The effects of video-based visual perceptual training on offensive game performance in ice hockey

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This Bachelor's thesis discusses the role of game sense and decision making in ice hockey. The aim of this research-based study was to develop a dry land training method to improve ice hockey player's decision-making skills.

The thesis consists of a theory section, game analysis section and an empirical section. The theory section deals with essential concepts of cognitive behaviour. The game analysis section discusses the characteristics of ice hockey, and the emperical part outlines how the study was planned and implemented.

The research was based on qualitative methods. The study was conducted among eight E1 junior players, of which four served as an experimental group and another four as a control group. The experimental group completed video-based visual perceptual training sessions, whereas the control group did not perform any additional training sessions. The percentage of right decisions increased 2.75 percent for the experimental group, and 0.25 percent for the control group.

Despite the promising results of the study, not enough data was collected to draw any scientific conclusions to confirm if visual perceptual training affected player's offensive game performance. Nevertheless, the research lays a salient foundation for future research, and provides practical implementations of decision making training.

Keywords

decision making, game sense, ice hockey, visual perception

Table of contents

1 Introduction

Ice hockey requires quick, appropriate decisions under high pressure. Technical and physiological abilities create the foundation for a good hockey player, but being able to fluently read the play and react to game situation, has become an important part of ice hockey skills as well. For a long time, game sense was considered as a gift, a talent, an innate ability that cannot be taught. This presumption has been debunked in number of studies showing the importance of deliberate practice. Expert decision makers have spent more time practicing skills compared to novice decision makers (Ericsson et al. 1993, 363; Williams 2000, 18, 747-748; Savelsbergh et al. 2002, 279; Baker & Cote 2003, 13).

This paper introduces two main research questions: first, can visual perceptual training (VPT) work as a functional and useful dry land training tool? Second, does VPT improve individual offensive game performance? The thesis focuses on the skill of decision making and means to improve it. More importantly, it introduces a method called visual perceptual training to support versatile training routine in ice hockey. VPT is a method used to develop athletes' anticipation and decision making skills. VPT can be modified and implemented in many ways. To provide a coherent introduction to the topic, I will present some previous studies on Visual Perceptual Training.

The thesis undergoes following three topic areas that are further divided into paragraphs; first topic area including paragraphs 2 to 7, present important psychological factors affecting cognition. Second topic area, paragraph 8, focuses on characteristics of ice hockey. Final topic area, paragraphs 9 to 11, presents the study, provides the results, and discusses the findings and conclusions of the study.

I believe that coaches must extend their training methods to better correspond to requirements of modern ice hockey. Visual perceptual training provides a creative and intuitive method to strengthen players' game sense. Including VPT in regular training schedule enables more diverse training environment, narrowing the gap between game sense, and technical and tactical abilities.

2   Cognitive process and cognitive development

Cognition is a concept that comprises a huge amount of mental processing, such as problem solving, reasoning, decision-making, calculating and producing language. Cognitive processing is present in many levels and different circumstances. Cognitive processes occur both intentionally and unintentionally, consciously and unconsciously. Complexity of cognitive process is highly dependent on brain development. Matured brain is able to process more information than adolescent brain and enables multidimensional functioning (Moshman 1998, 951; Casey et al. 2000, 243-246; Luna et al. 2001, 791; Fuster 2002, 383).

The following chapter deals with three important characteristics of cognition. I will first explain how cognitive processes work, both in theory and practice. I will then briefly introduce the concept of cognitive development and further examine the developmental characteristics of middle childhood and adolescence. Finally, I will conclude the chapter by covering the concept of situated cognition.

2.1   Cognitive Process

Cognitive process is a chain of cognitive actions in our brain, triggered by sensory input and concluded with an action. This process is constantly occurring in every living organism. Cognitive processes control, structure, and transform information (Mussen et al. 1990, 311). Following example of an ice hockey game demonstrates how cognitive process works:

1. Offensive player is skating with a puck towards the goal, defensive player is skating backwards, two meters away from the offensive player, trying to deny opponent's change to score.
2. Puck carrier notices that another offensive player is skating without a puck towards the net, while the defenseman is focused on the guy with a puck, letting the other offensive player unguarded. (sensory input and registration)
3. Offensive player thinks the best option would be to pass the puck to a teammate. (attention, perception, processing information)

4. After rapid processing of received information, offensive player makes the decision, and passes the puck to an open offensive player. (Decision and action)

As the previous example shows, there are different phases affecting the process of cognition. Each of these phases determine how the information is being processed, controlled and transformed. Mussen et al. (1990, 311-315) discuss three factors that have an effect on cognitive process.

Perception. "Perception can be defined as the detection, recognition, and interpretation of sensory stimuli" (Mussen et al. 1990, 311-312). For example, sounds are heard constantly, but not until they form a rhythm or a beat, they are perceived as music. Therefore, a sequence of rhythms or beats are perceived as music.

Attention. Attention is the filter defining what kind of information goes through the process. Brains are capable of handling limited amount of information, 3-year-old brain is far less developed than that of 25-year-old. 3-year-old child would not be able to understand the rules, tactics or statistics of basketball. As the child becomes older, one's brain will mature and is capable of more complex functioning, he or she will be able to learn and understand the essentials of basketball. (Mussen et al. 1990, 312-313).

Memory. Memory is a crucial part of cognition. Without memory, cognitive process cannot be completed, as none of its products would be lasting. There are three types of memory: sensory memory, short-term memory, and long-term memory. Sensory memory is the briefest type, as it can only exist within about one second. Everything you see, is registered in sensory memory, even if you cannot retain the knowledge afterwards. Short-term memory stores information for only a maximum of about 30 seconds, on the contrary, long-term memory can hold information for years. (Mussen et al. 1990, 313-315).

2.2 Cognitive Development

The more matured and developed the brain is, the more information it can process. The brain matures structurally, starting on prenatal life. At birth, the human has gained about 25 percent of its adult size, and it reaches half of its adult size by six months. By the age of two, the brain has obtained 75 of its adult size (Bloom & Lazerson 2001, 76). That is, the biggest growth in human's brain development occurs during the first two years, but it will not be fully developed until adulthood. .

In cognitive psychology, Jean Piaget's cognitive development model suggests that human undergoes four different stages before attaining adulthood. These four stages include: sensorimotor stage (0-2 years), preoperational stage (2-11 years), concrete operations (7-11 years) and formal operations (11-15 years) (Flavell et al. 1985, 133; Oakley 2004, 16). During the sensorimotor stage, the infant experiences the world through movements and sensations. Growing through the preoperational stage, children begin to think symbolically, learning then to assimilate words and pictures with objects. During this stage, children are very egocentric and tend to see things from their perspective (Flavell 1985, 150-163; Oakley 2004, 24). During the third, Concrete-operational stage, children start to acquire actions requiring logical thinking. The last stage, formal-operational stage underlines the acquisition of mental operations. Adolescents are able to understand abstract concepts and concrete objects are no longer required when learning (Flavell et al. 1985, 133; Oakley 2004, 25).

The following chapter demonstrates the affiliation of mental growth and cognitive development. Piaget's constructivist theory, as well as Leg Vygotsky's social constructivist theory will be discussed in chapter three.

2.2.1 Cognitive development in middle childhood and adolescence

It is impossible to generalize and address cognitive changes during maturation accurate, because they are individually dependent and affected by social and environmental variables, as well as neural maturation (Casey et al. 2000, 243-253; Fuster 2002, 383; Nagy et al. 2004, 1230-1231). Nevertheless, there are some changes in cognitive development that are characteristic for middle and late childhood.

According to Piagetian theory, middle childhood is considered as concrete operations stage. Flavell et al. (1985) examine that children of this stage are able to assimilate coherently structured mental procedures (Galotti 2011, 273-275). The further in concrete operational stage child grows, the more complex aggregations one can process. For example, children of concrete operational stage are able to categorize objects by their colour, shape or size. An older child may be capable of classifying all three dimensions simultaneously (Galotti 2011, 275). A concrete operational child identifies the difference between underlying reality and perceived appearance (Flavell 1993, 134). The word "concrete" refers to concrete objects that the concrete operational child can grasp when processing information (Galotti 2011, 276). That is, when calculating an arithmetic operation such as "5-2=3", concrete operational child will more likely understand this calculation using concrete objects: "Peter has five apples, but throws two of them away, he now have three apples."

The final stage of Piaget's theory is called formal operations. This stage requires systematic and abstract thinking (Galotti 2011, 374). A formal operational child can process both possible and hypothetical structures and abstract concepts, whereas concrete operational child is limited to concrete thinking and processing (Flavell et al. 1993, 133).

Mental abilities such as problem solving and reasoning abilities are developing throughout late childhood and continue to improve during adolescence. More complex cognitive skills like processing speed, response inhibition, and working memory reach their adult-level performance approximately at 14, 15 and 19 years of age (Luna et al. 2004, 1357).

3   Constructivist Learning Theories

Constructivism is a student-centred approach, emphasizing students' ability to build knowledge upon his previous learning of the topic. Learning is not copied from an authority, instead, learning takes place in realistic environment or situation. There are two major strands that constructivism can be classified: Jean Piaget's cognitive constructivist theory, and social-cultural constructivist theory by Lev Vygotsky. Constructivist theories are essential concepts of cognitive psychology, defining children's and adolescents' cognitive development.

3.1   Cognitive Constructivism

Jean Piaget (1896-1980) was a developmental psychologist, and a pioneer of constructivism theory, who was interested in biological development of learning. He believed that learning occurred through biological developmental phases. That is, in each of these phases, child learns and assimilates new ways to construct knowledge, while limitations related to previous stages are being released. In Piaget's cognitive constructivist theory, learning takes places in two ways; through assimilation, and through accommodation. Assimilation happens when new knowledge is built upon already existing knowledge, whereas accommodation occurs as ideas and beliefs are reconstructed or replaced. (Rauste Von-Wright et al. 2003, 158)

Piaget's cognitive constructivism theory underlines the importance of individualized learning. Each individual learns at a different rate and one assimilates new thing quicker than other. Therefore it is crucial to understand how much and how complex the assignments, exercises and problems are for different individuals (Powell, et al. 2009, 242-243).

The weakness of Piaget's theory is that it does not take into consideration that the outcome of thinking and learning are strongly affected by context and situation (Rauste Von-Wright et al. 2003, 158)

6

3.2 Social Constructivism

Another famous constructivist, Leg Vygotsky (1896-1934), emphasized the social aspect of learning to support the biological influence. Vygotsky described that all functions in child's cultural development occur in two levels: first in social level, then in psychological level. (Rauste Von-Wright et al. 2003, 158). This approach is commonly known as social constructivism. Vygotsky underlined the importance of social interaction and that it was an integral part of learning. Social constructivist learning combines the interaction between the learners and a personal critical thinking process. (Powell et al. 2009, 242-243).

Vygotsky's theory consists of various concepts. One of the most important concept is ZPD (the Zone of Proximal Development). Vygotsky suggests that ZPD has a major impact on child's cognition. ZDP is an environment in which child's learning is supported and helped by others. This theory supports the idea that learning experience is best enhanced when it is supported by others. For example, in the beginning of the task, student has certain limitations slowing down the learning process. With teacher's assistant, student is able to learn new concepts and overcome his previous difficulties. (Powell et al., 242-243).

Social constructivism not only emphasizes the importance of supported learning by teacher, but highlights the impact of peers in learning. Students should not only use teachers as assistants, but they should also work with other students. Working in pairs or groups combine different ideas and concepts together, and enables creating an environment where students can learn new concepts from each other. (Powell et al. 2009, 242-243).

3.3 Situated Cognition

Kirshner & Whitson (1997, 1) pointed out that cognitive learning theories have dominated American psychological research and suggest that these theories have created the foundation for situated learning theories or other philosophies that try to better reflect the social aspect of learning.

The approach of situated cognition examines learning as a broad, multidimensional and student-centred philosophy. This concept has been widely researched, especially during the last two decades by many psychologist (Braun, Collins & Duguid 1989; Lave & Wenger 1991; Resnick, Levine & Teasley, 1991; Nunes, Schliemann, and Carraher 1993, Reder et al. 1996, Kirk & MacPhail, 2002). Situated cognition is based on an idea that learning is an active process, affected by context, culture and social environment. Situated learning model often involves problem-solving, collaboration or technology. (McLellan 1996, 7)

Situated learning takes place in activity, by doing. Situated learning theorists argue that learning should not be looked as a transformation process of knowledge between persons. This type of transformation process is most often present in an ordinary class room sessions where the teacher shares his or her knowledge of certain matter to students. In that case, student is receiving information from teacher and is then creating and structuring new knowledge. Situated learning, on the other hand, occurs in more informal, non-classroom circumstances and the outcome of learning is highly dependent on situation where the activity takes place (Anderson et al. 1996, 6).

To get a precise image of situated learning, learning can be demonstrated as apprenticeship. Lave and Wenger (1991) gave examples of apprenticeship from all around the world to describe the purpose of situated learning in real life. Learning takes place often in the form of some sort of apprenticeship, especially in demanding and pragmatic work. It is a vital part in obtaining expertise by combining theory into practice and forces students to perform real life tasks, often under pressure. Lave and Wenger defined apprenticeship as emphasizing specific procedures to complete concrete tasks. Procedures were used to accomplish meaningful, and practical task. By the same token, importance of social context for learning was highlighted (Sawyer & Greeno 2009, 351).

Situated learning can be considered as a procedure where situational, environmental, and social aspects are highlighted. "The situative approach will continue to be central

of the learning sciences, because this new interdisciplinary field is increasingly demonstrating that learning is most effective when students work collaboratively to solve authentic problems in rich, real-world tasks" (Sawyer & Greeno 2009, 364).

4 Decision-making in sport

Decisions are made constantly, both consciously and unconsciously. Performance of the action is often preceded by a decision-making questions: "what should I do and why?" However, most of our decisions are intuitive and do not involve conscious processing of knowledge. Playing sports is continuous problem solving. Players are trying to choose the most efficient solution in particular moment of the match. In dual-sports, player is required to predict the action of the opposing player and to respond the action as efficiently as possible to win the opponent. In team sports, however, the decision-making process is far more complex and it requires more variables to be concerned of. Skilled team sport players are strong, athletic and have excellent sport-specific skills, but they are constantly able to make efficient decisions at the right time as well (Baker et al. 2003).

In order to better understand the difference between expert decision-makers and novice decision makers, it is important to scope the practice activities of experts and novices. Ericsson et al. (1993) suggest that in order to obtain expertise performance, it is predicted that minimum of thousand hours of deliberate practice must be accomplished (Baker et al. 2003, 13). However, the number of hours spent on deliberate practice with one particular activity is not the only factor defining expertise performance. Baker et al. (2003, 22) argue that "participation in other activities may indeed be a functional element in the development of expert decision-making skill". That is, as team sports require a wide understanding of pattern recognition, participating other activities seems to have positive effect on decision-making performance on court.

There are two ways to improve decision-making: through implicit and explicit learning. Implicit learning occurs unintentionally, without explicit information whereas explicit learning is provided intentionally, with explicit information. When learning implicitly, learning is obtained without an intention to learn. In explicit learning, information is provided for the learner to better understand the task and goals of specific action. Effectiveness of each approach is highly dependent on the complexity of the task. In low-complexity tasks, implicit learning is superior, whereas in high-complexity tasks, explicit learning is more effective (Raab 2003, 331).

5   Technology and Learning

Technology has become a common part of education in our daily lives. Computers, audio and video devices, tablets and other modern gadgets have partly replaced ordinary educational tools. What was earlier considered to be high technology, is now acknowledged as outdated and sometimes even useless. People tend to seek more advanced, handy, and effortless devices to help gathering information and solve problems. This is natural as technology advances and our demands change. However, it is often assumed that information technology enhances the learning process as is, even though questions like "How should we use it?" or "How do we benefit from it?" are not stated.

Previous questions bring us in the centre of learning. Learning occurs whether if it is passive or active, formal or informal, social or individual. Nevertheless, as mentioned in situated learning chapter, the context always affects the outcome of learning. Even the smallest adjustment in teaching or learning methods may have a huge effect on results. Jonassen, et al. (2008, 7) argue that in order to teach students meaningfully, it is important to shift the approach from technology-as-teacher to technology as partner in the learning process. That is, the technology used in studying should not be the crucial element of the teaching, but an efficient tool to enhance the learning process.

5.1   Efficient use of technology in learning

Before we start to use technology to support learning, we need to understand that our brain has to collaborate with technology. That is, the technology we use, must be brain friendly. Our brains have its limitations: it cannot process too many, or too complex matters and being functionally efficient at the same time. In such case, our cognitive abilities and demands for learning are unequal and sufficient cognition will not occur.

Itiel E. Dror (2011, 1-2) illustrates this dilemma in his example of internet passwords. Passwords are needed to obtain access to emails, plane tickets, hotel bookings, internet banking etc. The purpose of password is to protect our privacy and prevent any abuse

of our private accounts. However, we are asked to have a different password for different account. The principle is that one should never write the password down, password should contain numbers, upper and lower case letters and we are even asked to change the password every six months. This leads us to give up with many of these principles and one ends up having a single password or multiple passwords written down on paper because our brain simply cannot process complex requirements like this.

Brain friendly technology is critical when technology based learning is used. Brain friendly technology is designed based on learners needs, and when designed correctly, it enables students to fully concentrate on important tasks to enhance learning. However, if technology is designed in a way that prevents or reduces our brain to focus on given tasks, learning is not fostered and technology will not give the desired advantage. First, careful planning and examining the purpose of learning is vital. Second, evaluation of how technology would enhance learning, must be considered. Third, it must be scrutinized how the tool should be used in order to obtain the best possible learning outcome. Lastly, in order for this procedure to happen, one should bear in mind that learners and technologies should work in intellectual collaboration, supporting learner's cognitive responsibilities (Jonassen et. al. 2008, 7).

6 Perception

Perception is a cognitive process where objects, patterns, people or events are perceived. This ability may seem simple and self-evident but perception is a complicated cognitive process, occupying up to half of the total brain cortex space (Galotti 2014, 38). Perception is a wide subject which can be divided into visual perception, auditory perception, haptic (touch) perception and gustatory (taste) perception (Galotti 2014, 39). As my study investigates the effects of perceptual training, this chapter solely focuses on visual perception.

6.1 Visual Perception

Vision is used to define the location of objects as they are perceived from our point of view. Ability to visually recognize something we see enables us to grasp things, avoid things and approach things. Before crossing a street we look left and right to see if there is a vehicle approaching from either side. If so, according to our perception, we decide to either cross the street or wait. This illustration is a typical example of action and recognition. However, making the decision requires numerous other questions that need to be answered before the walk can be initiated: how far is the kerb? How wide is the road and how much time is required to cross is? How fast is the vehicle approaching? What type of vehicle is it? Therefore, "perception can be likened to thinking and other high-level processes such as reasoning and problem solving" (Wade & Swanston 2001, 2-3).

Good visual perception skills are required when pursuing the peak performance in any sport. Albeit motor skills and sport specific skills are essential abilities for skilful behaviour in sport, having an ability to rapidly extract critical information is a skill that distinguishes experts from non-experts (Mann et al. 2007, 457). Large amount of evince support that skilled performers search the display in a more systematic ways and efficient manner than less skilled performers (Savelsbergh et al., 2001, 279; Farrow & Abernethy 2001, 471; Williams & Hodges 2004, 5; Farrow & Raab 2013, 210).

6.2 Previous studies on perceptual training in sports

Gibson (1963, in Fahle & Poggio, 2002, 2) defines perceptual training: "Any relatively permanent and consistent change in the perception of a stimulus array following practice of experience with this array will be considered perceptual training" Perceptual training is a form of implicit training because it does not necessarily consist of conscious memorizing of events or facts. Therefore subjects of perceptual training are unable to describe what the outcome of learning is. They cannot define what is changed after the learning process compared to the beginning of the process.

A great amount of research has been published about perceptual expertise in sport. Most of the studies have examined the difference in perceptual skills between novice players and expert players (Williams, 2000; Savelsbergh et. al. 2002; Farrow & Abernethy, 2003). These studies clearly demonstrate that skilled players are able to predict future events and therefore to make better and faster decisions within a game, compared to novice players.

6.2.1 Video-based perceptual training for tennis players

Some studies suggest that visual-perceptual training may enhance player's decision-making skills. In one such study, Damian Farrow & Bruce Abernethy (2002) investigated the effects of implicit video-based perceptual training for tennis players. Thirty-two participants were required to test their anticipatory skills. Participants were divided into four groups, each performing different training method: implicit training group, explicit training group, placebo group, and control group. Outcome of the research was analysed with a test-retest method. Pre-test included a progressive temporal occlusion paradigm, which is described in the following paragraph. Pre-test was followed by four-week, group-specific training program. Post-test was performed three days after the last training session, and finally a retention test was performed 32 days later.

Training methods were somewhat similar for implicit and explicit group as the participants from both groups watched the same video of a tennis serve from the perspective of returner. In progressive temporal occlusion paradigm, video of a tennis serve was occluded at five different points during the serve. The task for the explicit training

group was to predict the direction of the service, whereas the implicit training group was required to estimate the speed of the serve. Another important difference between the two approaches was that the explicit training group received a plenty of additional information about the kinematics of the serve, whereas the implicit training group did not receive any explicit information about the serve at all.

Placebo training group watched a 20-minute video footage of professional tennis matches. Participants were then required to answer questions about the match to maintain participant's attention. Their task was to give a statement about how the increased match play knowledge might have positively affected on return of serve performance. The only task for the control group was to complete a weekly physical practice session and the three test sessions.

This study showed some crucial notions about the video-based perceptual training and its design. Less traditional, unconscious, implicit approach seems to be much more effective way to improve players' anticipatory performance compared to traditional, conscious, explicit method. Farrow & Abernethy gave one possible explanation for such outcome: "because participants in this group were exposed to several strategies suggested to improve anticipatory performance, they did not consistently attend to the most valuable anticipatory strategy, but rather sampled a number of different information sources with varying success". (Farrow & Abernethy 2001, 483)

6.2.2 Visual perceptual training for cricketers

Another visual-perceptual training research showed similar results. Hopwood et al. (2011) examined whether visual-perceptual training would enhance the fielding performance of cricket players. Twelve participants did the same test-retest design. However, seven players completed three additional perceptual-training sessions (training group) compared to the remaining four players (control group) who did not completed any other training sessions in addition to test sessions.

This study consisted of a test-retest design. Participants performed two different visual-perception tests: a video-based decision-making test and an in-situ fielding test. In

the *video-based decision-making test*, participants watched a life-sized video showed by a video projector of a tennis server. Participants were asked to predict the direction of a ball by moving left, moving right, or forwards as they would respond to a serve in a real game situation.

The other perceptual training test was called an *In-Situ Fielding Test*. In this test, the participants were required to field a total of approximately twenty balls in the cricket cover position. The test was concluded when the participant had fielded five balls that were hit to their right, five balls that were hit to their left, and five balls that where hit straight towards them.

The results of the experiment provide some evidence to support the following hypothesis: "Six weeks of video-based visual simulation training would improve inner-circle fielding performance more than regular on-field training alone" (Hopwood et. al. 2011). Training group, who completed the additional perceptual-training session, performed considerably better in both, video-based decision making test, and in-situ situ fielding test, compared to the control group.

7   Sport analysis of ice hockey

Ice hockey is an intense sport in which the players are required to do rapid movements with and without the puck, giving and receiving hits, shoot and pass the puck. These requirements make ice hockey a physically demanding sport. In addition to its physical nature, ice hockey is also a game where good, quick decisions are extremely important. The ice surface is limited, surrounded by boards, and the opposing team is doing their best to win the puck and gain possession. While ice hockey players are becoming faster, stronger and more skilled, reading the game and predicting future events of the game has become extremely important as well.

Ice hockey game consists of three periods, each period taking 20 minutes. Two teams are playing against each other. Each team has approximately 20 players in the roster, of which six are playing on the ice surface at the same time. These six players are: goal-keeper, left defenseman, right defenseman, left wing, center, and right wing. The team that scores more goals than the other after the regulation, will be determined as a winner. If the game is tied after the regulation, an overtime and, if needed, a shootout is played to declare the winner (IIHF Rulebook 2014, 37).

Figure 1. Ice Hockey rink and the zones (IIHF Rulebook 2014, 22)
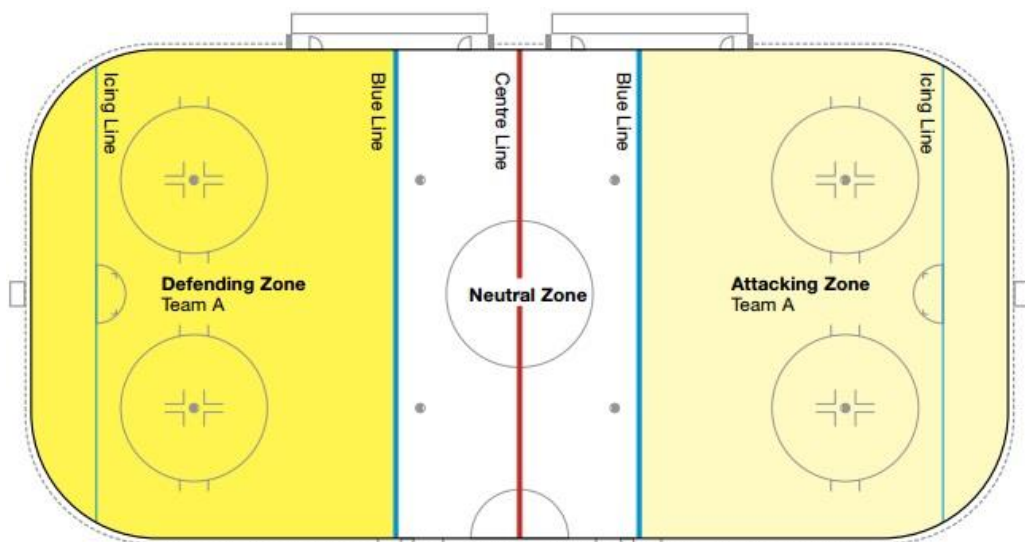
7.1 Tactics

Ice hockey is a game that requires technical skills and game sense. Great players master both of these skills and are able to use the right technical skills to execute appropriate decisions under high pressure and limited time. Ice hockey tactics are classified in two: individual tactics and team tactics. Individual tactics and team tactics should not be confused with team play systems or strategy. Both, individual and team tactics aim to create or take away the advantage of an opponent by using technical skills with a distinction that whereas individual tactics are performed by one player, team tactic is a collective action of two or more players.

Teaching progression pyramid by International Ice Hockey Federation illustrates the order of the game elements in teaching progression. Adequate level of the inferior stage must always be obtained in order to move to the next stage.

Figure 2. Teaching progression pyramid (IIHF coach development manual, level I, 2007, 3).
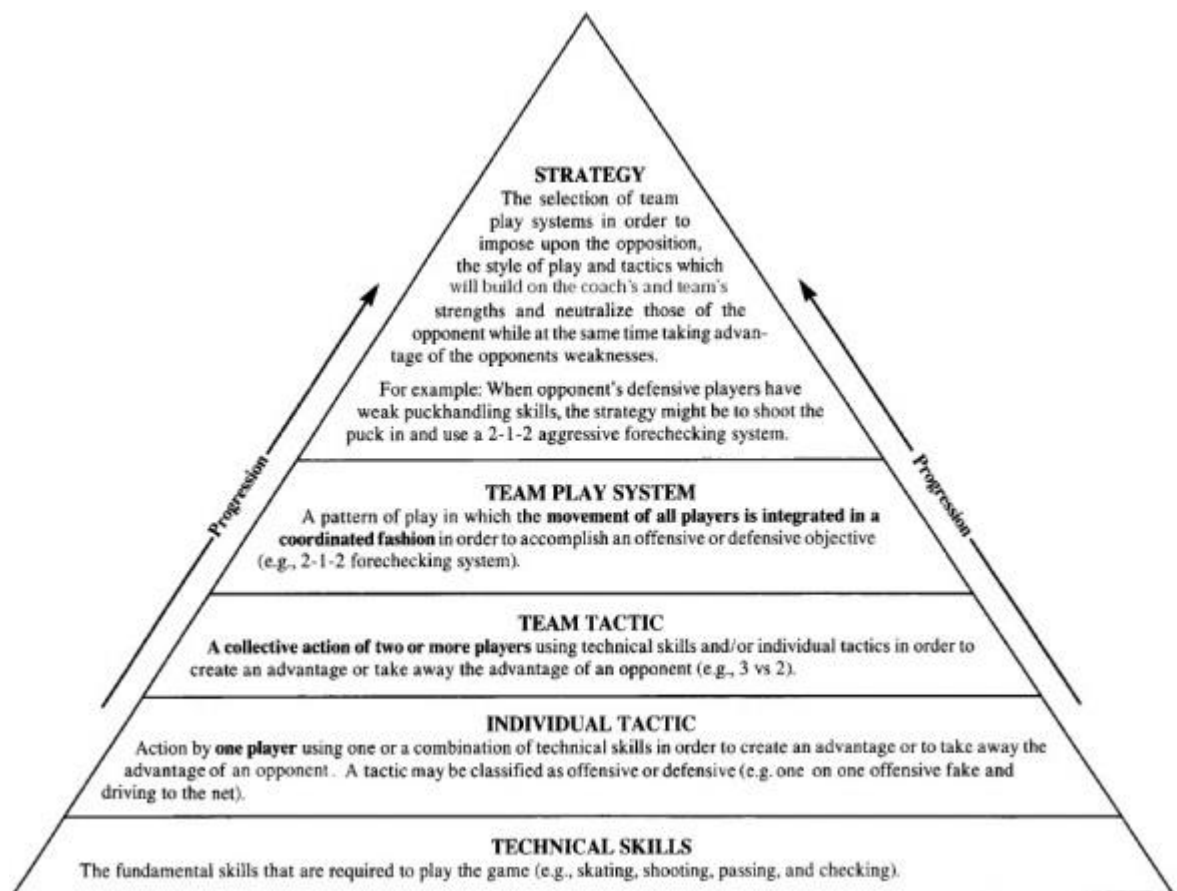
7.1.1 Individual tactics

Before introducing individual tactics, player must have reached an adequate level of technical skills. The higher the level of technical skills, the better the quality of executed individual tactic. Individual tactics is a result of set of skills performed and decision making process in a specific game situation. Individual tactics can be separated in two: offensive individual tactics and defensive individual tactics. (IIHF coach development manual, Level II, 2008, 4)

Figure 3. Ice hockey individual offensive and defensive tactics.

LEVEL I *Individual Offensive Tactics*	LEVEL II *Individual Defensive Tactics*
Attacking One-on-One • *Skating Fakes* • *Body Fakes* • *Shooting and Passing Fakes* • *Driving to the Net* • *Walkouts* **Shaking a Defender One-on-One** • *Turn-up* • *Delaying* • *Protecting the Puck* **Screening (Without the Puck)**	**Defending One-on-One** • *Positioning* • *Closing the Gap* • *Body Contact* **Defending an Opponent in the Defensive Corner** • *Positioning* • *Closing the Gap* • *Body Contact* **Defending Along the Boards** • *Pinning* **Backchecking**

The objective for offensive game from individual's point of view is to create a scoring change. Therefore it is important that players make appropriate choices at the right time, with or without the puck. Following stages are performed in every tactical decision: (International Ice Hockey Federation 2007, 19.1).

1. observing the situation
2. organizing and processing the information
3. selecting an appropriate response from the available options
4. executing the correct tactic

7.1.2 Team tactics

As discussed in previous chapters, ice hockey rink is divided into three zones: defensive zone, neutral zone and offensive zone. Each zone has its specific offensive objective. Breakout is a key element to create a successful attack, and it is initiated from team's defensive zone. All the players, including the goalie, need to be involved in the breakout and read the situation at hand to exit the zone successfully (Walter & Johnston 2010, 3).

Three attacking situations take place in the neutral zone: the rush, counters and regroups. The rush is a continuation of the breakout. Counters and regroups resemble each other, but while counters require speed, regroups are more controlled (Walter & Johnston 2010, 17-18). A team wants to attack quickly against unorganized defence, and counter attacks create a possibility to exploit the unawareness of opposite team. Regroups, on the other hand, are used against organized defence. If the opponents are already set up, regroups are a more effective way to break through the defence and enter the offensive zone (Walter & Johnston 2010, 25).

Maintaining the puck possession is a common goal for all coaches. Successful offensive zone entry is often followed by offensive zone play. Offensive zone entry results in successful rush, regroup or counter and is a key element when creating scoring changes. Effective offensive zone play may lead to drawing a penalty, which again gives a power play chance.
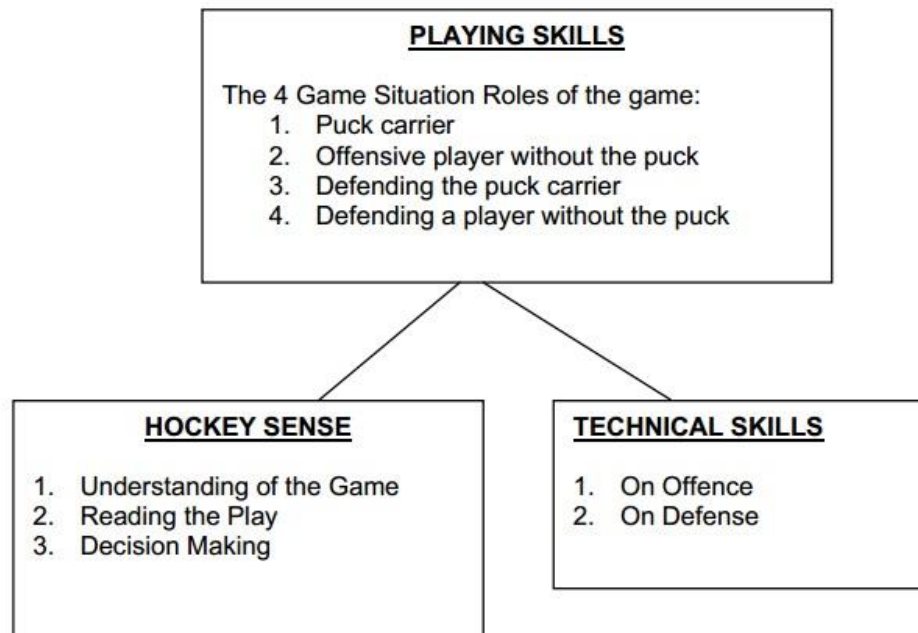
7.2 Hockey sense

Hockey sense consists of three separate tactical skills: understanding of the game, reading the play and decision making. Understanding the game and reading the game will be discussed later in this chapter. Decision making has been covered in chapter 5. Comprehending the team's common principles in different circumstances in game allows the player to improve the understanding of the game. (International Ice Hockey Federation 2008, 2). When understanding the game, player is able to better anticipate the developing game situation. Observing and analysing and anticipating events is

player's ability to read the game. Information process is followed by decision. Decision is made after the player is quickly observed and analysed the situation. Decisions constantly shape the direction of the game. Efficient decisions create two on one situations on the puck and scoring chances while inefficient decisions result in odd-man situations on the puck and scoring chances for the opponent.

Figure 4. Ice hockey skills (IIHF coach development manual, Level II, 2008, 2)

PLAYING SKILLS

The 4 Game Situation Roles of the game:
1. Puck carrier
2. Offensive player without the puck
3. Defending the puck carrier
4. Defending a player without the puck

HOCKEY SENSE

1. Understanding of the Game
2. Reading the Play
3. Decision Making

TECHNICAL SKILLS

1. On Offence
2. On Defense

The objective for offensive game from individual's point of view is to create a scoring change. Therefore it is important that players make appropriate choices at the right time, with or without the puck. When the team gains possession of the puck, playing roles can be categorized in two: first attacker, and second attacker. First attacker is an offensive player with the puck, second attacker is an offensive player without a puck.

The key for scoring opportunities is to create space. Ice hockey game consists of continuous one-on-one situations, offensive players versus defensive player. In these situations, offensive player challenges the defender with a technical skill or movement, in order to fake the defender and create space. These following steps occur in individual tactics (International Ice Hockey Federation 2007, 19.1).

7.2.1 Understanding of the game

Understanding of the game is a fundamental ability of hockey sense. When player understands the characteristics of ice hockey, predicting events and responding to specific game situations becomes easier. Adopting the "golden" rules of ice hockey is an efficient way to gain develop players' understanding of the game. Majority of the rules are also applicable to other team sports. There are two set of "golden" rules: The 10 "golden" rules of attack play and the 10 "golden" rules of defense play.

Figure 5. The 10 "golden rules" of attack play and defense play. (IIHF coach development manual, Level II, 2008, 12)

The 10 "golden" rules of attack play

1. Attack play starts as soon as the puck is received
2. The puck is always faster than the player
3. On offence you want width and depth
4. As soon as you get the puck you must move from a narrow space to a broad space
5. If a teammate is moving towards you, try to find a free zone /lane
6. The players without the puck look for a free place
7. The puck carrier always tries to move across the next line
8. After the offensive blue line one player must do strongly towards the net
9. Goals are scored from a slot (Prime Scoring Zone)
10. The defending starts as soon as the puck has been lost

The 10 "golden" rules of defense play

1. Defending starts as soon as the puck has been lost
2. On defense you want width and depth
3. There should always be one player forcing the puck carrier
4. The player with the puck should be directed to the outside
5. In the middle zone, there should be at least three players between the puck carrier and the blue line
6. In the defensive end you place yourself between the opponent and your own goal
7. You must see the opponent that needs to be guarded and the play situation
8. Guard specifically the opponent's stick (stick to stick)
9. In defensive zone cover the slot (Prime Scoring Zone)
10. As soon you get the puck, think of attack – play upwards

7.2.2 Reading the play

Players' ability to observe and search possible options in game is called "reading the play". Game situation, players' positioning, puck movement, and the direction of the play all have an effect on how the player reads the game (Luimula 2000, 6). Reading the play is a prerequisite for better decision making. Expert decision makers are capable for selecting the most efficient option under high pressure of the game (Baker & Cote 2003, 15).

7.2.3 Game situation roles

When a team gains possession of the puck, playing roles can be categorized in two: first attacker, and second attacker. First attacker is an offensive player with the puck, second attacker is an offensive player without a puck. When the team loses the possession of the puck, first attacker becomes first defender, second attacker becomes second defender. It is important that players know their game situation roles and that they are able to change roles when the possession changes. Ice hockey is an extremely fast sport and therefore responding quickly to alternating game situation roles is crucial.

Like in other team sports, gaining a one man advantage enhances offensive game, challenge the opponent and create scoring chances. Therefore, sensible movement without the puck is as important as it is with the puck. As mentioned earlier, there are two different offensive roles: "first attacker" and "second attacker". The player with the puck is called "first attacker" while all the rest of the players in offensive team are called "second attackers". Both roles have three options to develop the play. When the options are executed correctly, it will challenge the opponent and may result in creating scoring chances. These three objectives are scoring, winning space and making space (International Ice Hockey Centre of Excellence, 2014). However, choosing an inappropriate decision over an appropriate one may result in losing possession and odd-man situation is more likely to occur.

Figure 6. Game Situation Roles and transition (IIHF coach development manual, Level II, 2008, 6).
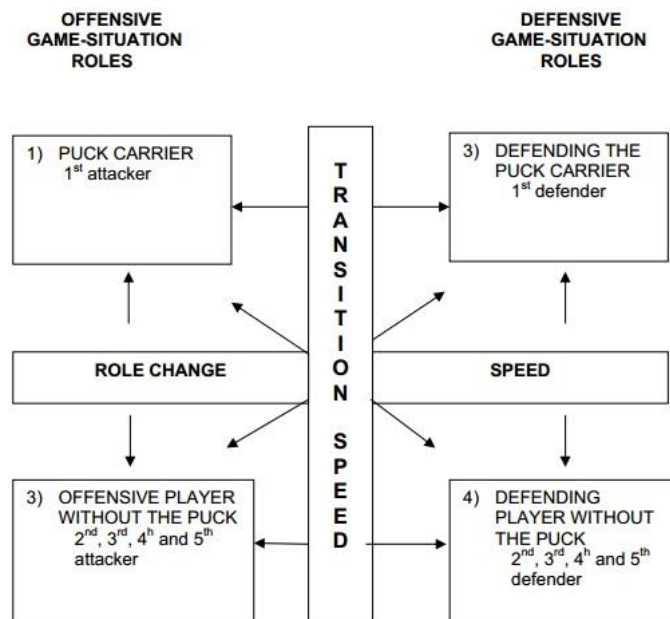
The objective for offensive game from individual's point of view is to create a scoring change. Therefore it is important that players make appropriate choices at the right time, with or without the puck. When the team gains possession of the puck, playing roles can be categorized in two: first attacker, and second attacker. First attacker is an offensive player with the puck, second attacker is an offensive player without a puck. Every individual tactical decision consist of these following steps: (IIHF coach development manual, Level II, 2008, 12).

1. observing the situation
2. organizing and processing the information
3. selecting an appropriate response from the available options
4. executing the correct tactic

In order to make a right decision such as score, win space or make space, player must be able to perform an adequate playing skill suitable for a specific game situation. For the first attacker, scoring is possible through shooting. Winning space is achievable with either carrying the puck or passing forward, while making space requires lateral or

backward movement of the puck. Following demonstration illustrates the utilization of playing skills as a first attacker in different game situation.

1. First attacker is trying to make space by passing the puck laterally since it would be the only decision that would result in maintaining or creating a 2 on 1 situation on the puck. (Figure 7)
2. First attacker is trying to win space by passing the puck forward because the decision could result in gaining 2 on 1 situation on the puck. (Figure 8)
3. First attacker is trying to score by shooting the puck. Player is inside the scoring the scoring zone and his teammates are supporting his attempt by going towards the net. (Figure 9)

Second attacker supports the puck carrier and his or her objective is to create width and depth to offense by providing passing options, confuse defenders and create scoring chances.

Figure 7. First attacker passes the puck laterally as an attempt to make space.

Figure 8. First attacker is trying win space by passing the puck forward.

Figure 9. First attacker is shooting the puck, attempting to score.

8 Empirical Research

8.1 Planning the research

Two E1 junior pre-season games and two regular season games were filmed and ana-lyzed for this research. The pre-season games were played September 17th and 28th. The regular season games were played October 25th and 26th.

Four players from EPS E1 juniors were picked up for the experimental group and four other players from the same team were selected for control group. Every student in the experimental group completed altogether ten visual perceptual assignment sheets be-tween the pre-season games and regular season games. Control group did not complete any assignments during the research period. Both, experimental group and control group participated dry land sessions before the practice.

The objective of the study was to examine a less-used method of off-ice training in ice hockey. Visual-perceptual training did not involve any physical activity and was in-tended to direct player's to come up with an appropriate solution by their own, instead of forcing them to choose the most suitable option from coach's perspective, neither to limit their options

The study was executed one to two times a week with four E1 junior ice hockey play-ers depending on team's schedule. These players were born in 2003 or 2004 being eleven or ten years old when the study took place. Those four were picked among the most skilled team in E1 age group

8.2 Offensive game sense analysis

Unlike analyzing save percentage or shots on goal, game sense is more complex and is highly reliant on game situation and positioning of the players. The findings for this

analysis were based on Anssi Arjala's and Vesa Petäjä's thesis called "An instrument for analyzing offensive game sense in ice hockey".

Using the instrument, it was possible to assess players' decisions when the puck possession was gained. The purpose of the instrument is not to analyze the outcome of the decision, but the intension. For example, if the observed player is trying to win space by passing the puck in front of him in a situation where a succeeded decision would result in creating a scoring chance, the decision is assessed as good decision, even if the pass goes wide. Decisions were analyzed in following fashion:

Figure 10. Instrument instructions (Arjala & Petäjä 2013)

1. Film a game
2. Choose a player you want to analyze
3. Pick up the incidents when the player gains the puck from the video and edit those clips into a single video clip. Clip of each possession should be 15 seconds long
4. Analyze the first three seconds of each possession and gather the information onto the paper version of the gathering sheet
5. Transfer the information gained onto the electric version of the gathering sheet
6. See the results from the result sheet

Intentions were analyzed by categorizing each decision in 15 variables and were identified by numbers from 1 to 15. Four variables are good decisions and the rest are evaluated as either forcing the play, settling or freezing. Variables 1-6 are intentions to score or to create a scoring chance, 7-9 are identified as winning space outside the scoring area, numbers 10-12 are actions for making space, 13-14 are variables for dumping the puck, and number 15 is corresponds to no action or action with no intention. Decisions were marked in the gathering sheet, and finally transferred to the result sheet showing the percentage of right decisions, forcing the play, settling and freezing (Arjala & Petäjä 2013).

Attachment 2 in the attachments section exemplifies the variables and shows how they are categorized. Note that the attachment is part of the Bachelor's Thesis of Arjala and Petäjä. The information of the thesis is found in the references section.

8.3   Research implementation

Materials used in this research were collected from E1 and D2 games using footage from Live Arena and Youtube.

The assignment was performed once to twice a week, seven times in total during the four-week experiment period. Each time the test was carried out, a player received a paper with five different game situations captured from real game situations. Game situations were demonstrated with both, video footage and paper illustration.

The assignment was to individually observe the situation, to look at the empty space, and to find an appropriate decision which would be performed when the situation would continue. The purpose was not to predict what would happen, but to provide the best solution in a given situation from subject's point of view. An important notion was that no guidance was allowed to give to the students. Assignments were done before the ice practice, once or twice a week, depending on team's schedule.

Visual-perceptual training was performed by following steps: first, video footage was showed and paused when the observed situation occurred. Then, the same footage was repeated. After that, students drew and explained the tactics they would execute in a given game situation. Finally the whole situation was played so the students saw whether their solution differed from the actual events.

Each assignment paper consisted of four to five offensive game situations. Students were asked to imagine playing as predefined player and executing a tactic with or without a puck. For instance: "If you were the offensive player with the puck, what would do you?" Then, the student drew and explained the solution on the paper.

Figure 11. Paused video footage from E1 game Jokerit Yellow – BJR Blue A

Figure 12. Same game situation demonstrated with a 2D illustration

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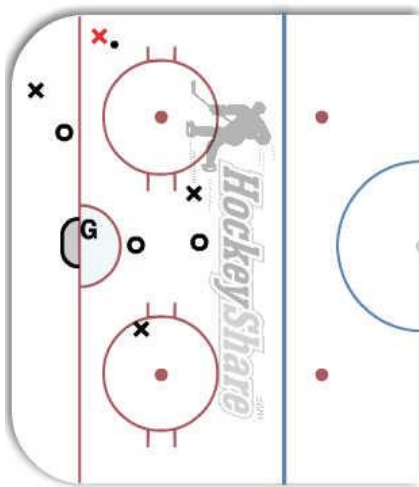
9   Results

Visual perceptual training program was completed by four E1 AAA junior players of Blues EPS team. The range of junior players' age was from 10 to 11 of age.

The results show improvements in both groups' performance. As the table 1 and 2 show, mean difference of good decisions increased 2.75% for the experimental group, whereas the mean difference of good decisions increased 0.25% for the control group. Table 3 illustrates how the pre-test and post-test results were distributed between individual players.

Table 1. Experimental group's result comparison between pre-test and post-test.

	Pre-test	Post-test
Mean	74,00 %	76,75 %
Standard deviation	2,00 %	1,79 %
Mean difference	2.75 %	
Standard Error	1 %	0,9 %

Table 2. Control group's result comparison between pre-test and post-test.

	Pre-test	Post-test
Mean	76,75%	77 %
Standard deviation	6,65 %	6,98 %
Mean difference	0,25 %	
Standard Error	3,30 %	3,50 %

Table 3. Individual comparison between experimental group and control group.

Variable	Group							
	Experimental				Control			
	Player 1	Player 2	Player 3	Player 4	Player 5	Player 6	Player 7	Player 8
Pre test results	72 %	72 %	76 %	76 %	67 %	80 %	85 %	75 %
Post test results	77 %	79 %	77 %	74 %	71 %	79 %	86 %	72 %
Difference	5 %	7 %	1 %	-2 %	4 %	-1 %	1 %	-3 %

10 Summary and discussion

10.1 Overview of the research

Visual perceptual training (VPT) provides a great tool to support off ice training, offering a possibility for injured player to participate the activity. VPT can be performed before or after the ice session, and it can be also arranged as separate activity. Individual players, lines, groups or teams can partake the activity and the session can be modified to meet the preferences of the players and the coach. VPT sessions were easily arranged and required only fifteen to twenty minutes to complete. With VPT, players were able to observe situations from other perspective, giving them a better view of what is happening, without the pressure of actual game situation. With a 2D view of the rink, players saw a better overview of the setup compared to real game situation, where limitations in our sight and pressure on the ice make it more difficult to make appropriate decisions.

Assessing players' decisions might be a challenging task as every game situation is different. The person responsible for analyzing decisions have to observe the situation and determine to which of the fifteen variables the decision belongs. Sometimes there might be a decision that cannot be strictly categorized in any of the fifteen variables. In such case the observer has to choose which variable describes the decision most accurately. However, each variable is precisely described, which makes it easier for the observer to use the instrument.

Despite the positive effects and promising results of VPT, the research encountered several issues. E1 2014-2015 season games started not until November, shortening the experiment period drastically. As a result, only four games in total were analysed, and the amount of data was very limited; 478 possessions were analysed in total. The average amount of puck possessions per player was 59.75, with a minimum of 10.25, and a maximum of 21.75. In order to make sound conclusions of the effectiveness of visual perceptual training, more players must be involved in the research. Two game prior and after the treatment did not provide enough reliable data to draw further conclusions whether VPT had significance or not.

This study had two research questions: First, can Visual Perceptual Training work as a functional and useful dry land tool? Second, does VPT improve individual offensive game performance? Answer to the first question is yes, VPT worked very well as a dry land tool. Answer for the second question is no, despite the promising results, there is not enough data to suggest that visual perceptual training improves individual offensive game performance.

Although the study did not provide scientific significance, it showed encouraging results for the future research. Players' enthusiastic attitude towards the experiment and creative solutions also indicated that there is a need for new, innovative methods to improve players' decision making skills.

10.2 Ideas for Future Research

In this chapter, I will represent several examples of how Visual Perceptual Training can be utilized in the future. These methods could be used separately, but a possible research could also combine features of different examples.

1) **One season long Visual Perceptual training program.** This approach would top this research's limitations. A season-long program with minimum of twenty players would provide more individual data, more games and therefore more possessions, giving extended amount of reliable data.

2) **Analysing players' own games.** This method would be similar to VPT method used in this research. However, with this procedure players could observe and analyse their own games. Players would be assigned to observe their own decisions and replay the upcoming events. Questions like "Would you make the same decision if you would able to replay the situation?", "If not, what would you do", "Why would you do so?"

3) **Extended use of data to analyse.** When analysing the data, one could assess number of puck possessions, puck possession of the team, shots on goal, shots from the prime scoring area etc. Extensive game data may provide evidence to

show if VPT is linked with better scoring changes and team's ability to better possess the puck.

In order to develop all-around players, coaches must create new ways to challenge players. Ice hockey is not only about physical and technical abilities; constant decision making under high pressure is also an extremely important factor among ice hockey skills. Therefore, it is extremely important to offer new ways to develop player's decision making skills together with technical and physical abilities. Visual perceptual training is a creative method which can be adjusted and applied in countless ways to expand coach's training toolbox.

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Attachments

Attachment 1. Visual-Perceptual Training assignment papers
Attachment 2. Decision variables and clarifiactions

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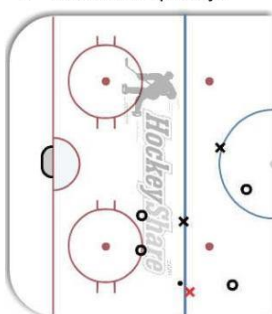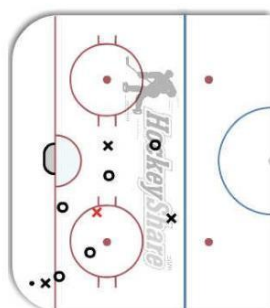
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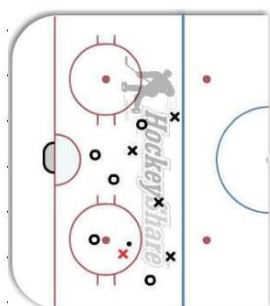
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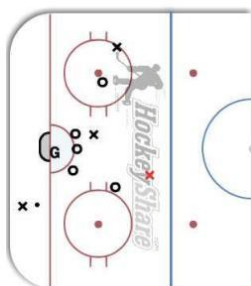
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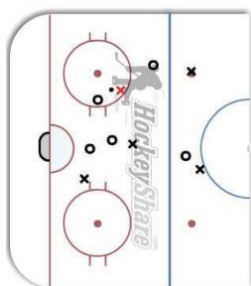
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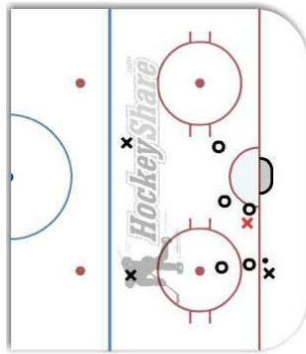
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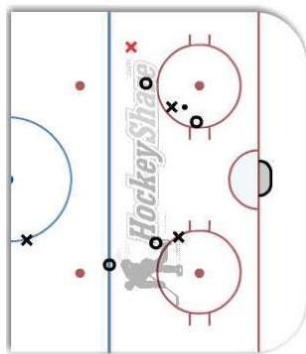
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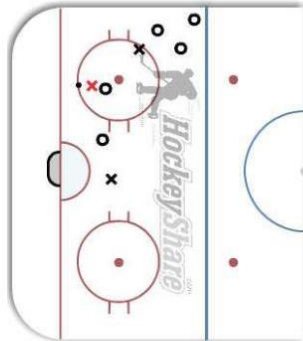
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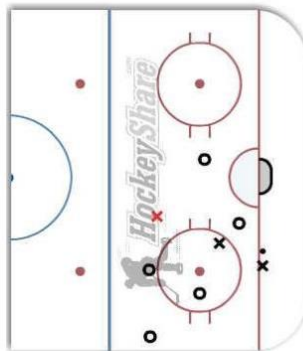
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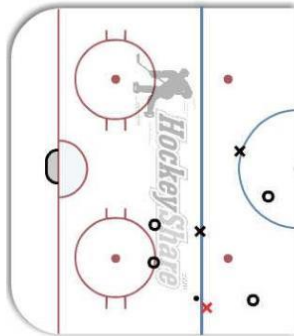
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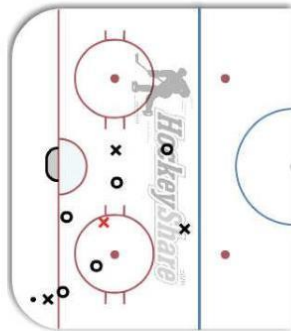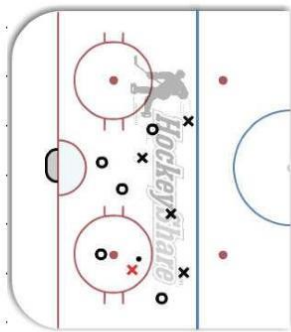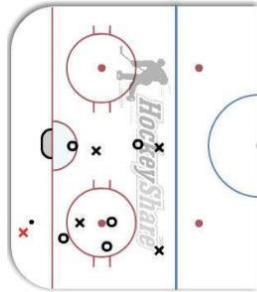
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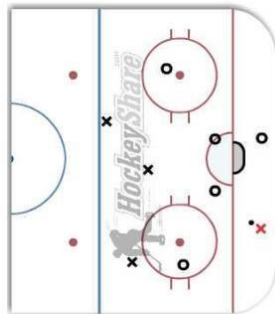
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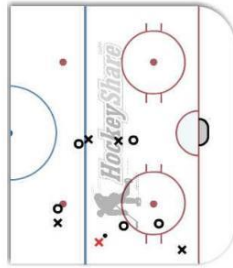
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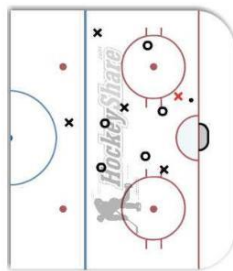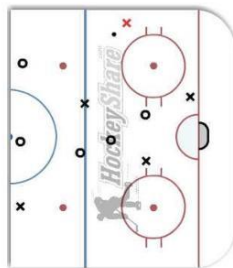
5. Kiekollinen pelaaja

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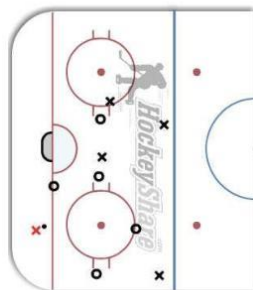
2. The variables

There are 15 variables identified simply by numbers from 1 to 15, for the player's actions. The numbering of the variables corresponds to the game priorities – numbers 1-6 are actions involving scoring, numbers 7-9 are variables for the action of winning space outside the scoring area, numbers 10-12 are variables for creating space outside the scoring area, numbers 13-14 are variables for dumping the puck and number 15 is the variable for no action or action with no intent.

The variables are:

1. The player tries to score from the scoring area, or from outside the scoring area with his teammates supporting the scoring by being in motion towards the net for a rebound and/or screening the goalie.
   Category: **Right decision (subcategory: The most efficient decisions)**

2. The player tries to score from outside the scoring area, because an attempt to win or make space would result in the puck carrier being in an odd-man-minus situation and under pressure from the opponent.
   Category: **Right decision (subcategory: The most efficient decisions)**

3. The player tries to score from outside the scoring area in a situation, where his teammates are not supporting scoring but enabling a better scoring change to be created by winning or making space
   Category: **Forcing the play**

4. The player tries to win space instead of scoring in the scoring area.
   Category: **Settling**

5. The player tries to make space instead of scoring in the scoring area.
   Category: **Settling**

6. The player tries to dump the puck instead of scoring in the scoring area.
   Category: **Settling**

7. The player tries to win space outside of the scoring area. The decision would result in gaining a scoring chance or a 2 on 1 situation to be maintained or created on the puck.
   Category: **Right decision (subcategory: The most efficient decisions)**

8. The player tries to win space outside of the scoring area. The other nine skaters on the ice are situated so that a 2 on 1 situation is possible to be maintained or created by winning space, but the player decides to try to win space to a situation where there would be an odd-man-minus situation and pressure on the puck.

2

49

Category: **Forcing the play**

9. The player tries to win space outside of the scoring area, though the other nine skaters on the ice are situated so that an immediate access to the scoring area is denied or to maintain or create a 2 on 1 situation on the puck. The player's decision would result in an odd-man-minus situation and pressure on the puck.

    Category: **Forcing the play**

10. The player tries to make space outside of the scoring area, because the other nine skaters are situated so that an immediate access to the scoring area is denied and making space is the only decision that would result in maintaining or creating a 2 on 1 situation on the puck.

    Category: **Right decision (subcategory: Sensible decisions)**

11. The player tries to make space outside of the scoring area, in a situation, where the other nine skaters are situated so that there would be a chace to immediately access the scoring area or maintain or create a 2 on 1 situation by winning space.

    Category: **Settling**

12. The player tries to make space outside of the scoring area, in a situation, where the other nine skaters on the ice are situated so that immediate access to the scoring area is denied and a 2 on 1 situation is possible to be maintained or created only by making space, but the player decides to try to make space to a situation where there would be an odd-man-minus situation and pressure on the puck.

    Category: **Settling**

13. The player is outside the scoring area and tries to dump the puck, because the other nine skaters are situated so that he is under pressure and has no chance of immediately accessing the scoring are or creating a 2 on 1 situation on the puck by winning or making space.

    Category: **Right decision (subcategory: Sensible decisions)**

14. The player is outside the scoring area and tries to dump the puck, although there is a chance of immediately accessing the scoring area or creating a 2 on 1 situation by winning or making space.

    Category: **Settling**

15. No apparent aim can be observed from the player's actions.

    Category: **Freezing**

3

According to our interpretation a player should always attempt to play according to the highest possible game priority in any given situation. However, with the exeption of getting the puck into the scoring area and thus creating an immediate scoring chance, the player's actions should lead to a situation, where his team has the chance of creating a 2 on 1 situation on the puck. If there is no action that would create such situation, the efficient thing to do is to dump the puck into a position, wherefrom the opponent has the longest possible distance to travel in order to reach the scoring area, and start defending. An even-man situation, for example 2 on 2, on the puck, is considered a chance to create a 2 on 1, unless the puck carrier is under imminent pressure from the opponent and in clear danger of losing the puck.

The variables are pooled into four bigger categories: right decisions, forcing the play, settling and freezing. The variables within a category all refer to the same kind of decisions. The right decision category, consisting of variables 1,2,7,10 and 13, has all the actions that are considered to be most efficient in the situation they were manifested. This category is further divided into two subcategories: the most efficient decisions and the sensible decisions. The most efficient decisions are related to scoring and winning space, whereas the sensible decisions are making space and dumping the puck in situations, where those are the highest priority possible to obtain. The forcing-the-play category, on the other hand, refers to incidents, where the player attempted to play to excessively high priority and, therefore, created a situation of low offensive efficiency and possibly high offensive risk for his team. A good example of such situation would be a player attempting to win space without the support of his teammates and ending up in a 1 on 2 or a 1 on 3 situation. The variables in this category are 3,8,9 and 12. Settling refers to the act of not attempting to play to the highest priority the situation enables, therefore settling for a play that is less than optimal in terms of efficiency. A good example of such incident could be a defender getting a lateral pass from his defensive partner in the defensive zone with a lot of free space in front of him, and not winning the space, but opting to wait for the opponent to pressure him and then playing the puck back to the other side with another lateral pass. Opting to pass to a worse placed teammate when you are 1 on 1 with the opponents goalie is another typical example of settling. Variables 4,5,6,11 and 14 are considered settling. The category of freezing consists of only one variable and refers to the act of not acting at all or acting without a clear intent.

4