the age of nine (Ward & Williams, 2003). Notably, the football fields and ice hockey rinks juniors play on are adjusted in size and thus considerably smaller than adults, which also contributes to the overall temporal pressure in youth games (see Buszard, Farrow & Reid, 2020). Another possible reason is also as Buszard (2022) hypothesizes that the actions perceived in the studies like passing and dribbling in football are arguably simpler than serving in tennis, although to me this is strongly depends on situational factors such as time pressure. This would also be consistent with findings from neuroscience which state that anticipatory performance is related to task difficulty, and when people's mental resources are not fully directed to performing a specific task, it leaves more capacity for anticipation and vice versa (Floyer-Lea & Matthews, 2004; Bar, 2007).

Like chess masters, expert athletes' ability to anticipate is believed to stem from their extensive domain knowledge and the visual and motor skills they acquire through rigorous training and real-world competition (Loffing & Cañal-Bruland, 2017). In sports, as in other areas of life, people use perceptual-cognitive skills and information acquired through experience to direct attention on factors that they deem likely to be important (Corbetta & Shulman, 2002). In the complex environments of sports, especially in team sports, there exists a combination of overabundance of information and limited availability of time. Even the finely tuned brains of expert athletes cannot process all available information at once. Therefore, attention must be allocated to what we perceive as the most critical sources of information. Expert athletes do this by using their domain-specific memory to recognize and anticipate in-game action patterns, which is expressed by guiding their visual attention proactively (Henderson, 2017). By focusing their attention and using their enhanced visual and motor skills to pick up advance kinematic cues, athletes prepare their body and mind to act proactively (Allport, 1987).

Since the inception of research on movement anticipation, the majority of studies in sports science have concentrated on visual anticipation—examining athletes' capacity to make precise predictions based on limited or imperfect visual cues. (Poulton, 1957; Williams & Jackson, 2019). It has been well established that athletes use visual cues of biomechanical movements and postures of their opponents to anticipate their future actions (Jones & Miles, 1978; Williams & Jackson, 2019). They can do this according to Goodale and Milder (1992), thanks to the two-visual pathway model that posits our brains process visual information in two distinct pathways. According to Goodale and Milder ventral stream is primarily involved in object recognition and is associated with more focused vision "what is it?". Dorsal stream is involved in detecting movements and spatial information "where is it?" and is also associated with peripheral vision (Stephen et al., 2002). The two systems involve different parts of the brain, ventral stream being involved in memory, recognition and conscious perception, while dorsal stream is involved in mediating the unconscious visual guidance of action taking place in the present moment. The interaction of the two visual stream forms the basis for visual anticipation in sports (Van der Kemp et al., 2008). Recently there has been calls to update the two-visual pathway model with a third visual pathway specialized for social perception (Pitcher & Ungerleider, 2021). This third pathway processes and responds to moving bodies, so although there is not yet any research on the subject it could be that this third pathway is important in visual anticipation in team sports like ice hockey. It could also be associated with other forms of anticipation as the authors suggest the third pathway is responsible for interpreting actions and behaviours of other biological systems.

Much of the resent research on visual expertise in sports has been linked to a gaze phenomenon called "Quiet Eye". Studies using eye-tracking data from professional and novice athletes have found visual gaze behaviour of expert athletes to be categorically different from that of less experienced athletes. The concept of the "quiet eye" refers to the expert's skill in directing visual attention to pertinent information while minimizing distractions, thereby facilitating an optimal assessment of the situation just before executing an action. Expert athletes have been observed to invest more time in assessing the situation before executing an action, with their duration of "quiet time" being longer compared to non-experts. The increased duration of quiet eye gaze has been linked to improved performance and increased accuracy in complex and dynamic situations which cause high information-processing loads on athletes, but not when performing simple tasks where such concentration of attention is not required. (Vickers, 2016.)

Superior anticipation of expert athletes cannot be explained through visual expertise alone. There exists a close connection between visual and motor expertise, and both have important roles in supporting the anticipatory processes (Abreu, Candidi & Aglioti, 2017). Studies comparing anticipation among athletes, individuals with comparable levels of visual expertise (such as coaches and sports journalists), and novices have highlighted the significance of motor expertise—the skills related to muscle activity—in anticipating opponents' actions based on kinematic cues. Research by Aglioti et al. (2008) and Wright et al. (2010) has shown that greater motor expertise is associated with heightened accuracy in predictions derived from kinematic information. Additionally, findings from Kinsbourne and Jordan (2009) support this connection between motor expertise and improved prediction accuracy. This is suspected to be due to the existence of the mirror-system in our brains that activates when we observe familiar actions being performed (Di Pellegrino et al., 1992). Watching familiar actions being performed activates the mirror-neurons in our brain and body with the level of activation depending on our level of motor expertise in the particular action. Experienced athletes can even reportedly feel specific muscle groups activate in their own body, as if they were performing the actions themselves, when watching someone else perform in their sport. This ability relies solely on motor expertise rather than visual expertise, as demonstrated by Calvo-Merino et al. (2006) through their study on gender-specific ballet movements.

Recently researchers have begun to pay more attention to the interplay of visual and contextual information in anticipation. Besides kinematic information, athletes seem to place significant importance on contextual information, in particular what kind of situational environment the actions take place in. Situation-specific factors such as opponent’s playstyle, current score, how much time is left in the game, the positioning of players on the field of play, etc. give context to athletes’ actions (Loffing & Cañal-Bruland, 2017). Similarly, like picking up and analysing kinematic cues, expert athletes seem to be superior to non-experts in utilizing contextual information in anticipation (Murphy, Jackson & Williams, 2018). As contextual information is usually picked-up well before kinematic information it affects how athletes interpret kinematic information (Kveraga, Ghuman & Bar, 2007). The growing number and role of data analysts employed by sports organizations to analyse opponents' action tendencies is also considered a sign of sports organizations understanding the importance of using contextual knowledge in attempting to interpret and anticipate opponents' physical movements (Cañal-Bruland & Mann, 2015, 2).

Besides giving context to actions, contextual information is thought to facilitate anticipation (Kveraga, Ghuman & Bar, 2007). Research on the use of contextual information in anticipation has shown that contextual information in sports becomes more important when kinematic information is not available or is limited (Murphy, Jackson & Williams, 2018). In dynamic, temporally constrained tasks, complete information of actors and the environment is rarely available when required. Most often performers will have to make quick and accurate judgments with limited information. In such situations, athletes are thought to combine the limited kinematic information with contextual information to make more accurate anticipatory judgments. Abernathy et al. (2001) found that expert athletes can anticipate their opponent's actions from the situation-specific context alone, before or without seeing any kinematic cues. Expert athletes rely on what Abernathy et al. called *situational probabilities*, when anticipating what opponents are likely to do in specific situations. The situational probability information is stored and retrieved from long-term memory and consists of the general domain-knowledge that is updated regularly based on the athlete's opponent's performances (Farrow & Reid, 2012).

An example of athletes' integrating information from different sources is the strategy goal keepers have adopted when trying to save penalty kicks in football. Tomeo et al. (2013) showed that goal keepers improved their goal keeping performance by integrating information of early kinematic cues with the ball trajectory in their anticipation. In the study goal keepers were observed to be able to effectively switch between motor simulation and visual cues when it best suited the situation, while expert football penalty kickers (who were not goal keepers) were observed to mostly rely on early kinematic cues. Because the goal keepers did not overly rely on the early kinematic cues and kept their eye on the ball, they were able to make saves also in such situations where the early anticipatory information was misleading, while other players could not. According to Tomeo et al. the study's results suggest that depending on a single source of early information, in this case movement kinematics, can lead to increased risk of anticipatory failure, while being able to redirect attention between information sources and integrate different information can lead to more successful anticipation and therefore also better performance in sports.

Anticipatory failure plays an important role in sports and together with deception is an emerging strand of anticipation research in sports (Jackson & Cañal-Bruland, 2019). Anticipatory failure occurs when athletes focus on misleading sources of information or interpret the available information in a faulty manner (McNevin, Magill & Buekers, 1994). In interactive sports, deception plays an important role when trying to outplay an opponent. The deception relies on disguising one's actions or providing misleading sensory information via false kinematic cues to the opposition. Successful deception deceives opponent's anticipatory processes and leads their expectations to differ from the intended actions.

Studies have shown that the athletes' ability to detect opponent's deceptive movements from their true movements relies largely on the athlete's own motor expertise (Sebanz & Shiffrar, 2009) as well as the integration of situational probabilities and kinematic information (Helm et al., 2020). Interestingly, novice players might sometimes have an advantage in anticipating non-deceptive movements. This is because, as stated by Mori and Shimada (2013), expert player's expectations of possible deceptive actions affect their judgment of non-deceptive actions negatively. Somewhat similarly to deception, athletes who are left-handed may have an advantage over right-handed athletes in certain situations and be disadvantaged in others. This is because most people are right-handed, and athletes have learned to place attention mainly to the right side of players' bodies. When trying to anticipate the actions of a left-handed athlete this means allocating attention to misleading and irrelevant information sources (Loffing et al., 2015). This may lead to both opponents and teammates struggling to anticipate their movements.

Overall, athletes' ability to distinguish meaningful information from irrelevant or misleading information and interpret information accurately is critical for anticipatory success, and failure to do so can lead to detrimental effects on performance. Because of this, it is also important to study how athletes can integrate information from different sources to make more accurate situational assessments. Common causes of anticipatory failure such as deceptive movements or irregularities like left-handedness also deserve more research attention.

2.4 Anticipation in Invasion Team Sports

All invasion team sports are characterized by the competition and coordination that takes place between and within the teams. The two teams are constantly trying to either defend and recover the ball (or puck) or maintain and move the ball towards the scoring zone to score a goal (Gréhaigne & Godbout, 1995, 492). Because the objective which both teams are trying to achieve is known, the variety, diversity, degeneracy and thus also unpredictability in invasion team sports originate from the teams and players' having multiple possible ways of achieving the objective (Hrsitovski, 2017). Depending on sport, the players may have assigned positions or roles such as forward, defender or goalie. Regardless of roles or positions, all players alternate between state of offense and defence, depending on the ball possession, while actively attempting to solve an unpredictable set of problems with the highest possible efficacy (Metzler, 1987).

Performing well in any team sport always requires coordination within the team while competing against the other team. The coordination and competition processes in team sports create an interesting dynamic where players must simultaneously act predictably for teammates and unpredictably for opponents. Without sufficient predictability coordination between teammates become impossible and without sufficient unpredictability opponent can anticipate and counter team's actions in advance. (Hrsitovski, 2017.) Team coordination is thought to be guided through perception and the use of shared affordances (Silva et al., 2013). Affordances are possible opportunities for action, and when they are shared within a team it means both you and your teammates recognize the same opportunities. The more successful teams and players can visually hide their intentions from opponents while sharing the same affordances with teammates. This means that they can anticipate each other's actions not just perceptually which could be misleading due to deception but through context as well. For example, a player in ice hockey may accurately predict specific teammate's intensions through deception because they share same mental models of a rehearsed attacking pattern, but because their opponents do not share the affordance, they might make wrong predictions from the visual information alone.

It is important to recognize that unpredictability is not always required, and high diversity of actions is only exhibited by individuals and teams when the environment requires it (Pol et al., 2020, 5). If a team's strategy proves so effective that the opposing team cannot counter it, or if there exists a substantial disparity in skill level between the teams, there may be no reason to pursue unpredictability. Reducing variability in one's actions can also be an efficient coordination strategy which leads to increased predictability between people who are attempting to coordinate their actions (Vesper et al., 2011). In football, it has been recognized that defenders generally exhibit more regular and synchronized movement behaviour than forwards who exhibit more irregular and unpredictable movements (Low et al., 2020). This may be because in invasion team sports defending is generally more organized effort between players, while offense is focused on disrupting the opposing team's organized defence to create scoring opportunities through numerical advantages. (Travassos et al., 2013, 89.)

One defining aspect of invasion team sports is the open nature of the sport. Players are constantly moving around the playing area and are forced to constantly monitor the activities and positions of multiple players at the same time. In fast ball sports like ice hockey, openness is combined with great temporal pressure and uncertainty, and players have large amounts of relevant information they must process simultaneously and very little time to do so (Nuri, et al., 2013). Without sufficient methods of identifying and processing relevant information players struggle to make quality decisions quickly. As previously discussed, expert athletes have honed their abilities to manage an abundance of information with remarkable effectiveness. Although individual expert athletes are very efficient at using relevant information in anticipation, they may still struggle coordinating with teammates.

Traditional training in team sports has focused on maximizing individual player's performance attributes while the coach's role has been to prescribe actions the team should try to execute during the games to ensure collective strategic and tactical behaviour. Tactics and strategy are widely regarded as important aspects for a team's success in invasion team sports, and through competition teams are encouraged to deploy appropriate tactics and strategies that help them outplay the opposition and achieve victory. Strategy refers to the overall playstyle of the team, e.g., how the offense and defence is organized. Strategies are discussed in advance between players and the coaching staff, while tactics refer to the specific choices players or individual players make during the game to outplay their opponent(s) (Gréhaigne, Godbout & Bouthier, 1999). Strategies are by their nature anticipatory as they try to anticipate opponent's playstyles (strategies) and answer to them effectively. Tactics on the other hand can be seen to provide ready-made-solutions to common situations that arise in sports, which may help to reduce the amount of information and time needed for decision-making.

Recently though, sports researchers have begun to challenge the importance of strategy and tactics in invasion team sports, and especially the traditional role of coaches as the prescribers of specific strategy and tactical actions (Pol et al., 2020). Research has shown that in complex and dynamic environments players cannot rely solely on strategy and tactics, and in many cases over reliance on coach's instruction can have negative consequences. Memmert and Furley (2007) showed that receiving more tactical instruction can lead to narrower breadth of attention and is detrimental to creative performance in invasion team sports. Memmert and Furley go on to state that when coaches give players too restricting tactical instruction it can lead to inattentional blindness in players and them to make inferior in-game decisions compered to ones they would otherwise make.

According to complex systems approach to invasion team sports, to deal with the excess of information teams need to develop ways to reduce unpredictability within the team to promote coordination while creating unpredictability potential to disrupt the coordination in opposing teams (Pol et al., 2020). The role of the coach and coaching staff, rather than giving specific instruction is to help synergize team action through creating training environment that allows players to develop shared affordances between all team members across all kinds of possible game-like situations. The idea comes from complex systems approach seeing invasion team game behaviour as self-organizing, where information exchanges among players create order within the game (Travassos et al., 2013). The role of a coach is to help create training environments that encourage players to develop decision autonomy and effective self-organizing tendencies in different game-like situations (Ribeiro et al., 2019). This way it is possible, as Pol et al. (2020) argue for teams maintain inter-team coordination while developing individual and team capacities to satisfy diversity potential and becoming less predictable for opponents.

The purpose of this chapter was to demonstrate the role of anticipation in invasion team sports. While there is much more to be written on the intricacies of the subject, it is apparent that it is a very complex phenomenon. The main takeaway from this chapter should be that anticipation in team sports is not an isolated individual effort. Success and failure in anticipation always depends on other players decisions, both opponents' and teammates', and like other aspects of the play it should be analysed through complex systems approach. That said, there is still a need to study the individual differences in anticipation within invasion team sports. The next chapter will explore the anticipation-decision making relationship to better understand the individual differences and possible reasons for them.

2.5 Individual Differences in Anticipation and Decision-making

It is evident that being able to anticipate opponent and teammate actions accurately is a huge advantage in sports. With so much research conducted in expert-novice differences in anticipation capabilities in sports and other domains, it is surprising how there is very little research focusing on the differences in anticipation between experts within the same domain.

Intuitively athletes and other sports experts understand that, especially in invasion team sports, some players seem to be able to anticipate the actions of other players to a greater extent. Although the reasons for this are not known, these players are often said to have higher game intelligence (game IQ). The term game IQ does not refer to player's general intelligence, and there is also no conclusive evidence that general intelligence is important for success in sports (Kalen et al., 2021). Instead, players with high game IQ (also called football IQ, hockey IQ, etc.) are thought to be better at assessing the current situation, anticipating possible developments, and making decisions in game. In other words, these players can "read the game" well and perform actions that are well suited for each situation.

Williams and Ford (2013) suggest that having high game intelligence is what separates the best players from others. In the highest levels of sports competition, with all physiological or anthropometrical (the measurement of the size, weight, and proportions of the human body) aspects being relatively equal, the differences between the best and the very best must be in how they approach the game. According to Williams and Ford, "perceptual-cognitive processes, skills and mechanisms – differentiate those with exceptional levels of game intelligence skill from those with less of this ability" (2013, 117–118). However, the research they cite in the article is conducted comparing the differences between experts and novices and therefore cannot fully explain the differences that exist among experts.

Although there may be some significant differences in the perceptual-cognitive processes, skills, and mechanisms between experts, there simply is no clear evidence of this. Without evidence, when suggesting that the differences between players must be in tactical, psychological, and game intelligence aspects, it feels as if Williams and Ford are reducing the complex human behaviour differences in these areas to be just being products of different amounts of expertise. Williams' and Ford's view may be due to a practice what Balague et al. (2013) call a tendency in sports studies and among sport practitioners to reduce human performance to something that is purely mechanistic. I would hypothesize that the differences in the game intelligence between experts, could be more qualitative in nature and more in line with what Williams and Ford describe as the processes underpinning the perceptual-cognitive skills such as the players having "more refined visual search behaviours and more forward-thinking rather than reactive thought processes" (118, 2013).

The problem with game intelligence as a scientific concept is that although it is commonly used among scientific literature and sports practitioners, it has not been defined well and often its meaning varies between contexts (Hristovski & Balagué, 2020, 1–2). Hristovski and Balague attempt to solve the issue with their theory of cooperative-competitive intelligence (CCI) (2020), which takes a complex systems approach to intelligence in team sports. Although game intelligence and cooperative-competitive intelligence are fundamentally different things they both share the idea that anticipation and other cognitive functions such as decision-making are important factors in player performance in competitive team sports. Anticipation is sometimes combined with decision-making in research because both rely on mental models and mental simulation (Afonso, Garganta & Mesquita, 2012; Klein, 2015). The anticipation-decision-making relationship is often also inseparable from results of actions in sports because dynamic situations require both fast intuitive decision-making and anticipation.

In situations where there is little time pressure there may be no need for anticipation and individuals may significantly benefit from extra deliberation (Moxley et al., 2012). In the complex and dynamic environment of invasion team sports, there is often very little time to assess the situation and players are forced to make decisions based on the limited available information. This forces players to rely on their expert anticipation and intuition to deal with the complexity of the search space (Gobet & Chassy, 2008).

It was De Groot (1978) who found that experts can perform fast and accurate automatic visual analysis of domain specific situations and near instantly come up with sufficient solutions for the task, while novices and people in the early stages of expertise must rely on instruction or slow methodological problem-solving mechanisms. In sports, intuition enables experts to analyse information from the situational environment rapidly and come up with probably appropriate solutions and motor responses automatically. According to Kahneman and Klein (2009), expert intuition is pattern recognition in which experts utilize their vast amounts of domain specific information stored in long-term memory to recognize familiar patterns and to find corresponding solutions and actions, without having to compare options. It is possible that the differences in intuition between experts can be explained by the quality and quantity of patterns individuals are able to access, which arise and are affected by engaging in deliberate play (Greco, Memmert & Morales, 2010) and the amount time invested in domain specific activities during childhood (Roca, Williams & Ford, 2012).

In temporally constrained complex environments, the availability of kinematic information vastly depends on the situation. In situations where the reliability of observable kinematic movements is low, athletes rely more on non-kinematic, contextual information. In invasion team sports, such as ice-hockey and football, contextual information is weighed more when the object of play (puck/football) is far away, and conversely kinematic information becomes more important when the object is near (Vaeyens et al., 2007). In fast ball sports, contextual information is also relied upon more in situations where players have no time to interpret opponent’s physical movements.

Recently there’s been some research attention on applying Bayesian decision theory for anticipation in sports. Bayesian decision theory suggests that the athlete considers all the available information but weighs the influence of information based on the credibility of its sources. When anticipating, the athlete combines prior (contextual) knowledge with current uncertain sensory information to make more accurate probabilistic assessments, while weighing the cons and pros of the actions. (Gredin et al., 2021.) Studying the visual anticipation of expert field hockey goal keepers Morris-Binelli et al. (2021; 2022) found that there may be some individual differences between athletes in integrating contextual and kinematic information. Some less experienced athletes may be more efficient in integration than expert athletes, and therefore possibly also more accurate in anticipation, suggesting either that perceptual expertise may not be developed as linearly as suggested by the broader expertise literature, or there might be other factors in play.

The extent to which cognitive components affect individual performance in sports, has been studied quite extensively, but the results may not always be generalizable across different sports. In their meta-analysis on examining the role of domain-specific and domain-general cognitive functions and skills in sports performance Kalen et al. (2021) state that when evaluating athletes, it is important to use domain specific analysis and tests. That said, anticipation does seem to be particularly important in invasion team sports. It has been hypothesized that in invasion sports the cognitive components of agility, which include visual scanning, anticipation, pattern recognition and knowledge of situations, explain the individual differences in reaction times better than the athletes' physical differences (Young, Dawson & Henry, 2015, 166–167).

Although recognized by practitioners, any cause or causes for individual differences in anticipation are not known. It does seem likely though that there would be multiple causes for the possible differences. To study such a complex issue as anticipation, a more holistic and quality-oriented approach may be needed. Based on extensive searches, the academic literature in sports science seems to lack such comprehensive approaches. Therefore, to find potential causes for individual differences in anticipation I suggest that we should look towards other fields of study, particularly the field of Futures Studies.

2.6 Futures Consciousness as a Human Anticipatory Capacity

As stated earlier, there is very little research on the differences in anticipatory capacity between experts in sports science. To get a better understanding of the role cognitive processes play in the anticipation process and why some individuals with comparable expertise might be better at anticipating the future, we must turn towards other fields of science that are engaged in studying anticipation, particularly Futures Studies.

Anticipation is a subject that has been studied quite extensively recently in Futures Studies, and interest towards anticipation among futures researchers has been growing particularly during the last decade (Ahvenharju, 22, 2022). Some futures researchers have called for the establishment of the "discipline of anticipation" (Miller, Poli & Roussel, 2018). From this study's point of view centralizing anticipation research within its own discipline could consolidate the fragmented research currently conducted across multiple fields. Alternatively, elevating anticipation studies within the realm of Futures Studies could achieve this as well.

Futures Studies as a field is generally focused on long-term futures thinking and research, but as Poli puts it "anticipation exhibits a variety of temporal patterns, from microanticipations embedded in perception to longer forms of social anticipation, ranging from seconds to years and decades" (Poli, 2010, 13). Based on available literature, there are no generally accepted differences between studying anticipation of near and distant futures. It could be possible that traits which might make some individuals better in long-term anticipation could also explain individual differences in short-term anticipation, such as in sports.

Tetlock and Gardners's (2016) study on superforecasters, is an interesting study that considers expert differences in forecasting, a phenomenon seen to overlap with anticipation. In their study Tetlock and Gardner compared the forecasting skills of experts within the same domains to find out what made some perform better than others in forecasting. Tetlock and Gardner identified a group of "superforecasters" who consistently made more accurate predictions than other participants. Tetlock and Gardner discovered that rather than the amount of domain experience or general intelligence, what explained differences in forecasting skill were the characteristics and behaviour of forecasters. These superforecasters scored especially high on the "Active Open Mindedness Test", which was created by Jonathan Baron (1991) to evaluate the willingness to carefully consider alternative opinions before reaching conclusions. The superforecasters were also more likely to consider different sources of information and evaluate different perspectives. They also changed or updated their situational assessments more frequently to consider new information and new developments. Rather than individual traits, it was the combination of these characteristics and behaviours which made the superforecasters perform considerably better in forecasting. (Tetlock & Gardner, 2016.)

Tetlock and Gardner's findings, although not directly related to anticipation in sports, give insight into the holistic nature of futures thinking. Similarly in the complex environments of invasion team sports, it could be that anticipation should be approached more holistically to understand how people anticipate in dynamic and complex environments. Rosen's (1985) theory of anticipatory capacities provides a holistic framework for studying individual differences in anticipation. According to Rosen every system has its own unique anticipatory capacities that allow and support anticipation. For people these anticipatory capacities include such abilities and traits as vision, memory, individual's behaviours, decision-making capabilities, other people they interact with, etc. (Ahvenharju 2022, 35).

Following Rosen's theory of anticipatory systems Ahvenharju, Minkkinen and Lalot (2018) have developed the concept of Futures Consciousness as a human anticipatory capacity (Ahvenharju, 2022). Futures Consciousness is a set of "psycho-social capacities of individuals that influence the attitudes and ways in which we think about the future" (Ahvenharju, 21, 2022.) The premise of Futures Consciousness is that individuals have different tendencies and capabilities in how we think and approach the possible futures. The theory suggests that if one has a high level of Futures Consciousness, they are more likely to be future-oriented, see the future as something they can actively affect and participate in, be more open towards possible alternative futures, have a more holistic perception of systems, and have a sense of concern for the future that involves others beyond themselves.

The five dimensions of Futures Consciousness are Time Perspective, Agency Beliefs, Openness to Alternatives, Systems Perception, and Concern for Others, which can be summarized as follows:

- **Time Perspective** refers to people's awareness of the passage of time, the connection between past, present, and future, and the sequential unfolding of events and their consequences. It highlights the importance of long-term thinking.

- **Agency Beliefs** describe the extent to which it appears possible to sway future events on both personal and societal levels. It emphasizes how the future is shaped by a complex network of interconnected individual actions. A key aspect of agency is the ability to distinguish between issues within one's influence and those outside one's influence.

- **Openness to Alternatives** equips us for the numerous potential surprises the future might hold. It involves thoroughly assessing established truths and commonly held beliefs to find innovative solutions and alternative approaches. Being open to alternatives necessitates a tolerance for the uncertainty of future.

- **Systems Perception** emphasizes the interdependence of human and natural systems and the complex impacts of our decisions. Comprehensive and integrated approaches enhance our ability to understand potential interactions and interconnections within and across various systems.

- **Concern for Others** describes one's care and dedication to contributing to the future well-being of other people, society, and future generations. The dimension emphasizes the interconnectedness of humanity's futures, and the importance placed on building a better world for everyone.

The five dimensions of Futures Consciousness "form a structure that builds on its parts" (Ahvenharju et al., 2021, 11). This means that one dimension alone does not lead to high Futures Consciousness, because it must be supported by other dimensions. According to Ahvenharju et al. (2021) Time Perspective and Agency Beliefs form the cognitive basis for Futures Consciousness to be possible. Systems Perception and Concern for Others - dimensions in combination broaden the conception of future outside self-orientation to also include interactions and relationships with other individuals, groups, and systems. Finally, the fifth dimension: Openness to Alternatives binds everything together through emphasis on the openness of the future with its open possibilities and alternatives which is the central motivation for Futures Consciousness.

Three of the dimensions are actor-centred: Time Perspective, Agency Beliefs and Openness to Alternatives, while two focus on actor's relationship to wider societal level: Systems Perception and Concern for Others. Systems Perception is linked together with Time Perspective emphasizing sequences, consequences, and causalities. Agency Beliefs is also linked together with Concern for Others as they relate to individuals' actions and their wider impacts.

According to Ahvenharju et al. Futures Consciousness is an inborn capacity that all humans have and that can develop further, but some people may have stronger tendencies in some of the dimensions. An individual who is high in one dimension is also likely, but not guaranteed, to be higher in others as well. (Ahvenharju, 2022.) To measure the individual differences in anticipatory capacities Futures Consciousness was operationalized into the Futures Consciousness Scale, a 20-item psychometric scale developed by Lalot et al. (2019) and further revised by Lalot, Ahvenharju and Minkkinen (2021).

The FC Scale enables empirical study of Futures Consciousness on individual and group level. It is a short, easy to use, and simple to interpret psychometrically validated tool that can be used in multiple ways and in many different contexts. Lalot, Ahvenharju and Minkkinen (2021) suggest four ways researchers can use the revised FC Scale. First, as a tool which can be used to measure and predict respondents' likelihood of engaging in future-oriented behaviour. For example, researchers Lalot, Abrams, et al. (2021) found out that heightened Futures Consciousness helped individuals to address the challenges presented by the COVID-19 pandemic. Secondly, the FC Scale can act as an indicative tool to reveal a person's strengths and weaknesses across the five dimensions of Futures Consciousness, helping to identify which dimension(s) may need to be strengthened. Third, the scale can be used to monitor individual changes over time, such as assessing how participating in a futures workshop affects participants' engagement with the future. However, Lalot, Ahvenharju and Minkkinen state that more research is needed to determine the scale's sensitivity to such pre- and post-variations. Finally, the scale could be applied to measure how futures education impacts the participating individual's Futures Consciousness over time.

Lalot et al. (2021) examined whether gender, age, income, perceived socioeconomic status, and political orientation were related to the FC score, which is the average score of the 20 FC Scale items. The results from a multiple linear regression showed significant but small effects of gender, with women reporting higher FC scores than men. Higher income and higher subjective socioeconomic status were also associated with higher FC scores. Additionally, more politically left-wing oriented participants reported higher FC scores. There was no effect of age on the FC score found by Lalot et al. Similar findings were made by Ahvenharju (2022), although in her findings also higher education level and contrary to Lalot et al. findings, older age was related to higher Futures Consciousness.

Although the FC Scale was initially designed to measure human anticipatory capacities for long-term social anticipation, its practicality and versatility make it a valuable tool for this study. There is also an increasing body of research which indicates that individuals who are more oriented towards the future are more likely to engage in various forms of future-oriented behaviour. These behaviours may be self-centered, such as improved delay discounting and reduced procrastination (Matta et al., 2012; Rebetez et al., 2016), or oriented towards others and society, such as greater participation in pro-environmental and civic activities (Lalot, Abrams et al., 2021; Milfont & Demarque, 2014). It could be that people who are future-oriented are also likelier to engage or rely on anticipation in the uncertain information environments of invasion team sports. Additionally, the lack of accepted differences between long-term and short-term anticipation capacities further supports FC Scale's use in studying short-term anticipation. Therefore, it can also be applied to study whether the human anticipatory capacities identified and conceptualized by Ahvenharju et al. (2018) could help explain individual differences in anticipation in ice hockey.

As the cognitive aspects of anticipation are not well-studied in sports science, their impact on an individual's capacity for anticipation remains unclear. The Futures Consciousness Scale offers a means to evaluate individual anticipatory capacities, which could be especially useful for comprehending anticipation in invasion team sports. In dynamic and complex systems like invasion team sports such as ice hockey, might individuals need anticipatory capacities like those required for long-term anticipation?

Several questions arise when considering how Futures Consciousness and its dimensions could relate to ice hockey. As Ahvenharju et al. (2021) argue that Agency Beliefs and the Time Perspective form the cognitive basis for Futures Consciousness, could these two dimensions be expected to be the prerequisites for anticipation in any domain? Agency Beliefs is expected to be connected to player performance in ice hockey as the dimension is so close to self-efficacy (Ahvenharju et al., 2021), a belief that is known to have a moderate positive relationship with performance in sports (Moritz et al., 2000). Anticipation involves projecting the future into the present. Therefore, would a player with a stronger future orientation be more inclined to anticipate longer timescales or do so with greater accuracy? Additionally, other interesting questions that arise regarding the remaining three dimensions of Futures Consciousness (Systems Perception, Openness to Alternatives and Concern for Others): do players require systemic perception to anticipate effectively in the complex and dynamic systems of invasion team sports? Is being open to alternatives related to a player's in-game decisions such as whether to pass or shoot? Given that ice hockey is a team sport, players are expected to have some level of concern for their teammates, but would this be reflected in the FC Scale, which focuses on the concern one has for the future of all humanity?

These are not questions that can fully be answered in this thesis due to the complexity of the topic. However, they help to highlight the possible relationships between the anticipatory capacities measured through the FC Scale and in-game anticipation as well as the overall player performance in ice hockey. By measuring ice hockey player's overall anticipatory capacities it is possible to gain new insights into the significance of general human anticipatory capacities on the in-game anticipation of invasion team sports. And accordingly, move closer to answering the question posed at the beginning of this thesis: what can explain the individual differences in in-game anticipation between expert ice hockey players.

3 METHODS

3.1 Participants

Participants in the study were 47 professional male ice hockey players from 4 of the 15 teams playing in SM-liiga, the Finnish Elite League, during the 2022/23 ice hockey season. Most of the participants were Finnish, but there were a few international players participating the study as well. Player ages ranged from 18 to 35 years (M = 24.00 years, SD = 4.10 years). The total number of games the players had played in SM-liiga ranged from 15 to 837 games, averaging 200 games and 5 seasons played in the league. The players did not receive any compensation for participating in the study.

3.2 Futures Consciousness Scale

The players were asked to complete the Futures Consciousness Scale, a psychometric test which measures individual's level of Futures Consciousness. The FC Scale was selected for the study because of its ease of use and short completion time (approximately 10 minutes), and because of its holistic approach to human anticipatory capacity.

The Futures Consciousness psychometric scale (Lalot et al., 2019), is a 20-item short survey graded in a 5-option Likert scale from totally disagree (=1) to totally agree (=5) (in Finnish 1 = täysin eri mieltä, and 5 = täysin samaa mieltä). The FC Scale was developed by a team of researchers from University of Turku: Lalot, Ahvenharju, Minkkinen, and Wensing (2019), based on work of Ahvenharju, et al. (2018), to measure and assess individual capacities to "understand, anticipate, prepare for and embrace the future" (Ahvenharju, et al., 2021, 2). The FC Scale is based on research in personality psychology and social psychology, and the twenty items were selected from fifteen validated psychometric scales based on a statistical analysis (Lalot et al., 2019). The FC Scale was later revised and refined by Lalot, Ahvenharju and Minkkinen (2021) due to limitations in some of the question in the original scale. The twenty items of the scale (as seen in Table 1) represent the five dimensions of futures consciousness: Time Perspective, Agency Beliefs, Openness to Alternatives, Systems Perception, and Concern for Others, identified by Ahvenharju, et al. (2018) to contribute together towards the individual differences in approaching the future.

Table 1. *Futures Consciousness Scale, dimensions and items (Lalot et al., 2021).*

Time Perspective

- Q1: I think about the consequences before I do something.
- Q2: I think about how things might be in the future.
- Q3: I am willing to sacrifice my immediate happiness or well-being in order to achieve something in the future.
- Q4: I consider how things might be in the future, and try to influence those things with my day to day behavior.

Agency Beliefs

- Q5: I believe I can succeed at most any endeavor to which I set my mind.
- Q6: I hardly ever expect things to go my way.
- Q7: I am usually able to protect my personal interests.
- Q8: I am always optimistic about my future.

Openness to Alternatives

- Q9: I often use new ideas to shape (modify) the way I do things.
- Q10: I am often on the lookout for new ideas.
- Q11: I often re-evaluate my experiences so that I can learn from them.
- Q12: I find it boring to discuss philosophy.

Systems Perception

- Q13: I think that all the Earth’s systems, from the climate to the economy, are interconnected.
- Q14: I have had the experience of feeling “at one” with nature.
- Q15: I think understanding how a chain of events occur is crucial.
- Q16: I easily see connections between events and things even when they first seem unrelated.

Concern for Others

- Q17: I show concern and care for peers.
- Q18: I believe in being loyal to all mankind.
- Q19: When they are in need, I want to help people all over the world.
- Q20: Benevolence (that is, helpfulness, honesty, forgiveness, loyalty, and responsibility) is an important life-guiding principle for me.

The FC Scale is in available in English and in Finnish. Since the revised FC Scale was only available in English during the data collection phase of this study, this study utilizes the initial Finnish translation of the FC Scale, which was privately provided by Ahvenharju. It is important to note that three questions in the Finnish FC Scale used in this study (Appendix 1) differ from those in the later version of the Finnish FC Scale.

3.3 Procedure

All 15 SM-liiga teams were contacted via e-mail and were sent information about the study together with a letter of invitation to take part in it (Appendix 2). The people contacted were either the head coaches or the general managers of the team, who functioned as links between the researcher and the players during the study. Four of the fifteen teams playing in SM-liiga agreed to take part in the study, with a few other teams showing initial interest ultimately declining to participate in the study often citing their tight training schedule as the reason.

The data collection was conducted as a web survey during the off-season between SM-liiga's seasons 2021/22 and 2022/23. Online links for the Futures Consciousness Scale were given to the contact people in the participating teams who then forwarded the links to all players within the teams. Players were told participating in the study is optional and the response rate was 37%. Players had the option to answer the FC Scale either in Finnish or English, most opting for the Finnish version. The FC Scale web survey included a brief introduction to the FC Scale as well as a request for a permission to store and use the players' data securely only for the purposes of the study. The participants were told all gathered data will be anonymized and the researcher alone has access to the data.

As there was no direct way to measure in-game anticipation in ice hockey, a few proxy indicators were used instead. Originally it was thought that various performance metrics related to passing would be used, as passing can be argued to require anticipation both from the player performing the pass as well as from the player receiving the pass. This unfortunately proved impossible, since statistics such as pass percentage (the percentage of successful passes from total attempts), key passes (the number of passes that lead to scoring opportunities) or pass interceptions (intercepting a pass between two opponents) were either not recorded by SM-liiga or were not publicly available. Therefore, it was thought that it is the best approach to use traditional and well-known performance metrics.

For all players participating in the study the following data from the regular season of 2022/2023 were gathered from the SM-liiga online database: a) total goals scored, b) total assists, c) total points (goals + assists), d) plus-minus score, e) time on ice, and f) distance travelled by skating. The number of games the players played during the season was also recorded as it was used to calculate the per game averages which were used in the analysis stage instead of total amounts. This was required due to the players having played a varying number of total games during the season.

3.4 Performance Analysis in Ice-hockey

Performance analysis is based on the recording of game actions. Invasion team sports have multitudes of different statistics that are recorded during the games either manually or automatically. This allows for the coaches or researchers to analyse in-game performance after and even during the games. Although performance analysis is widely used in both coaching and research practice, it might be wise to point out that it has some obvious limitations. The main limitation any kind of sports statistic faces is that they are outcome focused. The recordings report what has happened in a game, but do not reveal how or why the event or action has occurred. Sports analysts should be cautious when making interpretations from statistics alone since they cannot tell the full story. (Lord, Pyne, Welvaert & Mara, 2020.)

Evaluation of player performance in ice hockey is generally considered difficult (Schuckers & Curro, 2013). Since ice hockey is a low-scoring sport, there may not be enough goals (data points) per game to draw strong conclusions. Ice hockey is also a fluid sport with players coming and going on and off the ice without the stoppage of play. The fluidity leads to mixing of line-ups and players not necessarily always having the chance to impact the game right after stepping on ice. This becomes challenging for analysts especially with statistics like goals, assists and plus-minus score, where luck plays a large part and a player who plays well overall may often end up looking bad in these statistics. This is different from some other invasion team sports such as basketball where the line-ups are more static and there is way more data points related to scoring.

3.5 Statistical Analysis

The Kolmogorov-Smirnov test was used to examine the normal distribution of the variables. Pearson correlations were conducted for the variables with a normal distribution. These correlations examined the relationship between players' Futures Consciousness scores, obtained from the FC Scale, and in-game performance metrics gathered from SM-liiga online database. All statistical analyses were carried out using SPSS statistics v29.

4 RESULTS

This study investigates whether there is an association between anticipation in ice hockey and individuals' anticipatory capacities measured by the Futures Consciousness Scale. This chapter explores the statistical relationships between ice hockey players' Futures Consciousness scores and their in-game performance variables.

The primary hypothesis posited that a player's Futures Consciousness could account for differences in anticipation among individuals. The secondary hypothesis suggested that a player's level of Futures Consciousness would positively correlate with at least some of their in-game statistics, assuming that a higher ability to anticipate play in ice hockey would enhance overall performance.

However, due to the limited relevance of available in-game statistics to anticipation (discussed in Chapter 3), the study was unable to fully address the correlation between anticipation in ice hockey and individual players' anticipatory capacities measured by the Futures Consciousness Scale. Therefore, the results chapter will focus exclusively on testing the secondary hypothesis.

4.1 Sample Characteristics

Overall, 47 players participated in the study. Five players who had played in fewer than 10 games during 2022/23 season, along with four goal tenders, were excluded from the analysis because of the lack of relevant data. The final sample consisted of 37 professional ice hockey players with a wide range of experience. Out of the 37 players, 22 were forwards, occupying attacking positions, while 15 were defenders.

4.1.1 Futures Consciousness Scores

One sample t-test was performed to evaluate if there was a difference between the average FC levels of the ice hockey players in the sample and the general population averages in FC measured in Lalot, et al. (2021). In total FC the players in the sample ($M = 3.69$, $SD = 0.36$) scored significantly above the general population ($M = 3.52$, $SD = 0.45$), $t(36) = 2.57$, $p < .05$. The players reported significantly higher scores than average population in two of the dimensions: Time Perspective ($M = 3.93$, $SD = 0.5$), $t(36) = 3.84$, $p < .01$, and Agency Beliefs ($M = 3.9$, $SD = 0.42$), $t(36) = 7.94$, $p < .01$, as well as significantly lower than average scores in Systems Perception ($M = 3.51$, $SD = 0.67$), $t(36) = -4.66$, $p < .01$. No significant differences were found in either Openness to Alternatives ($M = 3.15$, $SD = 0.50$) or Concern for Others ($M = 3.88$, $SD = 0.52$) dimensions.

The average FC profiles of the two playing positions are illustrated in Figure 3. The average total FC score (*M* + *SD*) among forwards was 3.60 ± 0.35 while defenders scored a bit higher on average in total FC at 3.77 ± 0.36. Defenders, on average, reported slightly higher scores in four of the five dimensions: Time Perspective, Openness to Alternatives, Systems Perception and Concern for Others. Meanwhile, forwards scored higher than defenders only in Agency Beliefs. The only FC dimension with a statistically meaningful difference was Concern for Others ($t = 2.1$, $p < .05$), where defenders scored on average 3.95 ± 0.56 and forwards 3.81 ± 0.49.

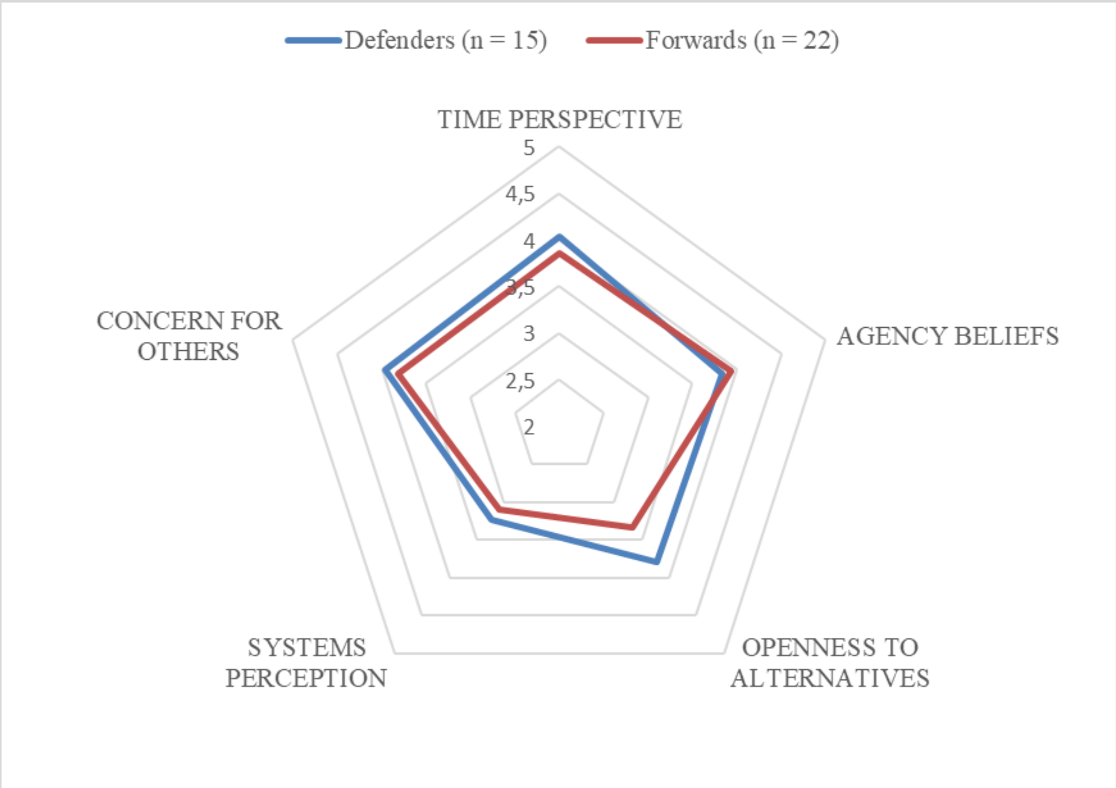

Figure 3. The average measured FC scores by dimension between the two playing positions.

4.1.2 In-game Performance Metrics

Means and standard deviations for the in-game performance variables assessed are presented in Table 2. The in-game performance variables were calculated for all players as well as between the two playing positions. As would be expected there were considerable differences between the playing positions in the averages of in-game performance variables, as forwards and defenders play two very different roles in ice hockey. The differences were most apparent with forwards scoring more goals and assists per game while defenders having more measured skating distance and time on ice per game.

Table 2. *Means and Standard Deviations for In-game Performance Variables.*

	All players		Forwards		Defenders	
Variable	M	(SD)	M	(SD)	M	(SD)
goals (PG)	0.08	(0.07)	0.12	(0.09)	0.05	(0.04)
assists (PG)	0.2	(0.13)	0.22	(0.14)	0.17	(0.11)
points (PG)	0.29	(0.18)	0.34	(0.19)	0.23	(0.14)
plus-minus	3	(-7)	-1	-5	3	(-9)
time on ice (PG) *	14:40	(3:52)	13:30	(2:56)	16:25	(4:28)
skating distance (PG)	3400 m	(800 m)	3300 m	(700 m)	3500 m	(1000 m)

Note: *n* = 37. PG = per game average, * time on ice measured in minutes and seconds.

4.2 Correlation Analysis of Futures Consciousness and In-Game Performance for All Players

Pearson correlations (at the .05, two-tailed level) were computed amongst FC Scale scores and in-game performance variables. When considering the entire population level (as shown in Table 3), no significant bivariate correlation between players' in-game statistics and their total Futures Consciousness or the FC dimensions were found. However, as was expected many of the in-game statistics as well as the dimensions of Futures Consciousness exhibited moderate to strong significant correlations between each other.

Table 3. *Pearson Correlation Matrix Between In-game Performance Variables and FC Dimensions. All players.*

		1	2	3	4	5	6	7	8	9	10	11	12
1	goals (PG)	--											
2	assists (PG)	.37*	--										
3	points (PG)	.72**	.91**	--									
4	plus-minus	.14	.19	.2	--								
5	time on ice (PG)	.12	.55**	.47**	.42**	--							
6	skating distance (PG)	.31	.68**	.65**	.38*	.85**	--						
7	total FC	-.14	.19	-.0	-.01	.19	.29	--					
8	Time Perspective	-.06	.17	.1	.16	.09	.31	.69**	--				
9	Agency Beliefs	.05	.24	.2	.12	.11	.29	.66**	.40*	--			
10	Openness to Alternatives	-.08	.04	-.	-.16	.23	.17	.63**	.2	.29	--		
11	Systems Perception	-.23	-.08	-.15	-.24	.07	.01	.74**	.37*	.40*	.3	--	
12	Concern for Others	-.15	-.05	-.1	.16	.11	.18	.69**	.46**	.31	.14	.52**	--

Note. n = 37. PG = per game average. **p* < .05; ** *p* < .005.

Further analysis was computed between all players' in-game performance variables and the 20 individual items of the FC Scale. The results of the analysis are shown in Table 4. Although there were no significant correlations between the players in-game variables and FC dimensions, a more detailed analysis of the dimensions revealed some interesting relationships. Five of the 20 individual items of the FC Scale had some degree of significant relationship with the players' in-game variables. Interestingly the five items came from the five different FC dimensions, with every FC dimension having one item that had some significant correlation with the in-game variables and three that did not have any significant correlation.

Item 1: "I think about the consequences before I do something" had a significant weak correlation with the players' plus-minus (r = .37) variable and a significant moderate correlation with skating distance (r = .40) variable. Item 8: "I am always optimistic about my future" had a significant weak correlation with players skating distance (r = .37) variable. Item 10: "I am often on the lookout for new ideas" had a significant weak relationship with players time on ice (r = .34) variable. Item 14: "I have had the experience of feeling 'at one' with nature" had a significant weak negative relationship with players goals (r = -.39) and points (r = -.34) variables. Item 18: "I believe in being loyal to all mankind" had a significant weak relationship with the skating distance (r = .36) variable.

Table 4. *Pearson Correlation Matrix Between In-game Performance Variables and the 20 individual items of the Futures Consciousness Scale. All players.*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
goals (PG)	--																									
assists (PG)	.37*	--																								
points (PG)	.72**	.91**	--																							
plus-minus	.14	.19	.2	--																						
time on ice (PG)	.12	.55**	.47**	.42**	--																					
skating distance (PG)	.31	.68**	.65**	.38*	.85**	--																				
I think about the consequences before I do something.	.23	.07	.16	**.37***	.13	**.40***	--																			
I think about how things might be in the future.	-.02	.01	.	.23	-.05	.03	.38*	--																		
I am willing to sacrifice my immediate happiness or well-being in order to achieve something in the future.	-.13	.11	.02	-.26	-.13	.09	.21	.03	--																	
I consider how things might be in the future. and try to influence those things with my day-to-day behavior.	-.17	.21	.08	.17	.31	.25	-.01	.13	.33*	--																
I believe I can succeed at most any endeavor to which I set my mind.	-.03	.01	-.01	.14	-.01	.	.18	-.01	.11	.15	--															
I hardly ever expect things to go my way. ***	.12	-.15	-.06	.16	-.14	-.05	.07	.23	.1	-.03	-.09	--														
I am usually able to protect my personal interests.	.19	.2	.23	.02	.08	.19	.31	-.07	.22	.	-.03	-.03	--													
I am always optimistic about my future.	.05	.17	.15	.21	.05	**.37***	.59**	.28	.42*	.11	.17	.04	.18	--												
I often use new ideas to shape (modify) the way I do things.	-.15	.04	-.04	.06	.23	.25	.16	.09	.11	.26	.34*	.2	.04	.3	--											
I am often on the lookout for new ideas.	-.06	.15	.08	.07	**.34***	.28	.01	.04	.11	.34*	.52**	.09	.04	.29	.69**	--										
I often re-evaluate my experiences so that I can learn from them.	-.15	-.03	-.09	-.22	.02	.05	.06	.03	.34*	.34*	.44**	-.27	-.08	.34*	.46**	.61**	--									
I find it boring to discuss philosophy.	.06	-.01	.02	-.26	.11	.	-.16	-.02	-.13	.13	.06	-.16	-.1	-.21	.19	.16	.31	--								
I think that all the Earth's systems. from the climate to the economy. are interconnected.	-.02	-.07	-.06	-.13	-.08	.02	.17	.17	.22	.04	.13	.08	.15	.25	-.07	.15	.12	.04	--							
I have had the experience of feeling ''at one'' with nature.	**-.39***	-.23	**-.34***	-.28	.08	-.11	-.18	-.06	.22	.02	.22	.01	.	.03	.34*	.32*	.3	.18	.14	--						
I think understanding how a chain of events occur is crucial.	-.2	.13	.01	.01	.29	.3	.14	.17	.31	.18	.28	.03	.02	.49**	.43**	.57**	.25	-.13	.07	.39*	--					
I easily see connections between events and things even when they first seem unrelated.	.15	.1	.14	-.1	-.09	.08	.44**	.36*	.24	-.03	.21	-.02	.25	.26	-.14	.02	.06	-.18	.06	-.1	.26	--				
I show concern and care for peers.	-.06	-.19	-.17	.01	-.04	-.14	.18	.09	-.06	.1	.2	-.22	-.03	.08	.14	.03	.09	.11	.23	.36*	.05	.01	--			
I believe in being loyal to all mankind.	-.01	.1	.07	.16	.19	**.36***	.51**	.27	.31	.27	-.11	.09	.16	.47**	.04	-.07	.	-.19	.41*	.26	.23	.08	.2	--		
When they are in need. I want to help people all over the world.	-.12	-.02	-.07	-.01	-.07	-.06	.27	.32	.09	-.22	.24	.31	.01	.12	-.01	.07	.09	.07	.36*	.26	.06	.29	.06	.22	--	
Benevolence (that is. helpfulness. honesty. forgiveness. loyalty. and responsibility) is an important life-guiding principle for me.	-.17	-.06	-.12	.22	.17	.2	.29	-.16	.2	.22	.27	-.03	-.09	.39*	.28	.27	.40*	-.05	.24	.08	.02	-.3	.29	.15	.04	--

Note. $n = 37$. PG = per game average. * $p < .05$; ** $p < .005$; *** the question is worded positively in the Finnish FC Scale.

4.3 Subgroup Analysis of Forwards and Defenders

Due to there being considerable differences in the roles forwards and defenders play in ice hockey which is also apparent in the in-game variables gathered for this study (Table 2), it was decided that the players should also be analysed separately in their own subgroups of forwards and defenders. This chapter delves into the subgroup analyses, focusing separately on forwards and defenders to uncover more nuanced relationships between Futures Consciousness and in-game performance.

4.3.1 Forwards

When examining forwards as a subgroup (Table 5) weak to very weak negative correlations were observed between their in-game statistics and both total Futures Consciousness and individual FC dimensions. Although these correlations were not statistically significant, the consistent negative trend suggests a potential, albeit weak, inverse relationship between Futures Consciousness and forwards' performance. The only significant negative correlation was identified between players' plus-minus scores and the Systems Perception dimension (r = -.51). Additionally, Systems Perception and Concern for Others dimensions displayed overall weak but not-significant negative relationships with forwards' in-game statistics, whereas Openness to Alternatives dimension exhibited a very weak positive correlation.

Table 5. *Pearson Correlation Matrix Between In-game Performance Variables and FC Dimensions. Forwards.*

	Variable	1	2	3	4	5	6	7	8	9	10	11	12
1	goals (PG)	--											
2	assists (PG)	.31	--										
3	points (PG)	.70**	.90**	--									
4	plus-minus	.33	.12	.24	--								
5	time on ice (PG)	.4	.78**	.77**	.27	--							
6	skating distance (PG)	.41	.77**	.77**	.21	.93**	--						
7	total Futures Consciousness	-.24	-.08	-.17	-.35	-.12	-.01	--					
8	Time Perspective	-.16	.12	.02	-.09	.04	.18	.61**	--				
9	Agency Beliefs	-.33	.01	-.15	-.41	-.03	.04	.73**	.3	--			
10	Openness to Alternatives	.12	.12	.15	-.19	.21	.27	.66**	.16	.52*	--		
11	Systems Perception	-.33	-.25	-.34	**-.51***	-.3	-.23	.81**	.39	.48*	.33	--	
12	Concern for Others	-.27	-.29	-.34	-.05	-.39	-.35	.69**	.39	.37	.09	.64**	--

Note. n = 22. PG = per game average. * *p* < .05; ** *p* < .005.

Results of the correlation analysis between forwards in-game performance variables and the 20 individual items of the FC Scale are presented in Table 6. Similar to the analysis of FC dimensions and in-game variables, the relationships between individual FC Scale items and forwards' in-game variables were generally negative or insignificant.

Significant negative relationships were found between the forwards' plus-minus variable and FC Scale item 3: "I am willing to sacrifice my immediate happiness or well-being in order to achieve something in the future" (r = -.43), as well as item 7: "I am usually able to protect my personal interests" (r = -.48). Item 12: "I find it boring to discuss philosophy" had a significant moderate relationship with forwards' goals (r = .44) and moderate but non-significant relationships with four of the other five in-game variables, excluding plus-minus. Item 14: "I have had the experience of feeling 'at one' with nature" demonstrated a moderate negative relationship with all six in-game variables, with goals ($r = -.47$) and points ($r = -.46$) being statistically significant. Items 17: "I show concern and care for peers" and 19: "When they are in need, I want to help people all over the world" had weak to moderate non-significant relationships with forwards' time on ice and skating distance variables.

Table 6. *Pearson Correlation Matrix Between In-game Performance Variables and the 20 individual items of the Futures Consciousness Scale. Forwards.*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
goals (PG)	--																									
assists (PG)	.31	--																								
points (PG)	.70**	.90**	--																							
plus-minus	.33	.12	.24	--																						
time on ice (PG)	.4	.78**	.77**	.27	--																					
skating distance (PG)	.41	.77**	.77**	.21	.93**	--																				
I think about the consequences before I do something.	.16	-.06	.02	.18	.02	.07	--																			
I think about how things might be in the future.	.04	-.11	-.06	.28	-.2	-.13	.50*	--																		
I am willing to sacrifice my immediate happiness or well-being in order to achieve something in the future.	-.36	.07	-.11	**-.43***	.0	.11	.07	-.01	--																	
I consider how things might be in the future, and try to influence those things with my day-to-day behavior.	-.08	.34	.22	-.05	.28	.37	-.2	.12	.38	--																
I believe I can succeed at most any endeavor to which I set my mind.	-.01	-.07	-.06	-.18	-.12	-.02	.39	.04	.06	.05	--															
I hardly ever expect things to go my way. ***	.4	-.07	.13	.33	-.03	.03	.08	.42	-.18	.03	.15	--														
I am usually able to protect my personal interests.	.05	.24	.21	**-.48***	.07	.02	-.15	-.18	.06	.12	-.24	-.34	--													
I am always optimistic about my future.	-.36	-.19	-.31	.12	-.02	.1	.48*	.24	.29	.21	.3	-.17	-.39	--												
I often use new ideas to shape (modify) the way I do things.	-.1	.12	.04	-.17	.17	.19	-.02	-.04	.02	.16	.47*	.15	-.19	.29	--											
I am often on the lookout for new ideas.	.02	.07	.06	-.22	.1	.2	.07	-.06	-.04	.15	.63**	.04	-.13	.31	.73**	--										
I often re-evaluate my experiences so that I can learn from them.	-.2	-.22	-.26	-.31	-.21	-.11	.12	-.06	.37	.34	.50*	-.19	-.08	.55**	.49*	.64**	--									
I find it boring to discuss philosophy.	**.44***	.28	.42	.02	.41	.41	.15	-.04	-.05	.12	.17	-.12	.17	.09	.17	.3	.3	--								
I think that all the Earth's systems. from the climate to the economy, are interconnected.	-.04	-.22	-.18	-.4	-.24	-.13	.08	.23	.2	.03	.15	-.03	.13	.26	.03	.27	.33	.17	--							
I have had the experience of feeling ''at one'' with nature.	**-.47***	-.32	**-.46***	-.42	-.32	-.38	.16	.05	.3	-.13	.3	-.08	.05	.27	.26	.14	.29	.11	.42	--						
I think understanding how a chain of events occur is crucial.	-.35	-.01	-.17	-.35	.05	.18	.32	.03	.33	.05	.47*	-.1	-.34	.52*	.46*	.44*	.33	-.05	.21	.39	--					
I easily see connections between events and things even when they first seem unrelated.	.01	.02	.02	-.09	-.17	-.11	.41	.45*	.03	.11	.3	.16	.	.04	-.12	.1	.06	-.08	-.11	.03	.32	--				
I show concern and care for peers.	-.07	-.21	-.19	.12	-.34	-.36	.31	.31	-.31	-.33	.17	-.07	-.1	.22	.12	-.06	-.01	-.13	.23	.41	.12	-.01	--			
I believe in being loyal to all mankind.	-.22	-.1	-.18	-.18	-.19	-.13	.24	.34	.43*	.28	.	.06	.03	.31	-.17	-.19	.05	-.01	.57**	.57**	.25	.07	.23	--		
When they are in need, I want to help people all over the world.	-.03	-.17	-.14	-.05	-.38	-.41	.46*	.31	.07	-.28	.41	.34	-.11	.05	-.1	-.08	.02	.05	.19	.55**	.12	.33	.3	.49*	--	
Benevolence (that is, helpfulness, honesty, forgiveness, loyalty, and responsibility) is an important life-guiding principle for me.	-.32	-.24	-.33	.03	-.07	.02	.24	-.06	.3	.01	.3	-.12	-.23	.68**	.4	.27	.58**	.01	.1	.17	.21	-.37	.16	-.11	-.08	--

Note. $n = 22$. PG = per game average. * $p < .05$; ** $p < .005$; *** the question is worded positively in the Finnish FC Scale.

4.3.2 Defenders

The subgroup analysis for defenders, as shown in Table 7, revealed more significant findings. Defenders' overall Futures Consciousness level exhibited significant moderate positive correlations with goals (*r* = .52), assists (*r* = .51), points (*r* = .59), and skating distance (*r* = .56) variables. Additionally, there were weak non-significant positive correlations observed between Futures Consciousness, time on ice, and plus-minus variables.

Table 7. *Pearson Correlation Matrix Between In-game Performance Variables and Futures Consciousness Dimensions. Defenders.*

	Variable	1	2	3	4	5	6	7	8	9	10	11	12
1	goals (PG)	--											
2	assists (PG)	.42	--										
3	points (PG)	.65**	.96**	--									
4	plus-minus	.37	.43	.47	--								
5	time on ice (PG)	.34	.63*	.63*	.41	--							
6	skating distance (PG)	.55*	.74**	.79**	.46	.83**	--						
7	total Futures Consciousness	**.52***	**.51***	**.59***	.18	.34	**.56***	--					
8	Time Perspective	.5	.35	.44	.28	.02	.38	.77**	--				
9	Agency Beliefs	**.67****	.51	**.63***	.49	.29	.49	.73**	.55*	--			
10	Openness to Alternatives	-.1	.08	.03	-.38	.02	-.02	.51	.14	.19	--		
11	Systems Perception	.34	.41	.44	-.08	.4	.43	.62*	.33	.41	.14	--	
12	Concern for Others	.34	.4	.44	.29	.47	**.62***	.69**	.51	.31	.13	.32	--

Note. *n* = 15. PG = per game average. * p < .05; ** p < .005.

Among the FC dimensions, Agency Beliefs variable had a particularly strong correlation across defender's in-game statistics, notably with goals (*r* = .67) and points (*r* = .63) having especially strong and significant positive correlation. Furthermore, the Concern for Others dimension diplayed a strong and significant correlation relationship with skating distance (*r* = .62) variable. Overall, four of the five dimensions of FC exhibited moderate positive correlations with defenders' in-game statistics. The only exception being Openness to Alternatives dimension which displayed no relationship to defender's in-game statistics beside a weak but non-significant negative correlation to defender's plus-minus score.

Results of the correlation analysis between defenders in-game performance variables and the 20 individual items of the FC Scale are shown in Table 8. Mainly positive or insignificant correlations between the defenders' FC and in-game variables were observed. Notably there were many more significant moderate to strong correlations between the individual items of the FC Scale and in-game variables for defenders.

Item 1: "I think about the consequences before I do something" showed a strong significant relationship with goals (r = .60) and skating distance (r = .58), a weak non-significant relationship with points, and a moderate non-significant relationship with plus-minus. Item 3: "I am willing to sacrifice my immediate happiness or well-being in order to achieve something in the future" had a moderate non-significant relationship with goals.

Item 5: "I believe I can succeed at most any endeavor to which I set my mind" exhibited a moderate non-significant relationship with plus-minus. Item 7: "I am usually able to protect my personal interests" had a strong significant relationship with goals (r = .66), a moderate non-significant relationship with plus-minus, and weak non-significant relationships with points and skating distance. Item 8: "I am always optimistic about my future" had strong significant relationships with goals (r = .62), assists (r = .57), points (r = .66), and skating distance (r = .62), along with weak non-significant relationships with plus-minus and time on ice.

Item 10: "I am often on the lookout for new ideas" showed strong significant relationships with assists (r = .52) and points (r = .55), a moderate non-significant relationship with time on ice, and weak non-significant relationships with goals and skating distance. Item 11: "I often re-evaluate my experiences so that I can learn from them" had weak non-significant positive relationships with assists and points, and a weak non-significant negative relationship with plus-minus.

Item 12: "I find it boring to discuss philosophy" had moderate to strong significant negative relationships with goals (r = -.57), points (r = -.52), and plus-minus (r = -.66), and weak to moderate non-significant negative relationships with assists, time on ice, and skating distance.

Item 15: "I think understanding how a chain of events occur is crucial" had moderate correlations with five of the six in-game variables: goals, assists, points (r = .52*), time on ice, and skating distance. Item 16: "I easily see connections between events and things even when they first seem unrelated" had a moderate significant relationship with goals (r = .53) and weak non-significant relationships with assists, points, and skating distance.

Item 18: "I believe in being loyal to all mankind" exhibited a very strong significant correlation with defenders' skating distance (r = .80), a moderate significant relationship with time on ice (r = .56), and moderate non-significant relationships with all other variables. Item 19: "When they are in need, I want to help people all over the world" showed weak non-significant relationships with assists, points, and skating distance. Item 20: "Benevolence (that is, helpfulness, honesty, forgiveness, loyalty, and responsibility) is an important life-guiding principle for me" had weak non-significant relationships across all in-game variables.

Table 8. *Pearson Correlation Matrix Between In-game Performance Variables and the 20 individual items of the Futures Consciousness Scale. Defenders.*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
goals (PG)	--																									
assists (PG)	.42	--																								
points (PG)	.65**	.96**	--																							
plus-minus	.37	.43	.47	--																						
time on ice (PG)	.34	.63*	.63*	.41	--																					
skating distance (PG)	.55*	.74**	.79**	.46	.83**	--																				
I think about the consequences before I do something.	**.60***	.23	.38	.49	.19	**.58***	--																			
I think about how things might be in the future.	-.11	.34	.25	.18	.02	.22	.33	--																		
I am willing to sacrifice my immediate happiness or well-being in order to achieve something in the future.	.42	.18	.27	-.13	-.26	.08	.33	.11	--																	
I consider how things might be in the future, and try to influence those things with my day-to-day behavior.	.19	.21	.23	.21	.13	.08	.13	.08	.32	--																
I believe I can succeed at most any endeavor to which I set my mind.	.2	.25	.27	.4	.	-.02	.02	-.16	.2	.21	--															
I hardly ever expect things to go my way. ***	-.12	-.21	-.21	.01	-.3	-.12	.06	.04	.33	-.2	-.38	--														
I am usually able to protect my personal interests.	**.66****	.13	.3	.44	.12	.35	.63*	.11	.41	-.14	.29	.21	--													
I am always optimistic about my future.	**.62***	**.57***	**.66****	.39	.25	**.62***	.68**	.42	.56*	.21	.11	.21	.68**	--												
I often use new ideas to shape (modify) the way I do things.	.17	.04	.09	.13	.1	.27	.35	.32	.29	.2	.03	.22	.42	.53*	--											
I am often on the lookout for new ideas.	.37	**.52***	**.55***	.17	.4	.32	-.04	.14	.36	.38	.29	.06	.3	.5	.51	--										
I often re-evaluate my experiences so that I can learn from them.	.16	.37	.36	-.26	.12	.16	.02	.15	.32	.28	.34	-.39	-.07	.24	.38	.56*	--									
I find it boring to discuss philosophy.	**-.57***	-.42	**-.52***	**-.66****	-.31	-.45	-.41	-.05	-.24	-.06	-.18	-.27	-.42	-.43	.09	-.23	.27	--								
I think that all the Earth's systems, from the climate to the economy, are interconnected.	.05	.27	.24	.16	.07	.22	.29	.03	.26	.07	.09	.21	.19	.28	-.29	-.07	-.21	-.2	--							
I have had the experience of feeling ''at one'' with nature.	-.1	-.01	-.04	-.3	.31	.09	-.44	-.29	.15	.06	.06	.05	-.05	-.12	.38	.49	.27	.19	-.3	--						
I think understanding how a chain of events occur is crucial.	.4	.48	**.52***	.19	.4	.37	.02	.35	.3	.21	-.01	.08	.42	.58*	.33	.70**	.11	-.33	-.14	.33	--					
I easily see connections between events and things even when they first seem unrelated.	**.53***	.21	.34	-.09	.0	.28	.49	.22	.51	-.18	.09	-.15	.54*	.46	-.15	-.04	.07	-.29	.34	-.24	.23	--				
I show concern and care for peers.	.08	-.13	-.09	-.13	.13	.03	.1	-.28	.22	.62*	.23	-.37	.04	.	.15	.09	.19	.36	.23	.3	-.05	.05	--			
I believe in being loyal to all mankind.	.47	.41	.48	.46	**.56***	**.80****	.72**	.18	.17	.35	-.25	.12	.29	.61*	.38	.11	-.05	-.38	.17	-.06	.23	.09	.19	--		
When they are in need, I want to help people all over the world.	-.1	.33	.25	-.08	.04	.22	.14	.33	.12	-.36	-.07	.28	.15	.27	.	.13	.11	.	.68**	-.15	-.07	.27	-.24	-.07	--	
Benevolence (that is, helpfulness, honesty, forgiveness, loyalty, and responsibility) is an important life-guiding principle for me.	.34	.27	.32	.36	.35	.35	.34	-.36	.09	.47	.19	.02	.08	.18	.07	.25	.15	-.18	.48	-.07	-.24	-.21	.42	.45	.16	--

Note. n = 15. PG = per game average. * $p < .05$; ** $p < .005$. *** the question is worded positively in the Finnish FC Scale.

4.4 Summary of Findings

The study analysed the entire population of players, examining bivariate correlations between Futures Consciousness (FC) Scale scores and in-game performance variables. Initial results indicated no significant correlations between overall FC scores or individual FC dimensions and in-game statistics, suggesting that at a population level, FC does not directly predict in-game performance. However, there were moderate to strong significant correlations among various in-game statistics and among FC dimensions, indicating strong internal consistency within these measures. A more detailed analysis of individual FC Scale items positive revealed that five specific items showed significant relationships with in-game variables, each representing a different FC dimension, highlighting that specific aspects of FC are connected to player performance.

Further analysis for subgroups revealed distinct patterns between forwards and defenders. Defenders exhibited significant positive correlations between higher FC levels and better in-game performance, particularly in the Agency Beliefs and Concern for Others dimensions. This suggests that defenders with higher Futures Consciousness tend to perform better in terms of goals, assists, points, and skating distance. Conversely, forwards generally showed weak negative correlations between FC and their performance metrics, indicating a potential, albeit weak, inverse relationship. More detailed FC Scale item-level analysis reinforced these findings by demonstrating predominantly positive or insignificant correlations between defenders' individual FC items and their in-game performance variables, as well as predominantly negative or insignificant relationship between FC Scale items and in-game performance for forwards. Some items, such as whether the player found discussing philosophy boring, appeared to have completely opposite relationship on the in-game performance of debfenders and forwards. These results highlight that while FC might not predict performance at a broad population level, it does have a meaningful impact on the performance of defenders and possibly a weak negative impact for forwards.

5 DISCUSSION

The starting point for this thesis was the interest in the differences in in-game anticipation among individual ice hockey players. The thesis aimed to find an explanation for the differences by exploring the linkages between player's in-game performance metrics and anticipatory capacities measured through Futures Consciousness Scale. This research process was guided by a research question: to which extent Futures Consciousness is associated with the differences in in-game anticipation between expert ice hockey players?

This chapter aims to explore the results of the series of analysis performed in this study and connect them to the wider body of work on anticipation and anticipation in invasion team sports. First, we shall examine the relationship between Futures Consciousness and ice hockey. Then, we will broaden our discussion to consider the wider implications of individual anticipatory capacities in invasion team sports.

5.1 Futures Consciousness and Ice Hockey

The somewhat conflicting results found in this study on the relationship between Futures Consciousness and ice hockey can be interpreted in various ways. Overall, the findings suggest that ice hockey is a complex sport, with different situational demands for different playing positions. A player's Futures Consciousness level appears to influence their gameplay to some extent, particularly for defenders. It is worth noting that there were no significant measured differences between forwards and defenders' overall Futures Consciousness levels or in individual dimensions, other than defenders scoring on average slightly higher in Openness to Alternatives dimension. This raises the question of whether player anticipatory capacities, as measured by the Futures Consciousness Scale, might be more necessary for defenders in ice hockey.

It has been recognized that in other invasion team sports defenders exhibit more synchronized and regular movement behaviour while forwards exhibit more unpredictable and irregular movements (Low et al., 2020). This is thought to be because defending in invasion team sports is more of an organized effort between players while offense is aiming to disrupt the other team's organized defence to create scoring opportunities (Travassos et al., 2013, 89). It may be that also in ice hockey, defenders need to rely more on anticipation while forwards need to find ways to be unpredictable.

However, this cannot really explain the differences found in the study because the in-game performance metrics used in this this study were mainly related to offensive and not defensive play.

The results suggest that the importance of Futures Consciousness in ice hockey may be related to the player's position or individual play style. Defenders with higher Futures Consciousness levels seem to be more likely to participate in their team’s offensive play, as indicated by their higher amounts of both goals and assists. Increased participation in offensive play would also explain why these defenders skated longer distances per game, as they would have needed to do so in order to cover more ice to support both attack and defence. However, whether more Futures Conscious forwards are more likely to participate in defensive play is unclear, as the study lacks in-game performance metrics related to defence. Given that Futures Consciousness was negatively related to forwards' skating distance per game, it seems unlikely that these forwards were heavily involved in both offensive and defensive play. It is possible though that the more Futures Conscious forwards could have been focused more on defence at the expense of their offensive performance.

To further understand the relationship between ice hockey and Futures Consciousness, the data was analysed on the individual dimension level. Defenders' Agency Beliefs and Concern for Others dimensions showed particularly strong positive relationships with their in-game statistics. Conversly, for forwards, these two dimensions, along with Systems Perception, had minor but negative relationships with their performance metrics. From the five dimensions of Futures Consciousness Time Perspective and Openness to Alternatives did not have any significant correlations with any of the in-game performance metrics. Time Perspective had a weak to moderate non-significant correlation across defenders in-game performance metrics indicating it had positive relationship with defender’s gameplay. Interestingly Openness to Alternatives dimension had the only non-positive relationship with defenders’ in-game performance as well as the only overall positive relationship with forwards performance metrics.

Possibly the main finding of this study are these large differences in the relationships of FC and in-game performance metrics for forwards and defenders. Although the differences are very interesting on their own, the complexity makes it challenging to draw specific conclusions on how FC affects ice hockey player’s performance. On one hand, defenders' Agency Beliefs dimension is positively associated with scoring goals and assists, indicating its importance. On the other hand, Agency Beliefs appear to be less important or even display negative relationship with scoring goals for forwards. Similarly, defenders who scored higher on the Concern for Others dimension skated longer distances per game, whereas forwards with higher scores in this dimension skated shorter distances.

Because forwards and defenders have such differing results based on the correlation analysis, the overall analysis becomes difficult. It could make sense to argue that defenders who have performed better in terms of the selected performance metrics have higher FC scores in part because they possibly have higher status in their teams. This would be in line with the finding of Lalot et al. (2021) who found that FC levels correlated with the subjective status and income, which in ice hockey often follow scoring the most goals in your team. Forwards having similar FC score averages to defenders, but their relationship with in-game performance being negative or non-existent disputes this claim among with many other similar ones.

The subgroup differences seemingly explain the correlations and more specifically the lack of correlations on the population level. Many of the positive relationships defenders' performance metrics have with FC are cancelled out by forwards' negative relationships and vice versa. Perhaps the best example of this is the Item 14 of the FC Scale ”I find discussing philosophy boring”, which had moderate positive relationships across forwards' in-game performance metrics as well as moderate to strong negative relationships across defenders' in-game performance metrics.

These conflicting results make it also difficult to provide a satisfactory answer for the research question. It does seem that Futures Consciousness affects player performance on some level depending largely on the player role. While we can see that FC, particularly Agency Beliefs and Concern for Others dimensions, are positively related with defenders in-game performance, this is not the case at all for forwards. From the results of this study, it then could be hypothesized that the individual anticipatory capacities measured with the Futures Consciousness Scale cannot explain the greatness of any forward.

The Futures Consciousness Scale measures anticipatory capacities on general and abstract level, without any specific relation to ice hockey or sports in general. It is of course possible that the items of the FC Scale are too abstract and distant from the world of invasion team sports, making them unable to measure the specific anticipatory capacities related to ice hockey. Although players' FC scores did correlate with many in-game performance metrics, dimensions like Agency Beliefs and Concern for Others might be more related to other dynamics of ice hockey than to anticipation.

Although Poli states that there is no clear difference between micro-anticipations of seconds and long-term anticipation of years, it is not entirely clear to me that the anticipation associated with sports and the anticipation associated with in Futures Consciousness are the same concepts. Anticipation in sports may be categorically different in that it involves anticipation and decision-making combined with the immediate consequences and feedback. An important question would be if it is even possible to measure individual anticipatory performance in invasion team sports without factoring in decision-making? I believe it is not entirely possible, especially when only observing in-game outcomes. We need to gain more insight into the entire anticipatory process in invasion team sports, as the capacities required for short-term anticipation might differ from those needed for long-term anticipation.

Using a method such as the FC Scale to measure general human anticipatory capacities has great potential because it can be applied across different domains. However, this approach also complicates the analysis. One challenge of combining this research method with in-game performance metrics is understanding how the relationship between players' anticipatory capacities and in-game performance functions. To address this, instead of focusing on outcomes, we should study how more Futures Conscious players perceive and act within the game to better understand how individual anticipatory capacities influence gameplay.

In summary, the study presents two equally intriguing and contradictory conclusions: 1) anticipatory capacities, as measured by the FC Scale, seem to be more important for defenders than for forwards, and 2) the FC Scale may not accurately measure the anticipatory capacities required in ice hockey, suggesting that the differences between defenders and forwards may be explained by other factors. Both possibilities raising more questions than answers.

5.2 Individual Anticipatory Capacities and Invasion Team Sports

The theoretical framework of the thesis established a research gap in sports science's understanding of anticipation. It was argued that the current dominant reductionist view sports science has on anticipation fails to fully explain the anticipation differences between individuals, especially in the complex and dynamic environments of invasion team sports like ice hockey. Therefore, new approaches, such that acknowledge the inherent complexity and systemic nature of anticipation in invasion team sports are needed.

This thesis's proposal was that human anticipatory capacities measured through Futures Consciousness Scale could possibly explain individual differences in anticipation. Because of the lack of anticipation specific data and in-game statistics which are related to anticipation in ice hockey, it was not possible to directly address the claim. Nevertheless, the results of the study raise important questions on the overall importance of anticipation in ice hockey, and on how we could find ways to measure individual anticipation in ice hockey that fit the different situational demands of different playstyles and playing positions.

It seems likely that if individual anticipatory capacities such as described by Ahvenharju et al. (2018) exist, they would affect anticipation in invasion team sports to some degree. In the model of Futures Consciousness Ahvenharju et al. have identified the five dimensions of FC which they believe are most critical for human anticipation. It may be that the anticipatory capacities measured in FC are too general for invasion team sports, but the approach used to construct the concept Futures Consciousness could be applied to anticipation in invasion team sports as well. There are possibly some forms of anticipatory capacities that players need in the short-term anticipation of sports. These anticipatory capacities would likely vary from sport-to-sport, but there could also exist similarities or universals across sports which have alike dynamics.

Especially in invasion team sport environments such questions of the FC Scale as Question 13: "I think that all the Earth's systems, from the climate to the economy, are interconnected" and Question 19: "When they are in need, I want to help people all over the world" could be interpreted differently if players were asked to consider the interdependences within ice hockey, or their readiness of helping teammates in need. I think, that to be effective, more sport-specific instruments to measure individual anticipatory capacities should also somehow include the cooperation-competition dynamic that is so fundamental in invasion team sports (Hristovski & Balagué, 2020). Such an instrument could illuminate the importance of anticipation in invasion team sports as well as stimulate a wealth of potential research topics Additionally, it could also prove valuable for talent identification purposes across invasion team sports.

Developing reliable ways to test individual anticipatory capacities and in-game anticipatory performance metrics in invasion team sports, would also provide valuable data on what kind of practice leads to better overall performance. There may be value for example in looking towards the aspects of anticipation that seem to have a larger impact on in-game performance such as the Agency Beliefs of defenders as demonstrated in this study. The ability to measure anticipation could also answer important questions like should teams focus on developing anticipatory capacities on a team or line-up level or alternatively have more focus on developing individual players' anticipatory capacities.

A question of importance for sports practitioners is if anticipation in sports is something that can be improved through practice and training. Ahvenharju (2022) states that Futures Consciousness is an innate capacity all humans have, and some people possess stronger tendencies in some of the dimensions. According to Ahvenharju Futures Consciousness cannot be taught, but it can be developed. She does not go into detail of how one would go to improve Futures Consciousness, but as it is not a skill but a set of interconnected capacities, I think it is safe to say that developing anticipation would require a holistic approach to training.

5.3 Limitations

All studies are bound to have some limitations, and this study is no exception. The first limitation being the limited number of participants. With overall 47 participants of whom 37 were used in statistical analysis, the sample size remained relatively small. Sizes of the forward and defender subgroups were also small, particularly of the defender subgroup. Because of the limited sample size, some more advanced statistical analysis methods such as linear regression were unavailable.

Certain limitations in the research process were unavoidable and evident from the start. One of these limitations is the absence of a method to measure anticipatory capacities specific to ice hockey or other sports. Another was the lack of in-game performance metrics which are related to anticipation or indicate some sort of anticipatory performance. There exists some statistics such as interceptions or pass-percentage which may have some connection to anticipation, but they were unfortunately not available because SM-liiga does not keep track of them, or the data is not publicly available.

The research method itself has some clear limitations since it is debatable if anticipation as a phenomenon is quantifiable itself. There are also some limitations within the selected in-game performance metrics, such as the relatively low number of goals during matches in ice hockey, but the bigger issue is the fact that statistics are reductionist by their nature. Statistics only represent the outcome of the process but not the process itself, which would be highly relevant to study the anticipation part of the process. In other words, although this research method measures whether a player's individual anticipatory capacities affect their in-game performance, it cannot explain how they do so. This study also relies on data collected from a single ice hockey season. Since Futures Consciousness is described as a stable individual trait that is unlikely to change significantly between seasons, it could and perhaps should be examined over multiple seasons.

5.4 Suggestions for Further Research

With all that said, this thesis offers a starting point for further integration of sports science and anticipatory studies. So far, these two fields have approached anticipation inside their own disciplines, but there is much to gain from bringing these viewpoints closer together. Anticipatory studies and the larger field of Futures Studies offers a more holistic view on anticipation that is sports science currently lack. On the other hand, sports science can offer valuable knowledge on anticipation in practice and invasion team sports could serve as real-word research settings to study anticipation and its effects.

Everyone engaged in studying anticipation should find the potential similarities and differences between short-term anticipation associated with sports and long-term anticipation associated with Futures Studies particularly interesting. Although this thesis aimed to explore this issue, the lack of in-game data connected to short-term anticipation did not allow the direct comparison of the two forms of anticipation. Unfortunately, this kind of anticipation related data is not necessarily readily available in the form of in-game statistics. However, such data could possibly be gathered through more qualitative methods such as player interviews or by simply asking coaches, sports analysts, or the players themselves to evaluate players based on their perceived ability to anticipate in-game.

While studying individual anticipatory capacities holds significant potential, ice hockey is fundamentally a team sport, and therefore most aspects of player's performance are in great degree affected by their teammates and opponents' abilities and actions. Because of this, in ice hockey anticipatory capacities should also be studied on line-up level, as line-ups in ice hockey are often relatively constant. One question for the people interested in the subject to consider is: would a line-up be more successful if each member had equally high in-game anticipatory capacities or if they exhibited varying levels of in-game anticipatory capacities?

Although I believe ice hockey as a fast-paced invasion team sport is an excellent research object for studying anticipation there are sports with altogether different dynamics that would make equally interesting research objects. Approaching anticipation in a systematic way across various sports would lead to greater general understanding of anticipation as a phenomenon in sports as well as provide important data and insight whether general anticipatory capacities exist in sports.

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APPENDICES

Appendix 1: The Futures Consciousness Scale in Finnish (The version used in this study)

Aikakäsitys

- K1: Mietin tekojeni seurauksia ennen kuin toimin.

❿K2: Mietin sitä, miten asiat voisivat olla tulevaisuudessa.
❿K3: Olen valmis uhraamaan tämänhetkisestä hyvinvoinnistani saavuttaakseni jotain tulevaisuudessa.
❿K4: Mietin mitä tulevaisuudessa voi tapahtua, ja yritän vaikuttaa siihen jokapäiväisellä toiminnallani.

Toimijuus

❿K5: Uskon, että voin menestyä lähes kaikissa pyrkimyksissäni.
❿K6: Odotan asioiden menevän yleensä omien toiveideni mukaan.
❿K7: Pystyn yleensä puolustamaan omia etujani.
❿K8: Suhtaudun tulevaisuuteeni optimistisesti.

Avoimuus vaihtoehdoille

❿K9: Hyödynnän usein uusia ideoita, jotta voin muokata toimintatapojani
❿K10: Etsin usein uusia ideoita.
❿K11: Arvioin usein kokemuksiani jälkikäteen, jotta voin oppia niistä
❿K12: Filosofiasta keskusteleminen on mielestäni tylsää.

Systeemisyys

❿K13: Mielestäni kaikki maapallon järjestelmät ilmastosta talouteen ovat yhteydessä toisiinsa.
❿K14: Minulla on kokemus luontoyhteydestä, eli olen tuntenut olevani yhtä luonnon kanssa.
❿K15: Tapahtumaketjujen ymmärtäminen on mielestäni tärkeää.
❿K16: Näen helposti eri tapahtumien ja asioiden yhteyksiä, vaikka ne aluksi eivät vaikuta liittyvän toisiinsa.

Vastuullisuus

❿K17: Osoitan huomiota ja huolenpitoa vertaisilleni.
❿K18: Uskon lojaaliuteen koko ihmiskuntaa kohtaan.
❿K19: Haluan auttaa ihmisiä kaikkialla maailmassa, kun he ovat avuntarpeessa.
❿K20: Hyväntahtoisuudella tarkoitetaan avuliaisuutta, rehellisyyttä, anteeksiantoa, uskollisuutta ja vastuullisuutta. Se on tärkeä elämääni ohjaava periaate.

Appendix 2: The Letter of Invitation Sent to All Teams in SM-liiga

Hei!

Olen tekemässä tutkimusta ennakoinnin roolista jääkiekossa. Tutkimuksessani olen kiinnostunut selvittämään: mitä ennakointi jääkiekossa tarkoittaa, miksi jotkut pelaajat (esim. Wayne Gretzky & Sebastian Aho) vaikuttavat olevan pelin ennakoimisessa parempia kuin toiset sekä kuinka pelaajien ennakointi- ja päätöksentekokykyä voitaisiin mahdollisesti kehittää. Tutkielmani tavoitteena on siis luoda lisää ymmärrystä ennakoinnin roolista jääkiekossa sekä tuottaa tietoa ja käytännön työkaluja suomalaisen urheilun ja jääkiekon kehittämiseksi.

Yhdistän tutkimuksessani Tulevaisuudentutkimuksen tieteenalan ja jääkiekon soveltamalla tulevaisuudentutkimuksessa käytettyä tulevaisuustietoisuus-testiä (Futures Consciousness), jossa arvioidaan yksilöiden ja ryhmien kykyä ymmärtää, ennakoida sekä omaksua vaihtoehtoisia tulevaisuuksia ja varautua niihin. Suunnitelmanani on teettää Tulevaisuustietoisuustesti Liigan pelaajille ja vertailla heidän testissä saamiaan tuloksia heidän pelitilastoihinsa (Wisehockey), näin pyrkien selvittämään onko pelaajien yleisemmän tulevaisuustietoisuuden ja heidän pelaamansa jääkiekon välillä mahdollisia yhteyksiä.

Olen saanut tutkimukseen tarvittavan luvan Liigalta, ja sekä Liiga että Wisehockey ovat luvanneet mahdollisuuden käyttää Wisehockeyn tarjoamaa dataa tutkimuksessa. Myös Jääkiekkoliitto on ilmaissut tukensa tutkimukselle. Toivon, että mahdollisimman moni Liiga-joukkue osallistuisi tutkimukseen, jotta saisimme mahdollisimman paljon tietoa ennakoinnista ja sen kehittämisestä.

Ystävällisin terveisin

Oskari Huhtaniemi

Turun yliopisto
[My UTU e-mail address]