The Impact of Motor Learning Paradigms on Smart Sport Exercises

Master Thesis Interaction Technology

J. Groeneveld, S1717626

University of Twente

22 January 2021

Version: **Final**

Supervisor 1: dr.ir. D. Reidsma (Dennis)
Supervisor 2: dr. D.B.W. Postma (Dees)
Supervisor 3: dr.ir. B.J.F. van Beijnum (Bert-Jan)

University of Twente
Department EEMCS
Research group Human Media Interaction (HMI)
Zilverling, room 2047 (secretariat)
PO Box 217
7500 AE Enschede
The Netherlands
Tel: +31 (0)53 489 3740 / +31 (0)53 489 3680

Preface

This thesis was conducted for my MSc Interaction Technology at the University of Twente. I enjoyed my years as a student in both the CreaTe program as a Bachelor student, and during the I-TECH program as a Master student. I will look back at these years with joy and I will miss the good times I have had.

Many people helped to bring this thesis to a successful end, I couldn't have done it without their help and contribution. First and foremost, I would like to thank my supervisor Dees Postma for his help, guidance, and feedback throughout this thesis. Dees, you inspired me many times with your astute insights and you helped me to become acquainted with the complex but interesting world of motor learning. I value your understanding, support, and intellect a lot. Both on academical and personal level you are very committed, making you a pleasant person to work with. Given the strange and uncertain times due to the COVID virus, I am especially grateful for our pleasant and enjoyable cooperation. Thanks a million!

Furthermore, I want to thank both Dennis Reidsma and Fahim Salim for thinking along with the more practical and technological challenges. Thanks, Wytse Walinga and Jeroen Koekoek from Windesheim Zwolle, for providing useful insights and feedback on both motor learning theories and on our practical implementations of these theories.

Finally, I want to thank my housemates, my family, and friend for their love and support. To my fiancé, Marieke, thank you for providing me with your unlimited love, endless support and encouragement, and reminding me to take a break sometimes.

Especially in the challenging times due to the COVID virus, I couldn't have done it without all of you!

Jorik Groeneveld
Enschede, January 2021

Glossary

CBA: Cognitive Based Approach
DSA: Dynamical Systems Approach

Motor learning: The acquisition and improvement of motor skills.

Design space: The design matrix constructed in this thesis with the dimensions approaches of motor learning (CBA and DSA) and skill level (novice and expert) defining the four quadrants

Volleyball terms:

Spike: Offensive action of hitting the ball (also known as *attack* or *hit*)
Attacker: The player who attempts the spike
Kill: A spike which directly results in scoring a point

Set: A ball played towards a position where the attacker can spike the ball
Setter: Player who sets the ball for the attacker to hit
Outside set: Most common set, delivered at the left side of the field
Back set: A set delivered behind the back of the setter, at the right side of the field

Bump: A term for forearm passing (also known as *pass*)

Side-out: The sequence of bump, set, spike

Table of Contents

Abstract

Skill acquisition and motor learning have been extensively studied since the 19th century. Over the course of the years, two distinctly different theoretical frameworks have emerged with respect to motor learning: the Cognitive Based Approach and the Dynamical Systems Approach. This research aims to illustrate how both motor learning paradigms impact the design of interaction technology for sports differently. We argue, by illustration, that different paradigms inspire fundamentally different exercises. Herein, we also consider the novice-expert distinction to show how novices and experts are treated differently in the two distinguished approaches of motor learning. This results in four smart sport exercises for volleyball which, in particular, focus on training the spike timing. These exercises are based on the two motor learning paradigms and the principal differences found between them. Besides the inherent theoretical value, we show that it is relevant to make a deliberate decision for either paradigm when designing for users (i.e. trainers). We presented the digital-physical manifestations of the four quadrants of our design matrix by means of a Lo-Fi prototype to volleyball trainers. Using the results of both a questionnaire and an interview, we show that it helps in the design of interactive exercises to be sensitive to the theoretical allegiance of your audience.

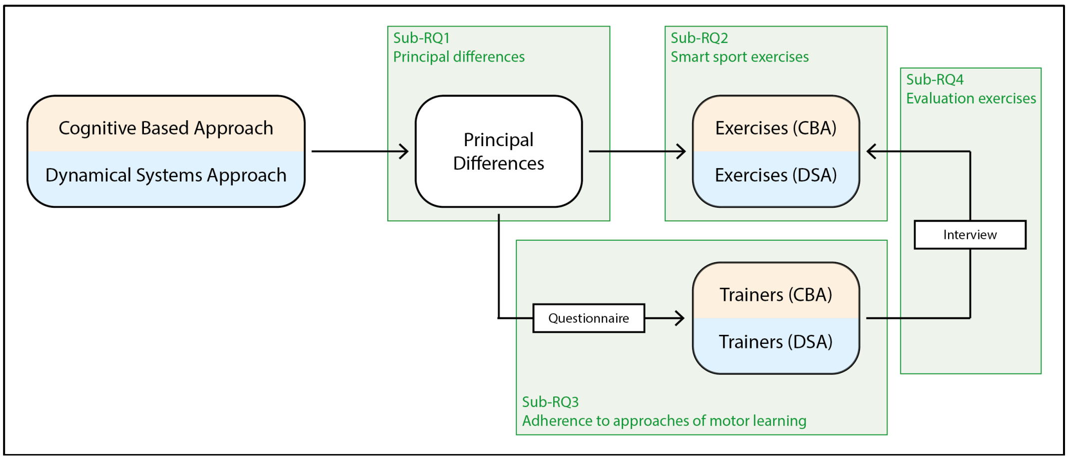
1. Introduction

This master thesis examines the impact of different motor learning paradigms on the design of smart sport exercises. The possibilities of technology are growing over the last decades and one of the disciplines to consider is sports. The presence of technology in sports is ever-growing; from fitness-trackers and heartrate monitors to goal-line technology and automated sports performance analysis systems. In global term, technology allows to: register, measure, analyze, and feedback. Interactive technologies, like the ones mentioned above, are frequently used to perfect performance, recently however its potential to enhance motor learning is becoming increasingly clear. For volleyball in particular, a project called Smart Sports Exercises (SSE) is started which examines the use of an interactive LED-floor during practice (Postma et al., 2019; "Smart Sports Exercises | Website of the ZonMw funded 'Smart Sports Exercises' research project," n.d.). The goal of the SSE-project is to support and improve volleyball training by using the LED-floor to provide feedback and even to guide the training. Using technology, exercises can be both supported and guided. These can be either traditional exercises, but the floor also allows for exploration of a field of completely new exercises. This thesis is part of the SSE-project.

Players and trainers alike can leverage the potential of technology and projects like the one mentioned above, in order to create a rich learning environment. However, what is considered a rich learning environment is a matter of perspective. When it comes to motor learning, two distinctly different approaches of motor learning can be discerned: The Dynamical Systems Approach (DSA) and the Cognitive Based Approach (CBA). The differences between the two approaches of motor learning and the impact of these approaches is illustrated in this thesis by designing fundamentally different volleyball exercises.

Volleyball can be considered to be a rather complex sport. Both players and the ball move around in three dimensions, the players only make short contact with the ball, and the players have a small area on which they move around with their team. The movements the players make are rather complex, so a proper learning strategy is required to ensure effective motor learning. What is considered to be a fitting motor learning approach heavily depends on the theoretical framework (approach of motor learning) the trainer adheres to. Under each of the two discerned approaches (CBA and DSA), a number of different motor learning theories can be found. We consider the approaches of motor learning to be important conditions to consider when designing smart sport exercises; this research examines the effect of these frameworks on the design of sport exercises. Hence, the main research question of this thesis is: *What is the potential impact of considering the two different approaches of motor learning when designing interaction technology for smart sport exercises?* The main research question can be divided into sub-questions, which are answered separately in order to contribute to the main question; figure 1.1 depicts the design of this thesis. First, the principal differences between the two approaches of motor learning are treated (Sub-RQ1). Based on these differences, exercises are designed (Sub-RQ2) and – by means of a questionnaire – trainers are subscribed to either of the two approaches (Sub-RQ3). Lastly, the exercises are presented to the different trainers and – by means of an interview – their thoughts on the exercises are collected in order to compare their school of thought with their preferences (Sub-RQ4). Below, we briefly touch upon the four sub-questions (Sub-RQ's).

Figure 1.1: Design of the thesis, depicting the four sub-questions (Sub-RQ's) which are to be answered. Sub-RQ1 in answered in chapter 4, Sub-RQ2 is answered in chapter 5, Sub-RQ3 is answered in chapter 6, and Sub-RQ4 is answered in chapter 7.



The first of four sub-questions is: *What are principal differences between the two approaches of motor learning which could contribute to the design of sport exercises?* By conducting a literature study and discussing the findings with motor learning experts, the differences are formulated and explained in chapter 4. The principal differences can help a person to both understand and implement the principal differences between CBA and DSA. Some examples are provided for implementing the theoretical paradigms in practice. This chapter lays the theoretical foundations of the thesis, by examining what the principal differences are and how they can affect the design of smart sport exercises.

The second sub-question is: W*hat do exercises look like when they are designed for different approaches of motor learning and for different skill-levels (i.e., for the four different quadrants)?* With the identified principal differences in mind, four different exercises for practicing a spike are designed and can be found in chapter 5. These exercises each fit one of the four dimensions of our design matrix, which is introduced in this chapter as well. These exercises are then validated by motor learning experts.

The third sub-question is: *What is the adherence to the approaches of motor learning among volleyball trainers?* By conducting and processing a questionnaire, this question is examined and answered in chapter 6. This chapter allows for examining two lines of inquiry: 1) Can we use the principal differences to distinguish between the two 'types of trainers' in preparation for the evaluation of chapter 7, and 2) Is the theoretical difference also present and relevant in practice.

The last sub-question is: *Is there a correlation between the adherence to an approach of motor learning and the preference for the designed exercises amongst volleyball trainers?* In chapter 7, we examine whether the adherence to an approach of motor learning affects the trainers' appreciation of the designed exercises. Due to the small number of interviewees, this chapter does not provide a significant result, it rather indicates how the exercises will be received in practice. In preparation of this chapter, questions based on the principal differences has been asked to trainers in order to label them as either CBA or DSA (using the results found in chapter 6).

Each of the subquestions is answered in a separate chapter. In order to introduce the reader to the Smart Sport Exercises project, chapter 2 provides a short background. This chapter also holds an introduction to the subject of volleyball, since the four designed exercises are concerned with training the spike timing in volleyball practice. Chapter 3 discusses the theories found in the literature which are used to define the two different approaches of motor learning. This chapter summarizes the findings of the 'Research Topics'; a literature study executed by the author of this thesis, prior to this thesis. These two different approaches of motor learning can be considered to be the cornerstone of this thesis since this thesis is based on this concept. The findings are discussed in chapter 8, alongside recommendations for future work. Finally, chapter 9 presents the conclusions of this thesis.

2. Background

This chapter introduces the project this thesis is a part of, and it provides some background on the topic of volleyball. The general challenges of volleyball are discussed along an explanation of the spike. Lastly, some obstacles/limits regarding volleyball are introduced, considering both the learner and the trainer.

2.1. Smart Sport Exercises project

This thesis is part of the Smart Sports Exercises project (SSE project). In this project, indoor sports training is researched, focused on a ‘smart indoor sports space’. The playing field of this sports space can both measure and project. Using the capabilities of this playing field, interactive exercises can be developed. The SSE project is especially focused on creating exercises for volleyball. According to the SSE information-page (“SSE information-page,” n.d.), the project is coordinated by the University of Twente, and carried out in collaboration with Windesheim University of Applied Sciences, Sportservice Veenendaal, InnoSportLab Sport en Beweeg!, and LedGo BV.

2.2. Volleyball

Due to the great number of variables, volleyball could be considered a rather complex game (Meininger, 2019). In volleyball the ball moves quickly, players have short contact with the ball, and a lot of players run around on a rather small field. In particular, the three-dimensional problem can be considered to be of great impact on the game (Meininger, 2019). Not only the ball, but also the players move in three dimensions in order to play a game of volleyball. In sports like hockey and football both the players and the ball mostly move in two dimensions. When playing a game of volleyball, the players should constantly estimate the trajectory of the ball and plan their jumps in order to meet the ball on the right time in the right sport in the air. Both player and ball are constantly moving in three-dimensional space. This should be kept in mind when designing exercises for volleyball.

2.2.1. What is a Spike?

A spike is the main action of an attacker, aimed at scoring a point. A properly executed and well-placed spike is hard to stop, making it a very effective way to score a point. Spiking a ball either results 1) in scoring by a *kill*; direct score by hitting the ball on the ground of the opponents’ court, 2) in scoring by a *touché*; the ball touches an opponent and lands on the ground outside the boundaries of the field, or 3) in making it the opponent harder to make a side-out themselves since it is hard to pass a spiked ball.

The spike consists out of three phases which each contribute to a hard and well-placed attack. At first, the player gains horizontal velocity during the run-up. Secondly, his horizontal velocity is transferred to vertical velocity during the third step, this is the jump. Lastly, when in the air the player opens up his shoulders; he brings his hitting arm back; twists his hip on the side of his hitting arm backwards (to create a greater range of motion); points his non-hitting hand to the place where he expects to hit the ball; then, at the height of his jump he rotates his hitting arm at the shoulder; whips his forearm forward; and makes quick contact with the ball, when whipping he should arch his whole body and rotate the hip of his hitting side forwards. When spiking the ball, it is beneficial to hit the ball at the height of the jump (Oden, 2018; Quora, n.d.; “SPIKING/HITTING,” n.d.; wikiHow, 2020) for multiple reasons: 1) it will maximize the power of the strike 2) it will enlarge the change of the ball staying out of reach of the blockers, 3) it allows for the smallest angle to hit the ball directed towards the ground.

2.2.2. Spike training methods

A volleyball player faces different challenges when he starts to learn to spike and tries to improve his spike. For the learner himself it is often hard to detect the errors he is making. When performing a spike for instance, the learner has little to no time to evaluate his actions while executing them. He can see the effect of his spike, but he can't see the different elements of the movement he is making. Also, every spike is different due to the variable environment. A set-up can be given flat and just above the net, or with a big arch and meters away from the net. Both set-ups require a different approach to the spike. In addition, since the learner is looking at the ball up in the air, it is hard for him to keep track of his footwork, let alone to detect errors in the stepping sequences.

To help the learner when learning and improving his spike, a trainer can assist. In order for a trainer to guide a learner properly, he must pay a lot of individual attention since there are many elements of the movement which can be executed incorrectly. The spike movement is a chain of smaller elements, in which prior elements influence the following elements, where should the learner start to change? Based on his experience, the trainer can guide the learner through his journey of learning and improving his spiking technique. Since some details of the spike movement are hard to see with the naked eye – especially when a trainer tries to learn multiple learners at the same time – technology could be helpful to assist him.

3. Literature Review

This chapter is based on the 'Research Topics' study, performed by the same author of this thesis. The 'Research Topics' study was performed as a preparation for this thesis. Parts on the topic of the *approaches of motor learning* and the *novice expert paradigm* are adopted in this thesis, in order to provide a solid understanding of these main concepts.

First, two different approaches of motor learning are considered. These are called the 'Cognitive Based Approach' (CBA) and the 'Dynamical Systems Approach' (DSA). Under each approach a number of different motor learning theories can be found. In this chapter, a few will be highlighted that characterize the fundamental characteristics of each approach. And lastly, based on both approaches of motor learning, novice-expert paradigms are compared with each other.

3.1. Approaches of Motor Learning

Motor learning makes an individual capable of developing new skills. By both practice and experience, one can learn and improve his motor skills (Davids, Button, & Bennett, 2008; Schmidt & Wrisberg, 2000). Motor learning can be described as the acquisition and improvement of motor skills. On the subject of motor learning, different theories have been formulated throughout the years. There is a number of principal differences between the theories which can be roughly allocated to two different approaches of motor learning, CBA and DSA. Notwithstanding the number of key-characteristics these theories share within one approach, (little) differences can be found between the theories within on approach. The 'Research Topics' considers the different theories under each approach into great detail. In this chapter, an overview of the theories within each approach is given. The distinction between the two different approaches of motor learning is based on the book by Edwards, Motor Learning and Control - From Theory to Practice (Edwards, 2010). In this book, Edwards distinguishes the' Cognitive Based Approach' (CBA) and the 'Dynamical Systems Approach' (DSA). CBA considers the information processing theories, whereas DSA treats motor learning as a construct of constraints, perception, self-organization, and emergence (Edwards, 2010, p. 121). These two approaches of motor learning are explained below.

3.1.1. Cognitive Based Approach

At its core, the theories found in the Cognitive Based Approach are formulated around the idea that cognitive processes allow for motor learning (Edwards, 2010). Movement skills are acquired and controlled as a product of cognitive processes, making the cognitive processes a central theme. Skilled movements are considered to be captured in a cognitive structure, called a motor program (Edwards, 2010). Since these cognitive structures are captured, they should be stored for recall when required. Cognitive based theories are about 'enrichment'. Skilled behavior originates from cognitive processes that are enriched by practice to represent the ideal motor movement better (Jacobs & Michaels, 2007). In the cognitive based theories, the central nervous system is responsible for motor control (Edwards, 2010). Based on information processing motor skills are learned, adapted, and executed.

A selection of theories found under CBA are the following: Three-Stage Model of Motor Learning by Fitts & Posner, Closed-Loop Theory by Adams, the Open-Loop theories explaining a trend in thinking, and Schema-Theory by Schmidt. The Three-Stage Model of Motor Learning by Fitts & Posner is a rather traditional model of motor learning, explaining the three stages a learner passes when learning and improving a motor skill. Fitts & Posner argue that the extent to which an individual is able to learn new motor skills is largely based on his ability to process information.

The three stages of motor learning are subsequently: the cognitive stage, the associative stage, and the autonomous stage (Davids et al., 2008; Edwards, 2010). Another theory explaining how an individual learns and improves his motor skills, is Adams' Closed-Loop Theory. This theory is based on the principles of a closed-loop feedback system, in which the results of actions are compared to the desired outcomes and adapted accordingly until the desired stage is reached (Adams, 1971). Adams identifies two traces, which – when combined – allow for the development of a motor skill: the *memory trace* and the *perceptual trace*. His theory seems most applicable to learning new skills and improving existing skills on a precise level, however, this method is cognitive demanding due to the constantly required attention (Edwards, 2010). In order to overcome the problem of high cognitive load, open-loop theories were formulated around the same time Adams' Closed-Loop Theory was proposed. These theories are based on the principles of an open-loop feedback system, in which there is no internal feedback system and an 'action-reaction' behavior is expected (Adams, 1971; Davids et al., 2008; Edwards, 2010). Open-loop control allows for quick movements in response to the environment, since all commands are prestructured. These open-loop theories are closely related to closed-loop control and, based on the shortcomings and advantages of both the open- and closed-loop theories, Schmidt has formulated his Schema-Theory. This theory explains how an individual learns and executes motor skills based on recognizing four pieces of critical information, create a schema out of it, which leads to the adaption/construction of generalized motor programs (Edwards, 2010; Schmidt, 1975). These abstract models capture a class of movement, which allows an individual to both react quick and appropriate on the environment, and change (finetune) the movement when needed.

3.1.2. Dynamical Systems Approach

Advocates of the Dynamical Systems Approach (DSA) argue that the whole body and its environment are stimulating movement. Whereas the Cognitive Based Approach has a strong focus on the brain being responsible for movement, DSA assumes a certain interaction with a larger environment being responsible. A movement is considered to be a reaction to the perception of a goal in a certain context given the constraints present. The main weakness of CBA was considered to be its closed design; where input from sources outside the body are not playing a significant role when executing a skilled movement (Edwards, 2010). DSA theorists responded to this weakness by providing theories in which movement arises from the interaction within complex systems (Edwards, 2010). Inherent to the vast number of factors relevant to a movement, it is hard to understand how these can be organized to produce coordinated movements. This is one of the primary concerns in all dynamical systems theories; the *degrees of freedom problem* (Edwards, 2010, p. 143). At its core, theories under DSA are about 'differentiation'. Skilled performance is thought to originate from perceptual differentiation, allowing the agent to make finer distinctions within the ambient array of information that is present. Motor learning is characterized by the process of identifying sources of information that provide a better fit between the agent and its environment (Jacobs & Michaels, 2007).

A selection of theories found under DSA are the following: Three-Stage Model of Motor Learning by Vereijken, Ecological Theory by Gibson, Constraints-Led Approach by Davids, Non-Linear Pedagogy by Chow, and Teaching Games for Understanding by Bunker & Thorpe. The three-stage model by Vereijken presents a dynamical systems-based alternative to the cognitive based three-stage model by Fitts & Posner. Based on Newell's degrees of freedom, this three-stage theory distinguishes subsequently: the novice stage of learning, the advanced stage of learning, and the expert stage of learning (Edwards, 2010). During the different stages the learner releases a greater amount of degrees of freedom in order to reach the expert stage, in which the learner exploits both internal and external forces in order to increase the efficiency and effectiveness of his movement (Davids et al., 2008). Gibson's ecological theory takes even more of the environment into account, as it has a stronger focus on the perceptions of an individual. This theory argues that perceiving information about the environment allows for determining movement possibilities without the use of cognitive functions (Davids, Araújo, Hristovski, Passos, & Chow, 2012; Davids et al., 2008; Edwards, 2010). In other words: based on the affordance of an object an individual acts. By altering the affordance of an object, Davids' constraints-led approach tries to allow for variability in learning in order to stimulate learning. By manipulating Newell's three constraints (organismic, environmental, and task) the affordance can be adapted. This approach allows a learner to learn implicitly instead of the more traditional explicit way (Davids et al., 2008). Non-Linear pedagogy by Chow agrees with this way of teaching, by viewing learners as non-linear and complex systems. Providing the learner with settings in which he can explore and find movement solutions himself results in great solution variability and stability (Chow, Button, Shuttleworth, & Antonio Uehara, 2009; Correia, Carvalho, Araújo, Pereira, & Davids, 2019; Renshaw, Chow, Davids, & Hammond, 2010). The last theory is teaching games for understanding by Bunker & Thorpe. They argue that a learner should start with playing the game rather than learning skills in isolated exercises (Chow et al., 2009; Davids et al., 2008). The focus of learning should be on 'why' rather than 'how' (Chow et al., 2009).

3.2. Skill Levels

During the 'Research Topics', both novices and experts are considered in great detail. This section provides the main similarities and differences between the views on novices and expert from the two different approaches of motor learning.

3.2.1. Novices

For theories part of either CBA or DSA, novices are described as individuals with a low level of practice and a lack of experience. This results in basic movements with inconsistent performance and a lot of errors. However, both approaches explain that performance increasement is fast. The biggest differences between CBA and DSA concern how learning is guided, how the environment is used, and how learning is approached. CBA argues that a learner is highly dependent on clear instructional feedback during practice in order to learn, DSA on the other hand explains that the learner should discover and explore so learning can emerge. Whereas CBA pleads for a strong focus on teaching *how* to perform movements, DSA wants learners to discover *why* certain movements are useful to learn. These differences find their origin in the fundamental difference between CBA and DSA.

3.1.1. Experts

According to both CBA and DSA theories, experts are considered to be experienced, have a high level of practice, and have developed movements with little to no errors. Their movements are accurate and stable. Since they are able to take their environment into account, they can perform in different contexts. However, because their learning is mostly about increasing efficiency and effectiveness, improvement is slow and takes a lot of practice. On the topic of practice, the biggest difference between experts from CBA and DSA can be found. Whereas CBA pleads for improvement by isolating movements in order to train them, DSA argues for a varied and challenging environment tailored to improving a movement without isolating this movement. This indirectly explains the difference in feedback. Theories within CBA argue how high-quality feedback is required to improve, where DSA theories argue that the environment should guide improvement.

4. Principal differences

This chapter introduces and explains a number of principal differences between the Cognitive Based Approach of motor learning and the Dynamical Systems Approach of motor learning. Given the vast number of theories within the approaches of motor learning (*Three Stages of Motor Learning, Closed-Loop Theory, Open-Loop Theory, Schema Theory, Ecological Theory, Constraints-Led Approach, Non-Linear Pedagogy, Affective Learning Design, etc.*), an attempt is made to formulate some common denominators for each approach. These common denominators can be opposed between the two approaches of motor learning, resulting in a list of principal differences. This list does not cover all the different aspects of motor learning, neither does it mention the similarities, nor does it mention all the possible differences. Such an elaborate study would far exceed the purpose of this research. This chapter answers the sub-question: *What are principal differences between the two approaches of motor learning which could contribute to the design of sport exercises?*

Given the nature of the identified differences, they can be used in multiple ways, for example: they can introduce people to the subject of motor learning and its different approaches, they can serve as a checklist to discriminate between CBA and DSA arguments in theories, and they can form the theoretical basis upon which sport exercises can be designed. Essentially, this list can help a person to both understand and implement the principal differences between CBA and DSA.

4.1. Method

In order to find and formulate principal differences between the two approaches of motor learning, multiple steps are taken. Chapter 3 provides a brief introduction to the two approaches of motor learning and discusses some of the theories found under each approach. As stated, chapter 3 is an overview of the more elaborate study performed in the 'Research Topics' (executed by the same author of this thesis) prior to this thesis. Accordingly, some of the key-characteristics of each approach are discussed and shape the theoretical basis for this chapter. Elaborating on the findings of chapter 3 in combinations with some explicit references, the basis of this chapter is formed. In consultation with motor learning experts this chapter is written. The experts did not add additional differences or points of interest, rather they confirmed the found differences and provided additional sources to address. The motor learning experts consulted are: Dees Postma (*University of Twente, Enschede*), Wytse Walinga (*Windesheim University of Applied Sciences, Zwolle*), and Jeroen Koekoek (*Windesheim University of Applied Sciences, Zwolle*). For each difference, briefly is touched upon the potential ways of practical implementations when designing smart sport exercises. Designing exercises with these differences in mind allows for the design of fundamentally different exercises.

4.2. Differences

This section contains the five principal differences found. A list with the discussed principal differences can be found in table 4.1. For each difference, an explanation of the two oppositions is given, supported by the potential contribution of the difference to the design of smart sport exercises.

Table 4.1: Principal differences between the Cognitive Based Approach and the Dynamical Systems Approach. The bullet points indicate the subdivision that can be made for the discussed differences.

Cognitive Based Approach	**Dynamical Systems Approach**
• Elementary Approach	• Holistic Approach
○ Search for the Ideal Movement	○ Search for an Adequate Action
▪ Variation to get more Generalistic	▪ Variation to get more Discriminative
▪ Prescribe Movements, Explicit Learning	▪ Allow for Exploration of Movements, Implicit Learning
○ Decoupled Movements	○ Whole (simplified) Movements

Elementary Approach versus Holistic Approach

The first principal difference discussed is the elementary approach versus the holistic approach. Advocates of CBA have an elementary approach towards the world, whereas advocates of DSA have a holistic approach towards the world. As becomes clear from (e.g. Davids et al., 2008; Edwards, 2010; Michaels & Carello, 1981), the two approaches view the world in a fundamentally different manner. For CBA, the world can be captured a model which consists out of different elements. Understanding the impact of relevant elements out of this model on movements, allow for the correct execution of movements. This implies that making mistakes originates in a difference between a person's model of the world and the reality. Basically, motor learning -according to CBA- is about recognizing these differences and improving your own model of the world, in order to have a (near) perfect match between your model and the reality.

Advocates of DSA, on the other hand, have a holistic approach towards the world. This means that DSA considers the world to be a complex combination of intimately interconnected elements. It is not possible for a person to grasp the world in a model, neither is it a necessity to execute movements properly. According to DSA, motor learning is about making a distinction between relevant and non-relevant information and reacting adequately to the environment upon this distinction. The following example tries to explain the impact of this principal difference: when a person is faced with an environment, from a CBA perspective this environment can be described in terms of the perception of height, width, and depth. These elements combined allow for a description of the environment. From a DSA perspective this same environment is perceived in terms of movements possibilities, like climbing the walls and find shelter from the rain.

This principal difference could be considered to be the most fundamental principal difference, as all the differences following in this chapter could be traced back to this principal difference: Elementary Approach versus Holistic Approach.

Search for the Idealized Movement versus Search for an Adequate Action

The second principal difference considers the search for the idealized movement from a CBA perspective, and the search for an adequate action from a DSA perspective, as becomes clear from e.g. (Davids et al., 2008; Edwards, 2010; Renshaw & Chow, 2018). Advocates of CBA argue that for every situation there exist an idealized movement to solve the problem the learner is confronted with. This makes the goal of a practice session from a CBA perspective, to learn and finetune a movement so it meets the idealized movement (Davids et al., 2008, pp. 96–98; Edwards, 2010, p. 268; Schmidt & Wrisberg, 2000, p. 7). The question: '*How to execute a certain idealized movement?*' plays a central role, and in order for a learner to learn and improve movements he should receive a lot of explicit feedback on his movements. It should be noted that a prerequisite for this approach is that there exist an idealized movement for every situation. This results in the idea that a learner should be guided towards the perfect execution of the envisioned idealized movement.

Advocates of DSA, on the other hand, argue that there does not exist one ideal movement for every situation. A principal idea of DSA is that there exist a number of adequate actions given a situation and that these movements should be discovered and explored (Edwards, 2010, pp. 268–269). A person benefits from the ability of performing movements which are adjusted to the situation since this improves the outcome of the movement. A major question in this approach is: '*Why and when should I perform which movements?*'. When a person is able to interpret a situation and understands how his movements affect the outcome, he can react to the context with an adequate action.

This principal difference finds its origin in the first principal difference: elementary approach versus holistic approach. Originating in the idea that the world can be approached using models, there should exist ideal movements to react to this world. Understanding the elements of this model allows for selecting the correct ideal movement given a situation. However, on the other line of thought, when viewing the world as a complex combination of intimately interconnected elements, it could be argued that there exists no such thing as an ideal movement. The impact of these two different starting points is large since it shapes the principles of how motor learning should be approached.

In practice, this difference could be implemented for a CBA-exercise by designing an exercise which explicitly states what the movement looks like which is trained for. Since the goal is to improve technique in order to acquire the idealized technique, one should only reward players when their technique increases. Also, a lot of repetition can work to polish the movement. For a DSA-exercise, the exercise should be more aimed towards scoring points and receive positive feedback when doing so. One is not explicitly concerned with increasing technique, but more with obtaining the goal of the game (e.g., scoring a point in case of volleyball).

Variation to get more Generalistic versus Variation to get more Discriminative

This principal difference has a rather close relation with the previous principal differences. Given from a CBA perspective that the world can be described using models, a person searches for the ideal movement to approach the world. However, since the memory of a person is limited, the person is not able to store every combination and variation of movements in his memory. Schmidt argues that this problem is solved by *generalized rules* which capture a variety of ways to perform a movement (Schmidt, 1975, p. 232). For instance, tossing a ball is constructed out of the direction to throw the ball, the force of the toss, the angle of the toss, and many more variables. By applying variation along the elementary dimension of movements, this person gets more generalistic (Edwards, 2010, p. 142). Once he is confronted with the effects of changing certain variables within a movement and has stored their outcomes, he is able to *construct* the desired movement out of the rules he has stored. So, he is able to control a wide variation of movements by adjusting the general model he made for a group of movements.

In contrast, from a DSA perspective a person should not be concerned with generalizing movements and understanding the effects of systematically changing parameters. One should be concerned with the exploration and exploitation of movements and environments, as can be found in e.g. (Edwards, 2010; Renshaw & Chow, 2018). A person should be presented with great variation of environmental conditions and movement components, in order to learn how to perform informed movements. Being able to *discriminate* situations allows for more adaptable behavior, for more adequate actions. The goal is not to reach some idealized state, rather to perform adequate actions contributing to a goal (scoring points in a game of volleyball for instance).

Both CBA and DSA recognize that variability of practice is a useful principle, but the envisioned use and outcome differs. Whereas the first uses variation to allow the learner to become more generalistic, the latter places a greater emphasis on allowing the learner to become more discriminative (Edwards, 2010). In practice this could be the difference between: practicing a spike when gradually changing the run-up with 3 degrees in order to understand what the effect is (CBA), and randomly be assigned to a position to perform a spike in order to explore how to make an adequate action given a great variation of situations (DSA).

Prescribe Movements versus Allow for Exploration of Movements

This principal difference again is explained in light of the principal difference: '*Search for an Idealized Movement versus Search for an Adequate Action'*. Recall that CBA searches for an idealized movement in an elementary approach towards the world. Since there exist an ideal movement, the learner should understand what this movement looks like and should be guided towards the execution of this movement. The most effective way to learn this ideal movement – according to CBA – is to prescribe movements to the learner and to provide explicit learning, as can be found in e.g. (Steenbergen, Van Der Kamp, Verneau, Jongbloed-Pereboom, & Masters, 2010, p. 1510). A person benefits from prescribed movements in order to gain and improve a mental image of the movement (Edwards, 2010, pp. 123, 252). This results in feedback to the learner which explicitly states what to improve and how to improve. By making explicit mention of points of improvement, a trainer allows his pupils to polish their movements in order to get closer to the execution of the ideal movement.

Opposed to this idea, DSA argues for an implicit way of learning in which the learner can explore movements. The learner should not be told what to do and how to do it, rather he should explore and discover movements (Bernstein, 1996, p. 205; Edwards, 2010). A pupil is not going to benefit from an explicit prescription of a movement. His goal is to search for an adequate action and in order to do so he should explore movements. When a learner is allowed to explore, he can gain deeper affinity with what actions are adequate given the context. From a DSA perspective there does not exist such a thing as 'the ideal movement', for that reason there is no major benefit in prescribing movements. DSA argues that a learner should implicitly be guided to his personal search for movements.

Decoupled Movements versus Whole Movements

The final principal difference is the view the two approaches of motor learning have on how movements should be considered and learned. From a CBA perspective there is theoretically no need for a realistic context to learn an idealized movement. An idealized movement is not necessarily dependent on the context, so it could just as good be practiced without the context. Continuing in this line of inquiry, since CBA considers a movement to be a combination of different elements of that movement, a movement can be learned by practicing the separate elements of this movement in isolation. From a CBA perspective one can decouple a movement of its context and decompose the movement into separate parts (Davids et al., 2008, p. 167; Renshaw et al., 2010, p. 124).

The contrasting view from the DSA perspective argues that a movement should always have a strong connection to its context and should not be split in separate isolated elements. For a novice who might not be able to perform the complete movement one could simplify the movement, for instance by freezing degrees of freedom like Bernstein argues (Edwards, 2010, pp. 146–150). However, the connection between information of the context and the movement itself should remain intact throughout practice (Davids et al., 2008, p. 167; Renshaw et al., 2010, p. 124).

5. Exercises

This chapter introduces four volleyball exercises which make use of a digital LED-floor. By making use of the literature found in chapter 3 and the principal differences found between CBA and DSA in chapter 4, we are able to design fundamentally different exercises. This chapter shows examples of what digitally aided sports exercises with a specific target group in mind could look like. By designing these four exercises, an answer is given to the following sub-question: W*hat do exercises look like when they are designed for different approaches of motor learning and for different skill-levels (i.e., for the four different quadrants)?* The design-space of this master thesis consists out of a matrix with four quadrants. On the top row of table 5.1, the two approaches of motor learning can be found: Cognitive Based Approach (CBA) and Dynamical Systems Approach (DSA). On the left column of table X, the two skill levels considered can be found: Novice and Expert.

Table 5.1: The design space with four quadrants. Designing exercises for a specific quadrant is sensitive to distinct design principles.

	Cognitive Based Approach	**Dynamical Systems Approach**
Novice	Quadrant 1 – CBA novice	Quadrant 3 – DSA novice
Expert	Quadrant 2 – CBA expert	Quadrant 4 – DSA expert

5.1. Method

Based on the principal differences found in chapter 4 in combinations with the characteristics of both the approaches of motor learning and different skill-levels discussed in chapter 3, four different exercises are developed. The aim of these exercises is to display what an exercise could look like when basing it on the concepts described in the theory. Every element of the exercises finds in origin in informed choices, considering the theoretical allegiance (Appendix F holds an overview of some of the thoughts considered when designing the exercises). This implies that one would never design the exercise we made for CBA when he is using the principles of DSA. In addition, designing the exercises has not been just an attempt to translate theories to theoretical exercises; rather, the exercises are designed from the theory with the practice in mind. One condition of the design was that the exercises should be realizable in reality (both in terms of acceptation by players, as well as the technological feasibility).

On a final note, a practical implementation of the exercises has not been done. As explained, an attempt is made to maintain a strong relation with the feasibility by considering how elements could be implemented when actually implementing the exercise. During the design of the exercises Fahim Salim (*University of Twente, Enschede*) is consulted on a regular base to ensure the concepts and ideas can be translated to the actual LED-floor which is a part of this project. Instead of implementing the exercises, a Low-Fidelity (Lo-Fi) prototype of each of the exercises is made using PowerPoint. This means that different elements of the exercises and reactions of the system are captured in slides and presented in predetermined scenarios which are filmed. These short film-fragments can be used to present the exercises, since they show how the LED-floor behaves as if it actually works. These Lo-Fi prototypes can serve two purposes. First, they allow for presentation to motor learning experts in order to evaluate the exercises, which is done in the last section of this chapter. Secondly, they can be used during the interviews in order to introduce the interviewees to the exercises and ask for their reaction (this is done in chapter 7).

5.2. The four exercises

Four exercises are designed which illustrate what designing for each of the four quadrants (of table 5.1) could look like, this section explains these exercises. Broadly speaking, the designed exercises represent the possible differences between the different practical interpretation of the theoretical differences. We are well aware that we will lose certain nuances when designing, but the complete image of one exercise should be as uniform as possible; adhering to just one of the four quadrants.

5.2.1. Quadrant 1 - Cognitive Based Approach, Novice

First, the trainer should explicitly state what the goal is of the exercise and what is expected of the learner. The explanation can be supported by projecting the goal of the exercise on the floor. The goal of this exercise is to learn the novice how to execute a perfect spike, this is taught by prescribing the movement and making use of explicit feedback.

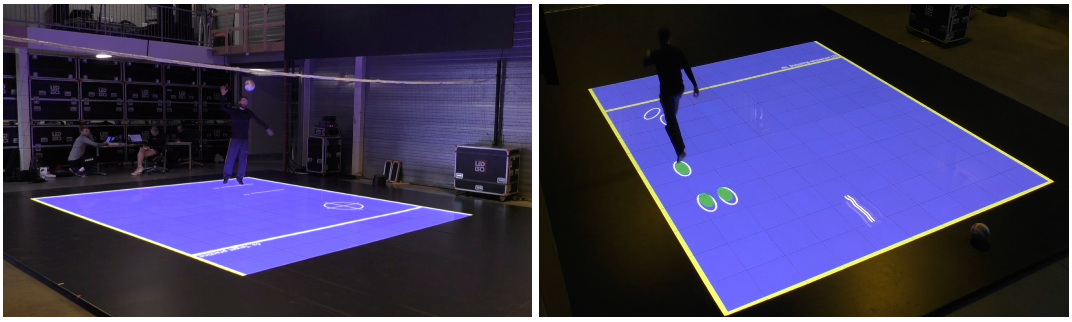
After explaining the goal, the learner is presented with a video of a professional executing a spike. This video has a strong focus on showing what a perfect spike looks like. By freezing frames during key-moments of the video, the spike can be explained using these images. These key-moments distinguished for this exercise are the run-up, the timing, and aiming for a specific location on the floor to hit the ball to (a target). This part of the exercise is again based on the principle of explicit learning and prescribing movements, in order to improve the declarative memory of the learner. Also, the principle of searching for the ideal movement is incorporated, by showing the learner what this ideal movement looks like.

After the introduction parts, three key-moments are practiced one by one. For every element, first the movement is explained and demonstrated, the exercise is explained, and lastly the learner gets to practice the element by executing the exercise. The three elements are explained below. By breaking down the spike in separate parts, the principle of decoupled movements is addressed. The spike is decomposed into different elements of the movement, which are each prescribed and practiced in isolation. Also, for every separate part of the movement, feedback is provided in order to give the learner knowledge of his results. This feedback is both real-time on the most recent execution, but also post-hoc in order to provide the learner with statistics and general trends observed in his movements. This gives the learner insight in his performance and allows for tailored practice of the separate movement elements:

The first element is to practice hitting the ball aimed at targets projected on the floor. The learner throws the ball for himself and hits the ball from a standing position aimed at a target. The floor projects where the ball has landed and measures the accuracy of the smash. A picture of the Lo-Fi prototype can be found in figure 5.1 (left image). The accuracy is presented real-time and after a certain number of attempts, a heatmap of the shots can be projected, giving the learner knowledge of his performance.

The second element is practicing the run-up. The run-up for a righthanded player consists out of a small left step, a big right step, and a small lest step again. The proper execution and the points of interest are explained, after which the learner can start to practice. The stepping sequence of the run-up is projected by use of footsteps on the floor. The learner gets feedback

Figure 5.1: Lo-Fi prototype of the exercise made for quadrant 1 - CBA novice. The left image shows the target practice, the right image shows practicing the run-up.



on how well he followed the projected footsteps. The realization of this element in the Lo-Fi prototype can be found in the right image of figure 5.1.

The third and last element is to practice the timing by performing a complete spike. A shooting-machine gives a consistent set-up which the learner must attack by performing a complete spike. The focus of this element is to hit the ball at his (the player's) highest point. Using IMU's the moments of reaching his highest point is compared with the moment of hitting the ball, feedback is given on the timing. This can for instance be done by projecting a gauge plot in which the learner can read whether his timing is excellent, good, or poor (on a scale from too early till too late).

After practicing separate elements of a spike, the learner should execute a complete spike. Using a shooting-machine the learner gets a consistent set-up which he must spike. When spiking he should focus on making the correct run-up, have a proper timing, and aim for targets on the opponents' field. Feedback can be given on all separate elements in the shape of dashboard with statistics.

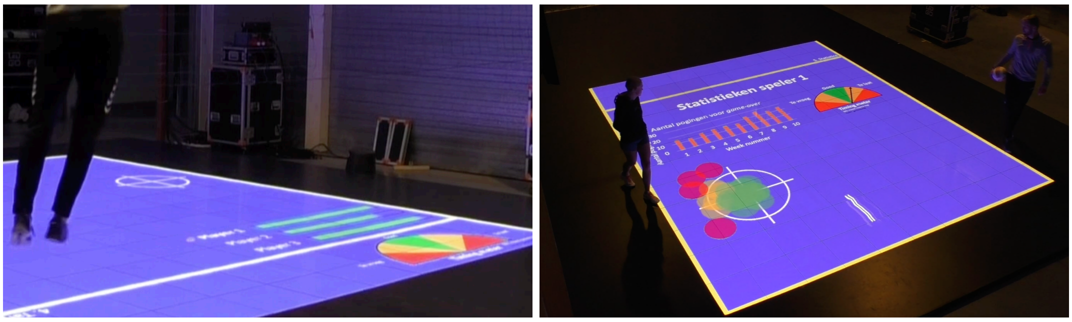
Additionally, a progression measure could be added to one or multiple of the above elements of the exercise. This progression measure allows the learner to progress to a next element only after his performance exceeds a certain threshold over the course of a predetermined number of tries.

5.2.2. Quadrant 2 - Cognitive Based Approach, Expert

First, the goal of the exercise should be explicitly stated and explained to the learner. Supportive text and image can be displayed on the floor. The goal of this exercise is to improve the spike timing in order to achieve the most ideal movement. This goal is based on the principle of the search for the ideal movement. The game, as described in the following steps, should be introduced to the learners. The game tries to ensure the maintenance of a high motivation among the learner while practicing in order to improve their spike timing. Steps a-d combined form the exercise: they are not steps to execute on after another rather they are executed as a whole. The exercise is constructed in such way that there is a great amount of repetition which allows the learners to polish their spike timing.

Every player starts with a 'health bar' and he must try to preserve his health as long as possible. Every time a player spikes a ball with a poor timing, health is subtracted from his health bar. When the health bar of a player reaches zero, the player is out of the game. The last player standing wins the game. This game is designed in such a way that the motivation

Figure 5.2: Lo-Fi prototype of the exercise made for quadrant 2 - CBA expert. The left image shows how feedback is given on the timing and what the health bars look like, the right image shows how statistics could be presented to the player after finishing the game.



of the players will remain high since they have a mutual competition. Also, over the course of multiple weeks players can see their own performance. This could also have a motivational impact: when performance increase, they can be happy about it and aim for more, when performance gets stuck or decreases, they know what to work on.

After each spike the moment the learner reaches his highest point is compared with the moment that he hits the ball. Feedback is provided on the number of milliseconds his timing is off, again in the shape of a gauge plot. Based on this number of milliseconds the timing of the spike is off, a certain amount of health is subtracted from his health bar. By providing the learner with explicit feedback on his timing in terms of milliseconds, the learner is enabled to interpret and extrapolate this information in order to change his movement aimed towards achieving the ideal movement. The left image of figure 5.2 show how this timing and subtraction of the health-bar is visualized in the Lo-Fi prototype. In addition, targets are projected on the field of the opponent; the learner should aim for them when he spikes the ball. Hitting the targets results in ‘health regeneration’, points are added to his health bar. It should be ensured that the amount of health the learner earns for hitting the targets is chosen such that it does not stimulate inexpedient behavior. The pith of the matter is to improve the timing, not to improve the aim. Returning too much health could lead to a poor execution of the idealizes movement.

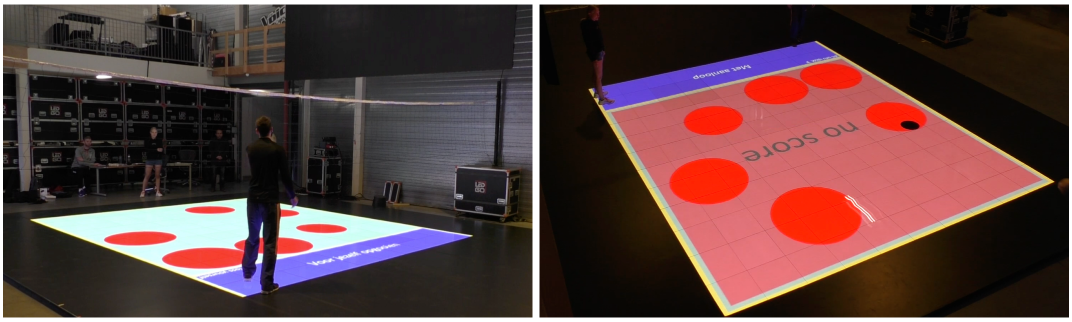
The learner or a libero should pass the ball to the setter, and the setter gives the set which the learner in his turn spikes. Due to human error the sets will have a certain amount of variation which allow for some variability. This variability of practice increases the generalizability of internal schemes for spiking. This element of the exercise is based on the principle of variation to get more generalistic.

Lastly, after all players have run out of health, statistics can be presented. These statistics can be presented per players, or for the whole team to be able to compare players. These statistics allow for insight and can be used in future practice to understand what the focus for a player should be. An example of what this statistics dashboard could look like in show in the right image of figure 5.2, depicting the Lo-Fi prototype.

5.2.3. Quadrant 3 - Dynamical Systems Approach, Novice

This exercise simplifies the spiking movement while trying to preserve a strong relation to the complete spiking movement. This is done by simplifying the movement without decoupling it from the goal: scoring a point. This whole exercise is based on the two principles of simplifi-

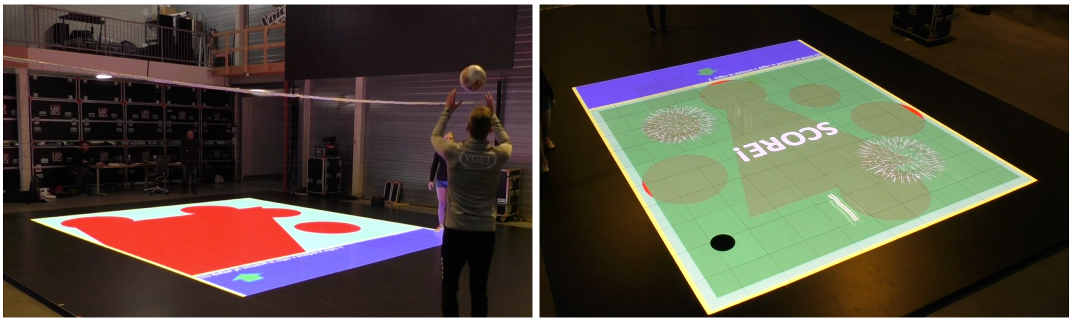
Figure 5.3: Lo-Fi prototype of the exercise made for quadrant 3 - DSA novice. The left image shows what the player sees prior to spiking the ball (the red circles represent opponents which should be avoided), the right image shows what the player sees when he hit an opponent instead of scoring the ball.



cation and searching for an adequate movement. The learners are told what the exercise looks like, but no explicit mention is made of the aim of this exercise to learn the spike. The learners should be told that the exercise consist out of four parts (3-6) and that the goal is to score by hitting the ball. When he scores the ball, an appealing visualization is shown stating that he scored the point. When he misses or hits an opponent a sober visualization is shown stating that he did not score the point, this is shown in the right image of figure 5.3.

When trying to score a point, the player must hit the ball on the ground of the opponent's field. While aiming for the ground he must avoid virtual opponents, represented by red circles projected on the ground. These red circles are projected on locations where one would expect them to stand in an actual game of volleyball, the left image of figure 5.3 shows what the opponents look like in the Lo-Fi prototype of this exercise. These virtual opponents also have a divined bounding box in which they can move randomly and their diameter changes slightly over time. One additional feature is to change their diameter based on the vertical acceleration of the player when he spikes. In order to reproduce the real-game benefit one has of hitting the ball at the highest point of his jump, the size of the opponents can be correlated to this jump. The moment the player jumps, the virtual opponents have their normal size. The closer the player gets to his highest point, the smaller the diameter of the virtual opponents becomes. At the highest point of his jump, the opponents are the smallest, making it easier to score for the player. This stimulates hitting the ball when being at the highest point of your jump, without explicitly guiding the learner to this behavior. The exercise consists out of four different variations, these are: 1) First of all, the learner must stand on one position. He tosses the ball up for himself and tries to score a point by hitting the ball on the group of the opponent, while avoiding the virtual opponents. 2) Second, the learner must stand on one position, someone else tosses the ball up (the set). The learner must hit the ball and try to score a point. 3) Third, the learner is instructed to start a few meters away from the net so he must make a run-up in order to hit the ball. The ball is tossed by someone else and the learner should try to score a point. 4) The final step is to again start a few meters away from the net and make a run-up in order to hit the ball. Now the learner must toss the ball towards the setter, the setter gives a set, and the learner must try to score a point. Adding this element results in more variation which allows for more challenging and varying situations.

Figure 5.4: Lo-Fi prototype of the exercise made for quadrant 4 - DSA Expert. The left image shows one of the possible defense scenarios, the player must spike the ball at the location the arrow indicates. The right image shows the animation of a player who scored a point when spiking the ball in the middle, with a different defense scenario compared to the left image.



5.2.4. Quadrant 4 - Dynamical Systems Approach, Expert

The learners should be told that they are supposed to spike the ball and that they should take into account the different variations they are provided with. The learners should try to score on the opponent's field by avoiding virtual opponents and the block-shadow (the area behind the block where one cannot score during the game since the block hinders this). When scoring the ball, he is presented with an animation which tells him he scored, the right image of figure 5.4 shows this for the Lo-Fi prototype. Right before the learner starts his spike, the digital field presents a new scenario which the learner must encounter. The ball is passed to the setter, he gives a set-up, the learner must spike the ball. Variation can be introduced using one, or a combination, of the elements explained below. This whole exercise is primarily based on the principles of variation to get discriminative and the search for an adequate movement. The learners are presented with a great variety of situations in which they should adapt and search for a fitting approach. The same visualization for the opponents is used as in exercise 3 (DSA Novice). The virtual opponents move and vary in size. Also, the opponents adapt to the jump of the learner, becoming smaller when he approaches the highest point of his jump. This is done because of the same reasoning as for exercise 3; to implicitly stimulate hitting the ball at the highest point of the jump.

Variations in the exercise can be introduced in different ways. For instance, the position where a set is given can differ, this is indicated by an arrow on the floor pointing where the set will come. This arrow is shown near the net and somewhere over the full width of the field. The player should attack on the position the arrow is appearing. The left image of figure 5.4 show one of the possible scenarios in which the player should spike at the left side of the field.

Another way to vary, is to present different defense scenarios based on the position where the set will come. The block-shadow and the virtual opponents can be configured in different ways, presenting the learner with a variation of challenging situations.

The last variation is based on a game-scenario in which players will try to pass the ball when the opponents attack. Sometimes this results in players still laying on the ground when a counterattack is made. In some scenarios the attacker must avoid his teammates when making the run-up for his spike. This is simulated by projected random obstructions on the floor which must be avoided by the learner.

5.3. Evaluation

In order to maintain a strong relation to the theory, the exercises were evaluated with a number of motor learning experts both during and after designing them. Dees Postma (*University of Twente, Enschede*) has been involved throughout the whole process of designing (from the first ideas till the final exercises). During weekly conversations the progression was discussed, and choices had to be justified.

For the second round of evaluation, both motor learning experts Wytse Walinga (*Windesheim University of Applied Sciences, Zwolle*) and Jeroen Koekoek (*Windesheim University of Applied Sciences, Zwolle*) were informed about this research and its details prior to presenting the exercises to them. The four Lo-Fi prototypes were presented to them and discussed. The question central to the conversation was: whether or not does the exercises translate the four quadrants to practice. In other words: did we correctly put the theory into practice? Both Walinga and Koekoek agreed to our practical interpretation of the theories; they were positive about the translation from the theory to practice.

The third and last round of evaluation is done with three ‘naïve’ motor learning experts. This means that prior to introducing and discussing the exercises, no extensive explanation is given about our research. The motor learning experts involved in this evaluation are Ivo van Hilvoorde (*Windesheim University of Applied Sciences, Zwolle*), Ludger van Dijk (*University of Antwerp, Antwerpen*), and Raoul Bongers (*University of Groningen)*. Prior to presenting the exercises they were told that we consider CBA to be the cognitive approach towards learning in which the goal is to reach an idealized state, and DSA to be the dynamical approach towards learning in which the learner is allowed to explore and discover an adequate action. After this introduction, the exercises were introduced and discussed. The central question of these evaluations was: *in which of the four quadrants they would place the exercise*, along with the question to *clarify their choices*. All three of the motor learning experts attributed the exercises to their intended quadrant.

The evaluations with all six motor learning experts give us a strong indication of the ‘correctness’ of the concepts we have used, and the exercises developed. This confirmation allows us to use the exercises during the interviews since they seem to correctly represent the quadrants.

6. Adherence to the approaches of motor learning

Using a questionnaire distributed among volleyball trainers, the adherence to the approaches of motor learning is examined. The questions formulated for this questionnaire are designed in such a way that they give insight in the theoretical allegiance of the respondent, allowing for analysis of their preference. This chapter tries to answer the sub-question: *What is the adherence to the approaches of motor learning among volleyball trainers?* Chapter 4 describes the principal differences found between CBA and DSA. Subsequently, these differences are used to design fundamentally different exercises, illustrating one of the four quadrants from the design-matrix. Using a questionnaire, this chapter tries to distinguish the preferences of trainers in practice. The questions of the questionnaire are designed using the principal differences as fundament, and also considering the four quadrants from the design matrix. This chapter is both an examination of the adherence, as well as a preparation to chapter 7, in which a parallel between the theoretical fundaments of the different exercises and the theoretical allegiance of the trainers is examined. In the chapter at hand, first the method used for collecting data is explained which is followed by the results found. Lastly, an interpretation of the found results is given.

6.1. Method

The questionnaire consists out of three questions, which can be assigned to two different types of questions. For both types of questions, the respondents are asked to either select or to value statements presented to them. The statements used are primarily based on the principal differences between the two approaches of motor learning (described in chapter 4). The principal differences are illustrated by both abstract and very concrete statements which embody the characteristic from one of the two approaches of motor learning. This results in a strong distinction in theoretical background between the statements, which in turn can be used to analyze the respondent's adherence to the approaches of motor learning. A respondent who chooses CBA-statements over DSA-statements can be classified as a trainer who adheres stronger to CBA compared to DSA. The complete questionnaire can be found in appendix D. After finalizing the questionnaire, the questions were discussed with motor learning experts Dees Postma (*University of Twente, Enschede*), Wytse Walinga (*Windesheim University of Applied Sciences, Zwolle*), and Jeroen Koekoek (*Windesheim University of Applied Sciences, Zwolle*). They endorsed the design and execution of the questionnaire. No other means of validation of the questionnaire has been performed.

The first two questions of the questionnaire can be assigned to the first type of questions: the '*selection of statements'*. For both these questions the respondents are asked to select a maximum of four statements out of a list of eight statements, in which they find themselves the most. Half of the statements they can choose from are formulated from the Cognitive Based Approach, the other half are formulated from the Dynamical Systems Approach.

The third question can be assigned to the second type of questions; this type of questions will be referred to as '*rating of statements*'. The rating of statements contains a total of 11 statements which the respondents must rate on the following 5-point Likert scale: *strongly disagree, disagree, neutral, agree, strongly agree*. Out of the 11 statements, seven statements are formulated from the Cognitive Based Approach and four statements are formulated from the Dynamical Systems Approach.

In order to collect data, volleyball trainers are addressed via multiple channels. A number of volleyball clubs is contacted (CSV Zwolle, Libero'99 Dronten, AVV Keistad Amersfoort, Bovo Aalten, Sudosa-Desto Assen, and Harambee Enschede). The volleyball clubs shared the questionnaire internally by directly addressing their trainers. The questionnaire is made using Google Forms, and analyzed using Microsoft Excel and Matlab.

6.2. Results

In total 58 responses are collected. Three duplicates were found and removed, leaving a total of 55 responses. The respondents were asked to fill in the age of their players: 69% of the respondents have players of 18 years and older, 31% have players which are younger than 18 years. The competition the teams of the respondents participate in vary from the highest Dutch competitions (Internationaal 2.5%, Eredivisie 5%, Topdivisie 5%, 1^e divisie 7.5%) till the lower Dutch competitions (3^e klasse 17.5%, 4^e klasse 5%, mix-recreanten 7.5%). About 40% of the respondents have 0-5 years of experience as a trainer, 29% have 5-15 years of experience, and 31% have over 15 years of experience. About 30% of the respondents have no education in volleyball training, the other respondents have had some sort of education (ranging from a beginner-course up till the highest certificate possible in the Netherlands).

Selection of statements

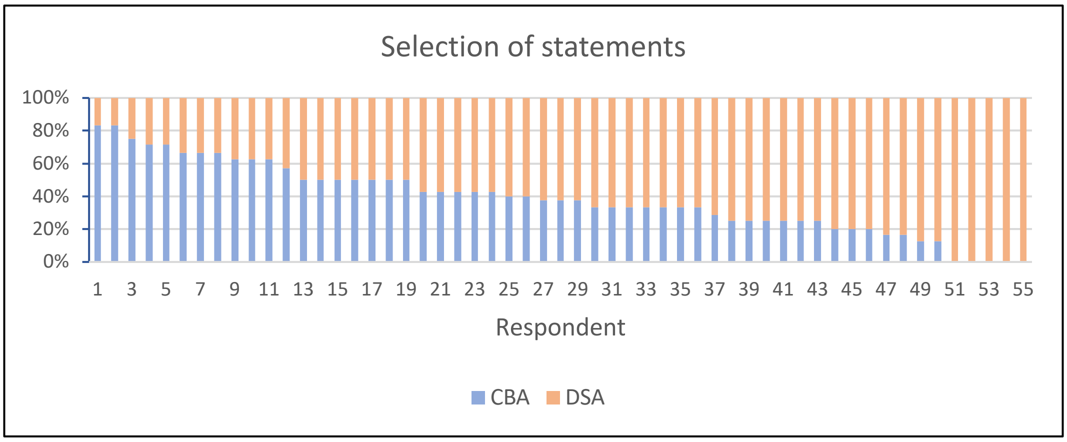
Based on the two questions from the type *selection of statements*, the graph of figure 6.1 is made. The respondents are presented with in total 16 statements, of which they could choose maximum 8 statements in which they could find themselves the most. Since the number of statements selected differs per respondent (between 2 and 8), percentages are used to visualize the results. The percentage of times CBA-statements are chosen are represented by blue bars, the percentage of chosen DSA-statements are represented by the orange bars. Lastly, the found percentages are ordered based on the CBA-percentages, in a descending order. The mean of the percentages of CBA-responses is 38.48% with a standard deviation of 21.37%, this suggests that trainers favor a DSA approach (based on the first type of question).

When testing the data (percentages found of the times CBA-statements are chosen) using a Kolmogorov-Smirnov test (non-significant), the null-hypothesis is not rejected. This indicates that the distribution of the responses (the data) is normally distributed. Visual inspection from probability density functions and cumulative probability density functions conforms this (appendix E).

Rating of statements

The third question of the questionnaire is of the second type of questions: *rating of statements*. This question consists out of 11 statements for which the respondent had to fill in how much he agreed with the statement on the scale as stated before (*strongly disagree* up to *strongly agree*). In order to provide descriptive statistics on the found results, the rating, in the form of a 5-point Likert-scale, is converted to numbers. This is done as following: 'strongly disagree'=1, 'disagree'=2, 'neutral'=3, 'agree'=4, 'strongly agree'=5. It should be noted that the original results from this 5-point Likert-scale is considered to be ordinal data. By converting them to numbers, these ordinal data are treated as being interval data. We have followed this procedure since we are interested in descriptive statistics in a study with a rather exploratory nature.

Figure 6.1: Distribution of the selected statements. The blue bars represent the percentage of selected CBA-statements, the orange bar the percentage of selected DSA-statements. The graph is based on the first two questions of the questionnaire.



The mean-scores for the rating on both the CBA-statements and the DSA-statements are calculated per respondent (dividing the sum of the mapped scores by the total of statements). The table of found mean-scores can be found in appendix A. Based on these found mean-scores two box plots are made, these can be found in figure 6.2. Both box plots indicate a normal distribution, where no outliers are observed. The median of each box plot lies inside the box of the other box plot, this indicates that on average there is no strong difference between the two sets of mean-scores. However, averaging might obscure potential effects within individual trainers, these are left out of scope for this study. Also, no strong dispersion of the data set is observed. The lower quartile of the boxplot based on the DSA statements has a score of 3.00, this means that 75% of the responses to DSA statements were positive. This meets the observation made for the previous type of questions, where we observe that the respondents are inclined towards DSA.

Figure 6.2: The first box plot (blue) summarizes the found mean-scores for CBA-statements, the second box plot (orange) summarizes the found mean-scores for DSA-statements. A mean-score of 1 represents a negative attitude towards the presented statements ('strongly disagree'), whereas a mean-score of 5 represents a positive attitude ('strongly agree'). A mean-score of 3 indicates a neutral attitude.

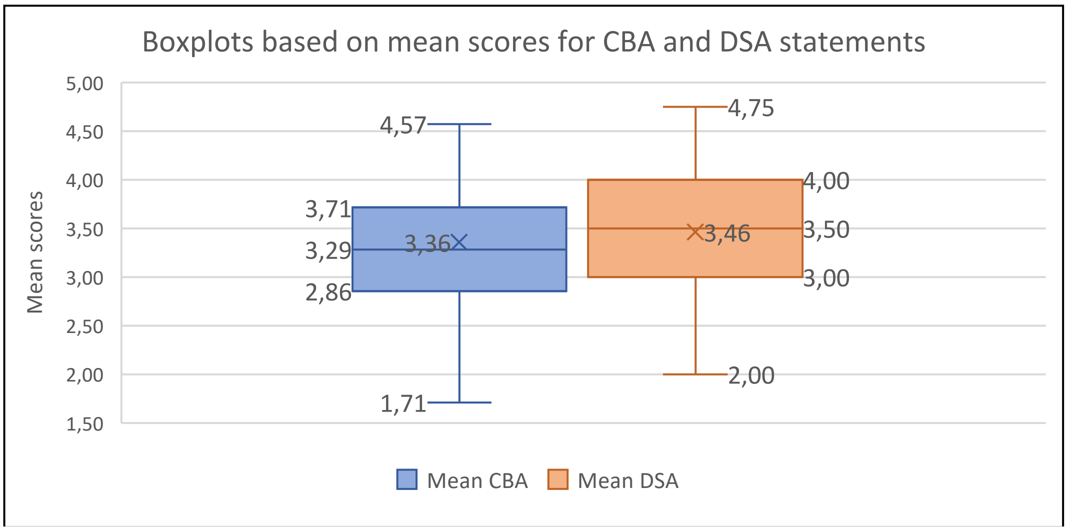
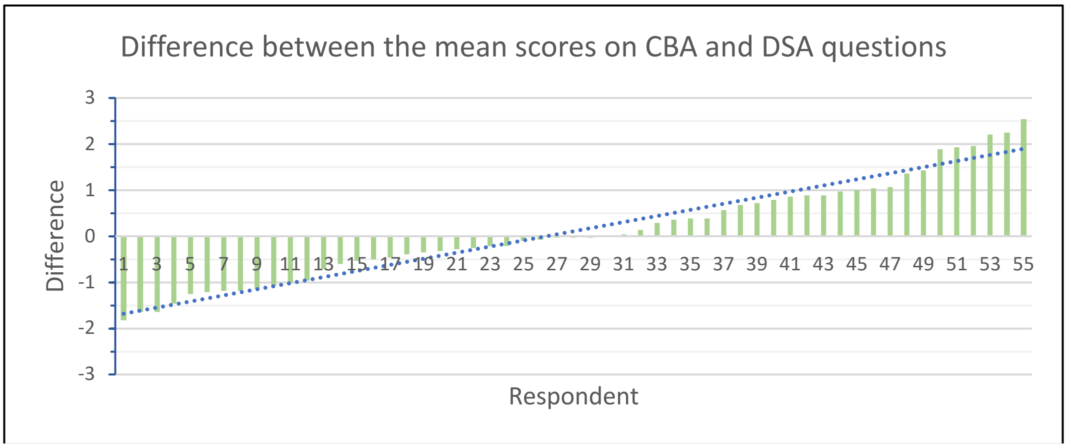


Figure 6.3: The found differences between the mean-scores (mean-score on CBA-statements subtracted from the mean-score on DSA-statements). The differences are ordered in ascending order. A value close to zero indicates that the respondent gave rather similar scores to statements of both approaches. A negative difference indicates a preference for DSA and a positive value indicates a preference for CBA. A linear trendline is plot which indicates the linear behavior of the responses.



In order to find the differences between the mean-scores, the mean-score on the CBA-statements is subtracted from the mean-score on the DSA-statements. The resulting differences are plotted in the graph of figure 6.3. When the mean-score on CBA-statements is larger than the mean-score on DSA-statements, this results in a negative difference. Recall that a mean-score of 1 represents a negative attitude towards the presented statements ('strongly disagree'), whereas a mean-score of 5 represents a positive attitude ('strongly agree'). The table of found mean-scores and the differences can be found in appendix A.

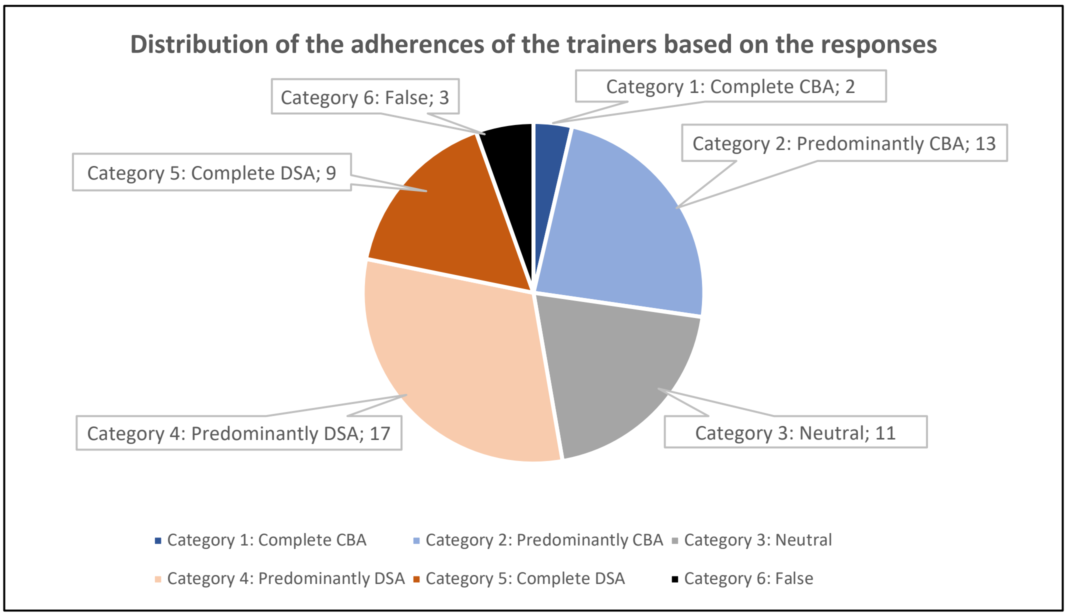
For every case where the mean-score on the CBA-statements is larger compared to the mean-score on the DSA-statements, a closer look is taken to the mean-score of the DSA-statements. In total, 29 times the mean-score on CBA-statements is larger. In addition, in 14 of these 29 cases the mean-score on the DSA-statements is larger than 3, which also indicates a positive attitude towards those statements. In 25 cases, the mean-score on DSA-statements is larger compared to the mean-score on the CBA-statements. For 15 of these 25 cases, the mean-score on CBA-statements is also larger than 3, indicating a positive attitude towards these statements.

Examining the internal consistency

Using the results found for the two different types of questions (*selection of statements* and *rating of statements*), a comparison is made between the two. First, the results are labelled based on whether the results of a respondent imply a preference for CBA or DSA. This is followed by a comparison between the results for the two types of questions.

For the *selection of statements* questions, the labelling is done by comparing the found percentages and check whether this difference exceeds a certain threshold. It is chosen to use a threshold of 35% difference. On average the respondents selected 6.5 statements, so this threshold of 35% difference implies a difference of choosing at least 2 statements more of one of the two approaches of motor learning (35% of 6.5 is 2.28). When the difference between the percentages is smaller than 35%, the respondent gets the label 'neutral' for this type of questions.

Figure 6.4: The distribution of the adherences to approaches of motor learning of the trainers. The labels for both types of questions on the questionnaire are compared for each trainer, and the trainers are divided into categories. The internal consistency between the categories 1, 3, 5, and 6 is 88%.



Regarding the *rating of statements*, the labelling is done by comparing the mean-scores with a threshold of 0.50. This value is chosen rather arbitrary; it implies a difference, but not necessarily a significant difference. This should be taken into account when drawing conclusions on these labels. When the difference between the mean is larger than the threshold, the respondent is labeled with a preference for either CBA or DSA for this type of question, otherwise he is labeled 'neutral'.

After labelling the results found for the two types of questions, the labels are compared. When the question from the first type (*selection of* statements) is labeled CBA and the question from the second type (*rating of* statements) is also labeled CBA, this means a match. The number of matches for CBA can be found in figure 6.4 as '*Category 1: complete CBA*'. This same principal holds for a match for DSA between the two types of questions, these matches for DSA are counted under '*Category 5: Complete DSA*', and the matches for neutral as '*Category 3: Neutral*'. When one label is CBA and the other DSA this is counted as a FALSE, this is '*Category 6: False*' in figure 6.4. In case one of the two labels is CBA and the other is neutral, the trainer is said to be predominantly CBA ('*Category 2: Predominantly CBA*'). When one of the two labels is DSA and the other neutral, the trainer is said to be predominantly DSA ('*Category 4: Predominantly DSA*'). The percentage of trainers who are Predominantly CBA or DSA exceeds 50%, implying that a large group of trainers does not completely subscribe to one of the two approaches of motor learning. All individual results can be found in the table of appendix B.

In order to assess the internal consistency, only the confirmative and contradicting results are taken into account. This means that the categories 1 (*Complete CBA*), 3 (*Neutral*), 5 (*Complete DSA*), and 6 (*False*) are taken into account. Since the categories 2 (Predominantly CBA) and 4 (Predominantly DSA) are neither confirmative nor contradicting, they are left out of scope when assessing the internal consistency. The number of matches, in which both types of questions present the same label, is divided by the total number of labels which are either confirmative or contradicting. This means that the sum of the categories 1 (*Complete CBA*), 3 (*Neutral*), and 5 (*Complete DSA*) is divided by the sum of the categories 1 (*Complete CBA*), 3 (*Neutral*), 5 (*Complete DSA*), and 6 (*False*). The internal consistency found is 88% `((2+11+9)/(2+11+9+3) = 22/25 = 0.88)`. The internal consistency tells something about how consistent the respondents were compared over the two types of questions.

6.3. Interpretation

The found results are used for exploratory research. The presented statistics are descriptive and not used to make significant claims. By mapping the 5-point Likert-scale to numbers and using certain thresholds to label respondents, assumptions and decisions are made which might influence the outcomes. This should be taken into account when interpretating the results and value the findings.

A great variety of trainers have filled in the questionnaire, covering almost the complete field of different trainers. Variation in years of experience as a trainer, the courses followed, the gender of the players they train, the age of the players, and the competition in which the team participates. Based on the two different types of questions it can be argued that there exists a very mixed preference on which approach of motor learning should be used and applied in volleyball exercises. In the complete spectrum ranging from CBA preference towards DSA preference, trainers can be found. This result argues that in practice the two approaches of motor learning appear not to be a dichotomy but a continuum.

The results from the first type of questions, *selection of statements*, show how mottled the preference of volleyball trainers is for a certain approach of motor learning. Where an s-curve could be expected in which a trainer either strongly prefers CBA or DSA, the preferences could be expressed using a rather linear formula; the responses range from a 100% preference to a 50%/50% ratio indicating no preference at all. This can be explained by different reasons (e.g. trainers simply have no strong preference, trainers are not aware of the theoretical differences, trainers responded randomly to the statements), but this is not the focus of this research.

The second type of questions, *rating of statements*, required that the used scale was converted to numbers in order to allow for calculate statistics. The found differences between the mean-scores on CBA and DSA statements can be described using a linear formula. As stated, 14 of the 29 trainers who had a preference towards CBA-statements also have a positive attitude towards DSA-statements (a mean-score above 3). In the case of trainers who had a preference towards DSA-statements, 15 out of the total of 25 trainers also have a positive attitude towards CBA-statements. Based on these findings it could be argued that for a large group (about 50%) of trainers, adhering to one of the approaches of motor learning does not necessarily imply a negative attitude towards the other approach of motor learning.

Labelling the found results for the two different types of questions in this questionnaire allows for an assessment of the preference of each respondent. Based on these results, 2 respondents are labeled with a preference for CBA, 9 with a preference for DSA, 11 with no preference, and 3 have a contradictory preference across the two types of questions. The internal consistency of the respondents (between the two types of questions) is 88%. The categories 2 and 4, *Predominantly CBA* and *Predominantly DSA* are left out of scope when calculating this internal consistency since they are neither confirmative nor contradicting. This method of labelling respondents can be used when processing the interviews in chapter 7.

7. Evaluation of the exercises

After the questionnaire is conducted and described in chapter 6, the respondents of this questionnaire were invited to participate in a follow-up interview. This chapter describes the procedure of the interviews, the results, and the interpretation of the results. During the interview, the exercises developed in chapter 5 are presented to the trainers and discussed afterwards. The sub-question to be answered in this chapter is the following: *Is there a correlation between the adherence to an approach of motor learning and the preference for the designed exercises amongst volleyball trainers?* The findings of this chapter show that it is not necessarily a given that when someone has a stronger adherence to one of the two approaches of motor learning, this person also prefers the corresponding exercise. This chapter attempts to explicate the preferences for exercises of trainers based on the interviews conducted. The small number of interviewees does not allow us not to make significant statements. This interview could be seen as a pilot for the eventual study; we perform preliminary research in order to gauge what type of reactions can be expected.

7.1. Method

The interview consists out of two parts. The first part introduces the trainers to the different exercises designed in chapter 5. The exercises are explained in neutral terms without explaining the design choices. Also, no mention is made of the fundamental differences upon which these exercises are developed, nor are the different skill levels taken into consideration mentioned. After one exercise is introduced and discussed using questions, the next exercise is introduced and discussed, until all exercises have been treated. All exercises are offered in random order, so the order of presenting differs per trainer. The questions are briefly explained below, the complete interview can be found in appendix C. The first question about the exercise asks for elements of the exercise the trainer likes, the second question asks for potential improvements of the exercise. The third question asks how big the chance is the trainer would implement this exercise into his trainings on a scale from 1 to 10 (in which 1 stands for "*I would never implement this exercise*" and 10 for "*I would definitely implement this exercise*"). The last question depends on the presented exercise: for CBA exercises the trainer is asked about his view on the detailed feedback the players receive during the exercise, for DSA exercises the question asks the trainer's opinion about the space the players get to discover adequate actions. The reactions they give are not used to actually improve the exercises, rather they help to understand their lines of thought when they asses the exercises.

The second part of the interview examines the preferences for the exercises of the trainers. In total, the trainers are presented with four different choices. Four times, the trainers are presented with two exercises of which they must select which one they would rather implement in their trainings. The four choices presented are: 1) *CBA-novice or DSA-expert*, 2) *CBA-expert or DSA-expert*, 3) *CBA-novice or CBA-expert*, and 4) *DSA-novice or DSA-expert*, table 7.1 holds a graphic overview of these choices. The four choices are presented in random order to the trainers, and the two options of the choices are also presented in random order. After each choice, the trainers are asked why they choose one exercise over the other.

Table 7.1: The design space with four quadrants where the four different exercises are designed for. The trainers are asked to choose which of two presented exercises they would rather implement in their trainings. The choices presented to the trainers are represented by the blue arrows.

	Cognitive Based Approach	**Dynamical Systems Approach**
Novice	CBA novice	DSA novice
Expert	CBA expert	DSA expert

After conducting the interviews, the results of the interviews are compared with the found results of the questionnaire. The questionnaire allows to state whether a trainer adheres stronger to CBA or DSA. This interpretation is done for each of the trainers and compared with the results from the interview. It is expected that trainers who have a stronger adherence to CBA, will also express preference for the CBA exercises (and the same regarding DSA). Also, the age and skill level of players to whom the trainer gives training are asked in the questionnaire. It is expected that the trainers will prefer the exercises which are designed for their type of players.

7.2. Results

After the questionnaire (described in chapter 6) was conducted, the respondents were asked whether they could be approached for future research. Out of the list of respondents who reacted positively, in total 20 respondents were asked to participate in this interview. This selection was made without taking knowledge of the results of the questionnaire. In total 3 respondents were able to make time for the interview. The interviews were conducted individually and online.

The first interviewee is trainer of a ladies-team from 18 years and older who participate in the '3e klasse' (Dutch volleyball competition[1]), this is considered to be skill-level expert. This trainer has 0-5 years of experience as a trainer and has no trainer certification. Following the procedure of labeling described in chapter 6, this trainer gets the label CBA (Category 2: Predominantly CBA). This trainer will be referred to as trainer 1.

The second interviewee (trainer 2) is trainer of a large group of children of 11-13 years, playing in the competitions CMV4-CMV6, this is considered to be skill-level novice. These are Dutch competitions based on the age of the children. Trainer 2 has over 15 years of experience and has the highest Dutch trainer certification possible, VT5[2]. Based on the questionnaire, this trainer is labeled with DSA (Category 5: Complete DSA).

The third and last interviewee (trainer 3) is trainer of a boys team of 14-16 years, playing in the 'Jeugd 1e klasse' (Dutch volleyball competition for youth[3]), this is considered to be skill-level novice. This trainer has 0-5 years of experience and does not have a trainer certification. Based on the questionnaire, trainer 3 is labeled with CBA (Category 2: Predominantly CBA).

[1] https://www.nevobo.nl/wedstrijdsport/zaalvolleybal/nationale-en-regionale-competitie/
[2] https://www.nevobo.nl/trainen-coachen/opleidingen-bijscholingen/overzicht-opleidingen-en-instroommoment/
[3] https://www.nevobo.nl/trainen-coachen/doelgroepen/jeugd-12-18-jaar/

7.2.1. Discussion about exercises

During all interviews, some general remarks were given alongside remarks in response to the exercises presented. Trainer 1 mentioned multiple times that all the exercises would help in managing his players; he considered the technological support as a mean to prevent discussion. However, he also missed the usage of all players during exercises, since opponents in the exercises are digitally represented. In his view, replacing actual players by digital representations is the loss of a meaningful method. Regarding the CBA-novice and CBA-expert exercises he was rather positive, especially the large amount of objective and precise feedback was considered to be very useful. He had some doubts by the fact that players would sometimes wait a long time before performing movements, and he would rather use players instead of digital representations of players. Interestingly, he himself made a link between the CBA-novice and the CBA-expert exercises, by referring to the latter when discussing the CBA-novice exercise. When discussing the DSA-novice exercise, trainer 1 liked the dynamic character of the exercise: "*it is nice that you must look where you can score rather than blindly hitting towards some general locations*". Regarding the DSA-expert exercise, he liked the fact that this game sticks to game-like scenarios. He added that he thought this exercise is great since it allows for a lot of repetition of the movement in a short amount of time.

During the discussion about the exercises with trainer 2 it became very clear that the level of expertise required for all four exercises was too high for the players she trains (children of 12 years and younger). She explained that the motor skills of these children are simply not developed enough to start practicing the spike. In addition, she mentioned that jumping too much is bad for these children. To conclude these remarks: all exercises presented are not conforming the needs and qualities of these children since their skill-level is lower than designed for. In reaction to this mismatch, she was constantly interpretating how she could change the exercises in order to make them fitting for her players. When discussing the CBA-novice exercise, trainer 2 explained that she recognized some elements of the exercise in her own exercises. She also makes use of indications for the stepping pattern and targets to hit at (using hoops e.g.). However, she explained that there are too many elements in this exercise which are too hard for her players, and for that reason she is not very likely to use this exercise. This trend continued for all the other exercises; she recognized and liked some elements, but she is not likely to adopt the exercises since they are simply too hard for her players.

Trainer 3 was in general very enthusiastic about the CBA-novice exercise. He recognized certain elements which he already applies in his trainings, but he saw how this technological implementation added value to these elements. Currently he uses chalk to draw circles on the floor in which the players must practice the stepping sequence of the run-up. Using the floor to project adaptable footsteps (based on size of the player and his dominant arm), this adds value to the concept he already applies. The same holds for showing images of a perfect execution. He currently does this by trying to make the movement himself in slow-motion however, using the still images on the LED-floor this explanation could become clearer in his opinion. When discussing the CBA-expert exercise, trainer 3 seemed to be very fond of the statistics and only replied to this rather than discussing the other elements of the exercise. He did not like both of the DSA exercises much since they are both concerned with scoring points. He explained that: "*scoring points is something for the games on Saturday, during training we practice technique*". Being able to practice game-like scenarios during the DSA-expert exercise was considered as a useful feature for higher skilled teams.

7.2.2. Approaches of motor learning

Trainer 1 has, according to the labeling of the questionnaire, a stronger adherence to CBA compared to DSA. After introducing and discussing the different exercises with the trainer during the interview, his preferences were asked. When provided with the choice between the exercises for CBA-novice and DSA-novice, the trainer chose CBA-novice. The trainer also preferred CBA-expert over DSA-expert. This is exactly as was expected, an agreement between the adherence of an approach of motor learning and a preference for the exercises based on this approach. Trainer 1 disliked the DSA-novice exercise and saw added value in the CBA-novice exercise, so for that reason he chose the latter when offered a choice between the two. He was convinced of the added value the CBA-novice exercise could have, since it "allows for practicing the basic techniques". This trainer also added that in his opinion, the DSA-novice exercise would be more relevant when executed with real players instead of projecting players on the floor. When choosing between the CBA-expert exercise and the DSA-expert exercise, trainer 1 indicated to have some trouble with choosing one. He liked the game element of the CBA-expert exercise however, he also saw added value in the strong relation of the DSA-expert exercise with actual game situations. He explained that in this choice the potential to implement decisive was, and he thought that CBA-expert exercise lend itself more for implementation. No clear mention was made of which exercise was in its principles better compared to the other, it was more a practical decision.

Based on the results of the questionnaire, trainer 2 appears to have a stronger adherence to DSA compared to CBA. However, when asking for preferences, the trainer chose the CBA-novice exercise over the DSA-novice exercise, and the CBA-expert exercise over the DSA-expert exercise. So, in both choices the CBA variant was preferred, which is directly opposed to what was expected. Regarding the CBA-novice exercise, trainer 2 recognized elements which could be useful for her players. However, both the CBA-novice exercise and the DSA-exercise were considered to be too advanced, and "*had to be changed in order to make them useful*" she added. When offered the choice between the CBA-expert exercise and the DSA-expert exercise, trainer 2 started with explaining that she would rather choose neither of them. Both of the exercises are too hard for her players, young children. But, when asked to still make a decision, trainer 2 explained that she beliefs that providing someone with a lot of incentives would lead to results. For that reason, she expressed a preference for the CBA-expert exercise: it would excite her players the most. The game element of the CBA-expert exercise would trigger the children this trainer trains, and for that reason she preferred the CBA-expert over the DSA-expert exercise.

When presented with the choice between the CBA-novice exercise and the DSA-novice exercise, trainer 3 expressed a strong preference for the CBA exercise. When presented with the expert exercises, again the preference was the CBA exercise. These results are in line with the expectations, since trainer 3 was labeled after the questionnaire to have a stronger adherence to CBA compared to DSA. Trainer 1 elaborated that he liked the attention to separate technical elements of the spike in the CBA-novice exercise. He explained that for his team, young boys who are still learning the basic movements, this focus on technique is very important. Also, he disliked the DSA-novice exercise since: "*it is only concerned with scoring, that is something for the game on Saturday, not for in practice*". He had this same comment for the DSA-expert exercise. In addition, he said that his team was not yet developed enough for the DSA-expert exercise, since it involves a combination of skill and game insight to execute an aimed spike. Why he preferred CBA-expert over DSA-expert, is largely supported by the fact that he recognized the statistics from his own trainings. The trainer often collects statistics himself, so he liked this element of the exercise a lot. The 'game element' of the CBA-expert exercise was also a pro since it would make his team very enthusiastic, he explained. Remarkably, trainer 3 added that he liked the element of the DSA-expert exercise in which the LED-floor assigns a random location to spike to a player. He explained that he considers it to be useful for his young players to explore the different positions in the field and not focus too much on just one position.

7.2.3. Skill-level

Trainer 1 gives training to ladies from 18 years and older who participate in the '3e klasse'. These players are not considered to be beginners, so practice is not focused on learning the basics of the movements. When offered the choice between the exercises for CBA-novice and CBA-expert, trainer 1 expressed a preference for the CBA-expert exercise. Also, between DSA-novice and DSA-expert, his preference lies at the DSA-expert. So, when offered a choice between exercises for either a novice or an expert, the trainer chooses for the expert exercises. This corresponds to the skill-level of the team this trainer trains. Trainer 1 explained that for his players, the timing element of a spike requires more attention compared to e.g. the stepping sequence, so for that reason he preferred CBA-expert. However, he added that the CBA-novice exercise could be useful to implement sometimes in order to practice the basics again. He considers the CBA-expert exercise to be more "structurally relevant", his preference was mostly based on this fact he added. When offered the choice between DSA-novice and DSA-expert, trainer 1 said he would "definitely go for" the DSA-expert exercise. Mostly, because of the dynamic nature of the exercise since "it provokes a quick reaction to changing situations".

The children which are trained by trainer 2, are young and learning how to play volleyball. They are considered to be novices. When the trainer was presented with the choice between the exercises for CBA-novice and CBA-expert, trainer 2 expressed a preference for the CBA-novice exercise. When presented with DSA-novice and DSA-expert, also a preference for the novice variant was expressed. No explicit reasons were given for these preferences other than that the expert exercises seemed too advanced for her players. However, she added that even the exercises she chose (the novice exercises) seem to be too advanced in her opinion. The preferences correspond to the expectations, the trainer preferred the exercises designed for the skill-level of the player she trains.

The team of trainer 3 consists out of boys from 14-16 year. These children are learning the basics of the movement and are considered to be beginners. The choice between the CBA-novice exercise and the CBA-expert exercise was easily made: CBA-novice. Trainer 3 liked the CBA-novice exercise since it has a strong focus on training the technique, which he explained as the most important subject for his team. The expert exercise seemed fun in his eyes, but more as a warming-up to get warm while playing a fun and competitive game. This choice is in line with the expectations, since he trains a team with novices. When offered with the choice between the DSA-novice exercise and the DSA-expert exercise, trainer 3 has some trouble choosing one. He started his reasoning with stating that the two exercises are very much alike and could be nicely combined. He liked the gradual increasement of difficulty in the novice exercise and the game-like scenarios of the expert exercise. He would like to see those two elements combined. However, when asked to make a choice, he expressed some preference for the DSA-expert exercise. This decision was mostly because he saw not much use in letting his team discover movements, in addition he liked the realistic game-scenarios of the expert exercise.

7.3. Interpretation

All trainers interviewed were very enthusiastic when presented with the exercises. They liked the potential of the technology to support them as volleyball trainers and were positive about the potential impact on the sport. Despite asking for it, this interview does not aim to find actual input for improvement, rather, the remarks given by the trainers are used to interpret their attitude towards the exercises. As stated at the beginning of this chapter, we are aware we cannot make significant claims based on this interview. Rather, we explore the *first* reactions to the designed exercises and collect input for future work. In addition, we have interpreted the found results which provide some preliminary results. Using the questionnaire, we are able to distinguish the (predominant) adherences of the trainers; i.e. whether they adhere stronger to CBA or DSA. These results can be used when processing the interview. Ideally, over 50 trainers should be interviewed in order to make significant claims about the found results. This chapter is a preparation on such research, some of the found results are discussed below.

At first glance, trainer 1 made choices as expected, he adheres mostly to CBA and he gives training to experts. When asked which exercises he preferred, he chose the exercises which are either CBA or expert, or both of them. Trainer 2 on the other hand selected the novice exercises, as expected, but preferred the CBA exercises over the DSA exercises. The latter was not expected since she adheres more to DSA, according to the questionnaire of chapter 6. Lastly, trainer 3 selected the CBA exercises over the DSA exercises, which is in line with the expectations based on the questionnaire from chapter 6. Also, when offered a choice between the CBA-novice exercise and the CBA-expert exercise, he chose for the novice variant. Considering DSA however, he chose DSA-expert over DSA-novice. The latter was not expected.

During the interview both trainer 1 and trainer 2 seemed to base their choices on other factors than the learning goal of improving the spike timing. During the interview it became rather clear that trainer 1 was mostly concerned with the potential of the technology to prevent discussion with his players. When discussing the exercises, in all cases he talked about how he could prevent a certain discussion and how nice that would be. It seemed that this was a big motivation to prefer one exercise over another. He also explained how other elements influenced his choices, but the discussion prevention seemed leading. Trainer 2 also had an own way of interpreting and viewing the exercises. The players she trains are children who simply have not fully developed their motor skills yet. For all exercises, she considered the required motor/skill level to be too high for her players. When discussing and comparing the exercises she seemed to make her own interpretation of an exercise, disregarding the actual exercise designed, and based her preferences on this own interpretation.

These observations can be considered to be an incitement for future research to obtain a clearer image of what motivates preferences and choices. The design lesson learned for researchers, is that one must attempt to be even more objective and impartial about such preferences. Not only the approaches of motor learning matter, but also other factors play a role and maybe their role is even more present compared to the approaches of motor learning.

8. Discussion

Despite the findings of this research, some points are still open for discussion. This section addresses topics which are considered when performing this research. Furthermore, lines of inquiry are proposed for future work.

The first point of discussion is largely based on the discussion of the research topics which has been performed as a preparation to this thesis, by the author of this document. During the research topics a decision is made to formulate two approaches of motor learning using the distinction made by Edwards (2010) as leading; this distinction is adopted in this research. Despite Edwards' elaborate and substantiated explanation of this distinction, using this one book as guiding 'colors' the study. However, the found distinction fits the general view on the duality of motor learning theories according to multiple motor learning experts (e.g. Dees Postma [*University of Twente*], Wytse Walinga [*Windesheim University of Applied Sciences, Zwolle*], and Jeroen Koekoek [*Windesheim University of Applied Sciences, Zwolle]*).

Despite the general accepted theoretical view of two different approaches of motor learning, the questionnaire illustrated that in practice this is not as black and white as the theories assume. In practice a volleyball trainer seems to prefer elements of both approaches, implying that the distinction between the approaches in real life may rather be a continuum instead of the theoretically proposed dichotomy. A trainer is not solely advocating one of the two approaches, he rather seems to prefer elements of both approaches, as is confirmed by the questionnaire. Due to the vast number of topics this thesis treats, no significant claims are made on this continuum found. For future work we propose that statistical analyses should be performed on our results, since there are more conclusions to be found. Also the impact of this distinction being a continuum rather than a dichotomy on the design of exercises should be researched.

Regarding the novice-expert paradigm, the research topics already explained that this is not a dichotomy, but is treated as such in order to emphasize the difference between novices and experts. Treating the paradigm as the continuum which it is, would substantially complicate this study. For future research, attempts can be made to implement elements which can be more gradually changed, in order to increase the difficulty and challenges of the exercise. For sake of illustrating the potential differences, treating this paradigm as a dichotomy seemed most suitable. However, during the interviews it appeared that our novice-exercises seemed to assume a skill-level which already exceeds the skill-level of young children. Future work should take into account the development of general motor skills of children in order to find suitable exercises. A broader spectrum of skill levels could be used to fill this gap and others, e.g. adding more steps (before novice, between novice and expert, and above expert) potentially allow for a far better covered field of skill-levels. This research was primary focused on the approaches of motor learning, considering the skill-level to a greater extend could also present interesting results.

This thesis provides five principal differences between the two distinguished approaches of motor learning. These principals are formulated by combining and generalizing a number of motor learning theories. Inherent to combining and generalizing a number of very specific and fine-tuned theories is the loss of subtleties. Future work could attempt to find more and more precise principal differences. Also, based on these principles we provide some practical implementations, future work could come up with a set of general design principles which could guide designers in designing smart sport exercises.

When moving from theory to practice, inevitably discussion arises. Practical implementations of theories tend to miss some of the sensitivities of the theories themselves. When designing the exercises, we were well aware of this fact and tried to consider the consequences of decisions. We designed four relatively straightforward exercises since they give, in our opinion, a good idea of what an exercise designed from a certain approach of motor learning could look like without losing obvious sensitivities. We are aware that these exercises do not cover the full extent of the four quadrants, making them not fully representative. However, they do illustrate that designing specifically for the quadrants results in significantly different exercises. Also, the exercises are intended to illustrate the possible practical differences between the four quadrants, they are not intended to make comparative claims about which approach is better. Further, there is a large number of possible ways to make a practical implementation of the two approaches of motor learning, many exercises can be designed which look different from the four we have made. This provides designers with a rich and varied design space to work from. In addition, the designed exercises are translated to Lo-Fi prototypes however, no actual implementation is made, neither has there been user tests. Future work should also implement and test exercises in order to evaluate how both trainer and player react to them in practice.

Considering motor learning theories, some sports (and components of a sport) tend to lend themselves better for one of the two approaches. A sport which is heavily depending on certain complex techniques might be better off with exercises with a lot of repetition aimed at achieving idealized techniques. In such a case, a CBA exercise will fit the sport better compared to a DSA exercise. One should be aware of the nature of the sport and the element which is practiced when designing and not jump to conclusions about the approaches of motor learning in general. For this research an attempt is made to have no preference for a certain approach of motor learning. Any colored thoughts and explanations are not made deliberately. The research should be considered to be an attempt of objectivity. We are aware that one could argue that the timing of a spike seems to be rather CBA in itself. Training certain elements could, as explained above, lend itself in theory more for one of the two approaches of motor learning. Hence, a fair comparison between CBA and DSA is very hard. Comparing CBA and DSA is not the goal of this thesis, we tried to examine their effects on designing exercises.

The questionnaire is used to obtain an impression of the adherence of trainers to the approaches of motor learning. As explained, no attempt is made to make statistically significant claims since that is out of the scope of this research. When interpreting the results however, some assumptions are made, and certain thresholds are chosen. These numbers are not based on statistical tests nor do they allow for significant claims. They are used to allow for interpretation of, and give meaning to, the found results. In order to make firmer claims, statistical tests should be applied. The method used however, allows for the demonstration of the mixed adherence to approaches of motor learning.

Only three interviews are conducted, this does not allow for a significant analysis of the subquestion. The findings are directly opposed to each other and strong indications are present that the interviewees based their answers on other factors than the approaches of motor learning. The first interviewee for instance, was rather concerned with preventing discussions in his team and substantiated his choices on this when asked for an explanation. The second interviewee trains children which are not (motorically) developed enough and made her own interpretations of the exercises which she then valued. Introducing more than just two skill-levels could maybe prevent some discussion since the exercises might be more fitting for the teams of the trainer, allowing him to evaluate the exercise without experiencing nuisance due to assumed skill-level of the exercises.

For future research to make stronger claims, first of all, more trainers should be interviewed. Also, the questions could be redesigned in order to get more information out of the trainers. One could for instance first get the trainers to rethink their view on what a good training is prior to asking questions about specific exercises. This could get them into a more abstract way of thinking about the exercises, compared to the practical view they had during these interviews. However, one could argue that the current interview questions allow for obtaining a more realistic view on how trainers' attitude towards exercises. Maybe their prime drive is not the approach of motor learning but play other (and seemingly less relevant) factors a much bigger role. This research does not provide a significant answer to the question whether there exists a parallel between the adherence to a motor learning paradigm and the preference for an exercise fitting that paradigm. More trainers should be interviewed in order to gain more insight on this topic.

9. Conclusion

This thesis aims to describe the potential impact of considering the two different approaches of motor learning when designing interaction technology for smart sport exercises. As this thesis made clear, designing from the different approaches of motor learning, taking into account the skill-level, results in distinctive different exercises. In total four exercises are designed which illustrate elements of the principal differences between the two approaches of motor learning, taking skill-level into account. Different steps are taken in order to answer the main research question: *What is the potential impact of considering the two different approaches of motor learning when designing interaction technology for smart sport exercises?*

First, principal differences between the two approaches of motor learning are formulated in chapter 4. Doing so, the first sub-question is answered: *What are principal differences between the two approaches of motor learning which could contribute to the design of sport exercises?* The four differences found in chapter 4 can be used in multiple ways, for instance helping a person to both understand and implement the principal differences between CBA and DSA. They can also serve as a checklist to discriminate between trainers who adhere to CBA or DSA, and form the theoretical basis upon which sport exercises can be designed. The five differences are: *Elementary Approach versus Holistic Approach, Search for the Ideal Movement versus Search for an Adequate Action, Variation to get more Generalistic versus Variation to get more Discriminative, Prescribe Movements (Explicit Learning) versus Allow for Exploration of Movements (Implicit Learning), and Decoupled Movements versus Whole (simplified) Movements*. These five differences are explained in chapter 4, followed by the potential contribution of the difference to the design of smart sport exercises.

In total four different exercises are designed in order to answer the second sub-question: W*hat do exercises look like when they are designed for different approaches of motor learning and for different skill-levels (i.e., for the four different quadrants)?* In chapter 5 this question is answered by first introducing a design space with four quadrants which allows for the design for specific target groups. These quadrants are formulated based on the dimension CBA or DSA, and the dimension Novice or Expert. After developing the exercises upon theoretical principles adhering to the quadrant designed for, the exercises are presented to motor learning experts. The experts were able to subscribe the exercises to their correct quadrants, indicating a good fit between the theory and our practical interpretation by means of four exercises.

Thirdly, the adherence to the approaches of motor learning amongst volleyball trainers is examined by means of a questionnaire. This is done in chapter 6, answering the third sub-question: *What is the adherence to the approaches of motor learning among volleyball trainers?* A great variety of trainers has filled in a questionnaire, covering almost the complete field of different trainers who can be found. The found results illustrate that in general trainers don't strictly adhere to one of the two approaches. When presented with statements, almost all of the trainers gave preference to both statements related to CBA and statements related to DSA. Multiple explanations for this phenomenon can be given, but this mixed view present within almost every trainer itself is an interesting observation. Also, a mixed view is present between the trainers. The distribution of preference for CBA and DSA covered a wide variety of different configurations, from predominantly either of the approaches to an equal distribution of both approaches, however, trainers are inclined towards DSA. Interestingly, about 50% of the trainers who adhere to one of the two approaches of motor learning, also have a positive attitude towards the other approach of motor learning. This implies that for about 50% of the trainers adhering to one approach does not necessarily mean a negative attitude towards the other approach.

The last subquestion addresses whether there is a correlation between the adherence to an approach of motor learning and the preference for the designed exercises amongst volleyball trainers. Based on the three interviews conducted, no significant claims can be made regarding the correlation between the adherence and the preference. We observed that the first interviewee did indeed chose the exercises which correlate to the approach of motor learning he adheres to; this was a perfect fit. However, the second interviewee chose the other approach compared to what was expected. The third interviewee chose the exercises from the approach of motor learning as expected, however, he chose exercises for different skill-levels. Furthermore, during the interviews strong indications were present that the trainers based their choices on other factors than the learning goal of improving the spike timing. Based on these findings, one can argue that when designing smart sport exercises, one should also make secondary factors as objective as possible. Also, the motor development of the players should be taken into account when designing, children for instance are simply not developed enough to perform certain exercises. This preliminary interview did not provide sufficient results to formulate a significant conclusion. More research should be performed on this topic.

In order to answer the main research-question, four sub-questions are answered. First, five principal differences between the two approaches of motor learning are formulated. Secondly, four volleyball exercises are designed illustrating what designing from one of the four quadrants of our design-space could look like. Thirdly, using a questionnaire the adherence to the approaches of motor learning among volleyball trainers is researched. And lastly, the correlation between the adherence to an approach of motor learning and the preference for the designed exercises is examined by means of interviews. The main research-question of this thesis is: *What is the potential impact of considering the two different approaches of motor learning when designing interaction technology for smart sport exercises?* Considering the differences between the two approaches allow for the design of smart sport exercises which are consistently and coherently fitting one approach of motor learning, as confirmed by multiple motor learning experts. Taking into account these differences allow researchers to design theoretically consistent exercises, moderating or even diminishing theoretical contradictions within exercises. This thesis contributes to the design of future smart sport exercises by illustrating how designing such exercises could be performed. An extensive study is done in order to describe theoretical differences and illustrate how they can be used in practice when designing exercises. In addition, the theoretical inclination of volleyball trainers is researched by means of a questionnaire. This confirmed the assumption that the field of trainers is rather molded with respect to the theories of motor learning, which pledges for taking into account both approaches of motor learning when designing smart sport exercises. This thesis describes the first steps towards designing theoretically consistent smart sport exercises and the impact of this; now it is time to make impact on the world of sports by implementing such smart sport exercises.

References

Adams, J. A. (1971). A closed-loop theory of motor learning. *Journal of Motor Behavior*, *3*(2), 111–150. https://doi.org/10.1080/00222895.1971.10734898

Bernstein, N. A. (1996). *Dexterity and Its Development* (M. L. Latash & M. T. Turvey, Eds.). L. Erlbaum Associates.

Chow, J. Y., Button, C., Shuttleworth, R., & Antonio Uehara, L. (2009). *Nonlinear pedagogy : implications for teaching games for understanding (TGfU)*. Retrieved from https://www.researchgate.net/publication/38183987

Correia, V., Carvalho, J., Araújo, D., Pereira, E., & Davids, K. (2019). Principles of nonlinear pedagogy in sport practice. *Physical Education and Sport Pedagogy*, *24*(2), 117–132. https://doi.org/10.1080/17408989.2018.1552673

Davids, K., Araújo, D., Hristovski, R., Passos, P., & Chow, J. Y. (2012). Ecological dynamics and motor learning design in sport. In N. Hodges & A. M. Williams (Eds.), *Skill Acquisition in Sport: Research, Theory and Practice* (pp. 112–130). https://doi.org/10.13140/RG.2.1.2297.0089

Davids, K., Button, C., & Bennett, S. (2008). *Dynamics of Skill Acquisition | A constraints-Led approach*. Retrieved from www.HumanKinetics.com

Edwards, W. H. (2010). *Motor Learning and Control From Theory to Practice*. Retrieved from www.cengage.com/highered

Jacobs, D. M., & Michaels, C. R. (2007). Direct learning. *Ecological Psychology*, *19*(4), 321–349. https://doi.org/10.1080/10407410701432337

Meininger, A. (2019, August). Volleybaltraining volgens principes van motorisch leren - Een interview met Dr. Remo Mombarg en Arjan Taaij. *VOLLEY TECHNO 2*, 38–43.

Michaels, C. F., & Carello, C. (1981). *Direct perception*. Englewood Cliffs (N.J.) : Prentice-Hall.

Oden, B. (2018, July 22). Improve Your Volleyball Hitting. Retrieved July 31, 2020, from https://www.liveabout.com/master-volleyball-hitting-3428904

Postma, D., Van Delden, R., Walinga, W., Koekoek, J., Van Beijnum, B. J., Salim, F. A., … Reidsma, D. (2019). Towards smart sports exercises: First designs. *CHI PLAY 2019 - Extended Abstracts of the Annual Symposium on Computer-Human Interaction in Play*, 619–630. https://doi.org/10.1145/3341215.3356306

Quora. (n.d.). How do you spike a volleyball? Retrieved May 6, 2020, from https://www.quora.com/How-do-you-spike-a-volleyball

Renshaw, I., & Chow, J. Y. (2018). A constraint-led approach to sport and physical education pedagogy. *Physical Education and Sport Pedagogy*, *24*(2), 103–116. https://doi.org/10.1080/17408989.2018.1552676

Renshaw, I., Chow, J. Y., Davids, K., & Hammond, J. (2010). A constraints-led perspective to understanding skill acquisition and game play: A basis for integration of motor learning theory and physical education praxis? *Physical Education and Sport Pedagogy*, *15*(2), 117–137. https://doi.org/10.1080/17408980902791586

Schmidt, R. A. (1975). A Schema Theory of Discrete Motor Skill Learning. *Psychological Review*, *82*(4), 225–260. https://doi.org/10.1037/h0076770

Schmidt, R. A., & Wrisberg, C. A. (2000). *Motor Learning and Performance: Schmidt, Richard A., Wrisberg, Craig A.* (2nd ed.). Human Kinetics; Subsequent edition.

Smart Sports Exercises | Website of the ZonMw funded “Smart Sports Exercises” research project. (n.d.). Retrieved July 1, 2020, from http://smart-sports-exercises.nl/

SPIKING/HITTING. (n.d.). Retrieved May 6, 2020, from https://volleyball-basics.weebly.com/spike.html

SSE information-page. (n.d.). Retrieved November 18, 2020, from https://www.utwente.nl/en/eemcs/hmi/hmi-projects-folder/hmi-project-smart-sports-excercises/

Steenbergen, B., Van Der Kamp, J., Verneau, M., Jongbloed-Pereboom, M., & Masters, R. S. W. (2010). Implicit and explicit learning: Applications from basic research to sports for individuals with impaired movement dynamics. *Disability and Rehabilitation*, *32*(18), 1509–1516. https://doi.org/10.3109/09638288.2010.497035

wikiHow. (2020, May 26). How to Spike a Volleyball. Retrieved July 31, 2020, from https://www.wikihow.com/Spike-a-Volleyball

Appendices

Appendix A – Mean scores

The Likert-scale used to examine the attitude of trainer towards statements formulated form either of the approaches of motor learning is convert to a score (strongly disagree = 1, up to strongly agree = 5). The mean-scores for the rating on both the CBA-statements and the DSA-statements are calculated per respondent, this table holds the found mean-scores.

	Mean CBA	Mean DSA	Difference
1	4,57	2,75	-1,82
2	4,14	2,50	-1,64
3	4,14	2,50	-1,64
4	3,71	2,25	-1,46
5	4,00	2,75	-1,25
6	3,71	2,50	-1,21
7	4,43	3,25	-1,18
8	4,43	3,25	-1,18
9	3,14	2,00	-1,14
10	3,57	2,50	-1,07
11	4,00	3,00	-1,00
12	3,71	2,75	-0,96
13	3,71	3,00	-0,71
14	3,86	3,25	-0,61
15	3,29	2,75	-0,54
16	4,00	3,50	-0,50
17	3,71	3,25	-0,46
18	4,14	3,75	-0,39
19	3,86	3,50	-0,36
20	3,57	3,25	-0,32
21	3,29	3,00	-0,29
22	3,00	2,75	-0,25
22	3,71	3,50	-0,21
24	3,71	3,50	-0,21
25	3,86	3,75	-0,11
26	3,57	3,50	-0,07
27	3,29	3,25	-0,04
28	3,29	3,25	-0,04
29	3,29	3,25	-0,04
30	3,00	3,00	0,00
31	3,71	3,75	0,04
32	2,86	3,00	0,14
33	3,71	4,00	0,29
34	3,14	3,50	0,36
35	2,86	3,25	0,39
36	2,86	3,25	0,39
37	3,43	4,00	0,57
38	3,57	4,25	0,68
39	3,29	4,00	0,71
40	3,71	4,50	0,79
41	3,14	4,00	0,86
42	2,86	3,75	0,89
43	2,86	3,75	0,89
44	3,29	4,25	0,96
45	3,00	4,00	1,00
46	2,71	3,75	1,04
47	2,43	3,50	1,07
48	3,14	4,50	1,36
49	2,57	4,00	1,43
50	2,86	4,75	1,89
51	2,57	4,50	1,93
52	2,29	4,25	1,96
53	2,29	4,50	2,21
54	2,00	4,25	2,25
55	1,71	4,25	2,54

Appendix B – Labelled results

Labeling of the results of the two types of questions of the questionnaire.

	Selection of Statements			Rating of Statements				Comparison
#	%CBA	%DSA	Labelling	Mean CBA	Mean DSA	Labelling		
1	43%	57%	Neutral	3,71	2,75	CBA		*Predominantly CBA*
2	25%	75%	DSA	3,71	3,00	CBA		FALSE
3	83%	17%	CBA	4,00	3,50	Neutral		*Predominantly CBA*
4	40%	60%	Neutral	3,00	4,00	DSA		*Predominantly DSA*
5	38%	63%	Neutral	3,57	3,50	Neutral		Neutral
6	63%	38%	Neutral	3,71	3,50	Neutral		Neutral
7	25%	75%	DSA	2,43	3,50	DSA		DSA
8	43%	57%	Neutral	3,14	3,50	Neutral		Neutral
9	83%	17%	CBA	4,14	2,50	CBA		*Predominantly CBA*
10	33%	67%	Neutral	2,29	4,25	DSA		*Predominantly DSA*
11	57%	43%	Neutral	3,86	3,50	Neutral		Neutral
12	33%	67%	Neutral	2,86	3,00	Neutral		Neutral
13	40%	60%	Neutral	3,57	3,25	Neutral		Neutral
14	71%	29%	CBA	3,29	3,25	Neutral		*Predominantly CBA*
15	67%	33%	Neutral	3,29	3,00	Neutral		Neutral
16	71%	29%	CBA	2,86	3,25	Neutral		*Predominantly CBA*
17	33%	67%	Neutral	3,57	4,25	DSA		*Predominantly DSA*
18	25%	75%	DSA	2,86	3,75	DSA		DSA
19	50%	50%	Neutral	4,43	3,25	CBA		*Predominantly CBA*
20	0%	100%	DSA	3,29	2,75	CBA		FALSE
21	63%	38%	Neutral	3,57	2,50	CBA		*Predominantly CBA*
22	0%	100%	DSA	3,29	3,25	Neutral		*Predominantly DSA*
23	25%	75%	DSA	3,29	3,25	Neutral		*Predominantly DSA*
24	20%	80%	DSA	3,00	2,75	Neutral		*Predominantly DSA*
25	20%	80%	DSA	2,86	3,25	Neutral		*Predominantly DSA*
26	33%	67%	Neutral	3,71	3,25	Neutral		Neutral
27	63%	38%	Neutral	3,71	2,50	CBA		*Predominantly CBA*
28	0%	100%	DSA	3,71	4,50	DSA		DSA
29	25%	75%	DSA	4,00	3,00	CBA		FALSE
30	43%	57%	Neutral	3,43	4,00	DSA		*Predominantly DSA*
31	50%	50%	Neutral	3,86	3,75	Neutral		Neutral
32	67%	33%	Neutral	4,14	2,50	CBA		*Predominantly CBA*
33	43%	57%	Neutral	3,71	3,50	Neutral		Neutral
34	50%	50%	Neutral	3,14	4,50	DSA		*Predominantly DSA*
35	33%	67%	Neutral	2,71	3,75	DSA		*Predominantly DSA*
36	33%	67%	Neutral	3,71	3,75	Neutral		Neutral
37	33%	67%	Neutral	3,71	2,25	CBA		*Predominantly CBA*
38	13%	88%	DSA	2,86	4,75	DSA		DSA
39	75%	25%	CBA	4,43	3,25	CBA		CBA
40	0%	100%	DSA	2,29	4,50	DSA		DSA
41	50%	50%	Neutral	3,14	2,00	CBA		*Predominantly CBA*
42	17%	83%	DSA	3,00	3,00	Neutral		*Predominantly DSA*
43	50%	50%	Neutral	4,00	2,75	CBA		*Predominantly CBA*
44	17%	83%	DSA	2,57	4,00	DSA		DSA
45	50%	50%	Neutral	2,86	3,75	DSA		*Predominantly DSA*
46	38%	63%	Neutral	3,29	4,00	DSA		*Predominantly DSA*
47	13%	88%	DSA	2,00	4,25	DSA		DSA
48	29%	71%	DSA	4,14	3,75	Neutral		*Predominantly DSA*
49	0%	100%	DSA	1,71	4,25	DSA		DSA
50	25%	75%	DSA	3,71	4,00	Neutral		*Predominantly DSA*
51	50%	50%	Neutral	3,14	4,00	DSA		*Predominantly DSA*
52	20%	80%	DSA	2,57	4,50	DSA		DSA
53	67%	33%	Neutral	3,86	3,25	CBA		*Predominantly CBA*
54	43%	57%	Neutral	4,57	2,75	CBA		*Predominantly CBA*
55	38%	63%	Neutral	3,29	4,25	DSA		*Predominantly DSA*

Appendix C – Interview

#	Onderdeel	Omschrijving/tekst	Beeld
1	Welkom en introductie	*Ik ben een master student Interaction Technology aan de Universiteit Twente. In mijn studie richt ik mij op het inzetten van technologie om problemen oplossingsgericht te lijf te gaan. Je kan denken aan het ontwikkelen van intelligente en interactieve systemen, die automatisch voldoen aan de wensen van zijn gebruikers. Termen als mens machine interactie en kunstmatige intelligentie komen vaak terug in mijn studie.* *Voor mijn master thesis onderzoek ik het potentieel van het inzetten van een interactieve LED-vloer tijdens een volleybaltraining. Deze interactieve LED-vloer kan de positie van spelers bepalen en op basis daarvan projecties op de vloer tonen. Deze vloer kan op die manier een trainer ondersteunen tijdens het trainen van spelers, en biedt daarnaast mogelijkheden voor nieuwe spelvormen en andere toepassingen. Tijdens mijn onderzoek heb ik vier verschillende oefeningen ontwikkeld die gebruik maken van de interactieve vloer, vandaag wil ik met jou in gesprek gaan over deze oefeningen.* *Tijdens het interview zal ik vier keer een oefening introduceren. Pak eventueel pen en papier erbij zodat je aantekeningen kan maken bij de oefeningen. Stel dat er dingen opvallen (zowel tips als tops) dan kan je die later mogelijk gemakkelijker ophalen en benoemen.*	Foto van de vloer
2	Informed consent	Deelnemer vult de informed consent in.	
		Interview	
1	Introduceren en bespreken van de oefeningen	Onderstaande lijst wordt afgewerkt voor alle 4 de oefeningen. De volgorde wordt voor het interview random bepaald. De procedure is per oefening hetzelfde: 1. Introduceren oefening door ze bondig te presenteren (in powerpoint)	Presentatie met de oefening Slides met de vragen

		2. Na introduceren van de oefening, open vragen: a. *Kan je elementen uit deze oefening noemen die je aanspreken?* b. *Waar zie je ruimte voor verbetering in deze oefening?* 3. Daarna: *Hoe groot is de kans op een schaal van 1 tot 10 dat je deze oefening in jouw training zou gebruiken als dat mogelijk zou zijn (waarbij je bij 1 de oefening nooit zou gebruiken, en je bij 10 de oefening zeker weten zou gebruiken)* 4. Tenslotte, oefening afhankelijk: a. CBA-oefening: *Wat vind je ervan dat de speler heel gedetailleerde feedback krijgt? (Denk aan de feedback op de timing, de gezette stappen en het raken van de 'targets'.)* b. DSA-oefening: *Wat vind je van de ruimte die de speler krijgt om zelf te ontdekken welke beweging effectief zijn om te scoren?*	
	Tegenstellingen	Nu alle vier de oefeningen geïntroduceerd zijn worden ze met elkaar vergeleken. De keuze wordt gemaakt binnen de approach of motor learning en binnen de expertise. 1. *Als u een oefening moet kiezen, welke van deze twee oefeningen zou je dan gebruiken in uw training?* Bied aan: - CBA-novice vs DSA-novice - CBA-expert vs DSA-expert - CBA-novice vs CBA-expert - DSA-novice vs DSA-expert 2. Vraag per keuze de volgende open vraag: a. *Waarom gaat jouw voorkeur uit naar [*de gekozen oefening*] boven de ander?*	Slides waarop de twee opties tegenover elkaar worden gezet (ondersteund door hele korte omschrijving van de oefening ter opfrissing)
Einde interview			
	Dankwoord	*Nogmaals, hartelijk bedankt voor het deelnemen aan het interview.*	

Appendix D – Questionnaire (in Dutch)

The questionnaire used to classify trainers as either CBA or DSA. The colored (CBA) and (DSA) were not included in the questionnaire presented to the respondents.

Ethics

Deze enquête wordt gehouden ten behoeve van het *Smart Sport Exercises* project, gericht op het onderzoeken en ontwikkelen van een *Spike Timing Trainer*. Dit onderzoek wordt uitgevoerd door Jorik Groeneveld, master student aan de Universiteit Twente. Het doel van deze enquête is om inzicht te krijgen in verschillende training- en coaching-stijlen. Daarnaast wordt er onderzocht hoe deze verschillen in stijl te relateren zijn aan de doelgroep die getraind wordt.

De gegeven antwoorden zullen anoniem verwerkt worden en niet worden gepubliceerd en/of gedistribueerd worden aan derden. De gegevens zullen enkel gebruikt worden in de context van het Smart Sports Exercises project, waar dit afstudeeronderzoek deel van uit maakt. De data worden verwerkt en opgeslagen conform de regels en richtlijnen zoals opgenomen in de Algemene Verordening Gegevensbescherming (AVG). U heeft het recht om ‘vergeten te worden’. Dat betekent dat u, zonder opgaaf van reden, mag vragen dat uw gegevens gewist worden, tenminste binnen 24 uur na het afnemen van de enquête.

Door onderstaand te accepteren gaat u akkoord deel te nemen aan dit onderzoek. Deelname aan het onderzoek is geheel vrijwillig en u kan de enquête op elk gewenst moment verlaten. Door te tekenen geeft u tevens aan dat u naar wens geïnformeerd bent en dat alle eventuele vragen naar wens beantwoord zijn.

Bij voorbaat dank voor de deelname namens,

Jorik Groeneveld
j.groeneveld@student.utwente.nl

Vakje die gecheckt moeten worden om de enquête te starten

- ○ Ik ga akkoord

Volgend scherm

Algemene vragen:

Als u trainingen verzorgt voor verschillende leeftijdsgroepen en/of verschillende niveaus, vul deze enquête dan in met één specifieke groep in gedachten.

1. Aan welke leeftijdscategorie geeft u volleybaltraining?
   - Jonger dan 12 jaar
   - 12 tot 14 jaar
   - 14 tot 16 jaar
   - 16 tot 18 jaar
   - 18 jaar en ouder

2. In welk team zitten de spelers die u traint?
   - Mini's
   - Jongens C
   - Meisjes C
   - Jongens B
   - Meisjes B
   - Jongens A
   - Meisjes A
   - Volwassenen Heren
   - Volwassenen Dames

3. Op welk niveau[4] speelt het team dat u traint? (Afhankelijk van 3)

   3a. (Mini's en Jeugd)
   - CMV 1-3
   - CMV 4-6
   - Jeugd 1e klasse
   - Jeugd 2e klasse
   - Jeugd 3e klasse
   - Jeugd Hoofdklasse
   - Jeugd Topklasse
   - Anders, namelijk: […]

   3b. (Volwassenen)
   - Eredivisie
   - Topdivisie
   - 1e divisie
   - 2e divisie
   - 3e divisie
   - Promotieklasse
   - 1e klasse
   - 2e klasse
   - 3e klasse
   - 4e klasse
   - 5e klasse
   - 6e klasse
   - Anders, namelijk: […]

[4] https://www.nevobo.nl/wedstrijdsport/zaalvolleybal/nationale-en-regionale-competitie/

4. Hoelang geeft u volleybaltrainingen?
    - 0 tot 5 jaar
    - 5 tot 10 jaar
    - 10 tot 15 jaar
    - 15 jaar of langer

5. Welke trainersopleiding[5] heeft u?
    - Beginnerscursus
    - VT2: Diploma tot de 1e klasse
    - VT3: Diploma 1e klasse t/m 3e divisie en Topjeugd
    - VT4: Diploma 2e divisie t/m Topdivisie
    - VT5: Diploma Eredivisie
    - Geen
    - Anders, namelijk: […]

Volgend scherm

Voorkeur van approach of motor learning ontdekken:

Vink aan waar u zich het meest in kan vinden, maximaal 4 aanvinken:

- Om een beweging goed aan te leren moet de speler deze beweging zo vaak mogelijk en onder gelijke omstandigheden uitvoeren. (CBA)
- Bij het oefenen van een beweging is de context van de beweging essentieel (DSA)
- Een speler kan de smash het beste aanleren door een consistente set-up te krijgen, idealiter middels een ballenmachine (CBA)
- Om een aanval goed aan te leren laat ik de spelers eerst de verschillende onderdelen van de smash los van elkaar oefenen (bijvoorbeeld: uit stilstand een bal tegen de muur slaan, de stappen van de aanloop oefenen zonder bal) (CBA)
- Om spelers een beweging aan te leren laat ik de spelers eerst zelf zoeken naar een passende uitvoering (DSA)
- Als ik een smash aanleer zou ik op een kast gaan staan, houd ik een bal vast en laat ik de spelers een voor een de bal uit mijn handen slaan (CBA)
- Om de smash goed te leren is de leerling gebaad bij veel verschillende soorten set-ups (DSA)
- De techniek van de speler hoeft niet perfect te zijn, als hij de bal maar weet te scoren wanneer hij een aanval doet (DSA)

[5] https://www.nevobo.nl/trainen-coachen/opleidingen-bijscholingen/overzicht-opleidingen-en-instroommoment/

Volgend scherm

Vink aan waar u zich het meest in kan vinden, maximaal 4 aanvinken:

- Ik geef het liefst zo min mogelijk expliciete feedback over de uitvoering van beweging tijdens een training (bijvoorbeeld: '*kantel je handen iets meer naar binnen bij een bovenhandse bal*') (DSA)
- Ik laat mijn spelers zien hoe een perfecte beweging (smash, block, pass) er uit ziet (CBA)
- Een speler is het meest gebaat bij vroege specialisatie (CBA)
- Een speler moet zelf ontdekken op welke plekken hij het beste kan staan in bepaalde situaties (DSA)
- Als ik een speler variatie aanbiedt (bijvoorbeeld verschillende soorten set-ups, of verschillende kwaliteit van passes) dan doe ik dit om hem te trainen in het zoeken naar adequate manieren om verschillende scenario's aan te pakken; ik train hem om met een passende oplossing te komen (DSA)
- Ik geef een speler veel feedback op de uitvoering van een beweging (CBA)
- Een aanval is opgebouwd uit verschillende bewegingen, deze losse bewegingen is isolatie trainen is een effectieve manier om de aanval aan te leren (CBA)
- Een speler leert impliciet het beste, spelenderwijs leren werkt dus beter dan expliciete uitleg (DSA)

Volgend scherm

Geef op de volgende schaal aan in hoeverre u zich kan vinden in een statement.

	Sterk mee oneens	**Oneens**	**Neutraal**	**Eens**	**Sterk mee eens**
1. Zodra een speler een vaste positie heeft laat ik hem zoveel mogelijk op deze positie trainen (CBA)	O	O	O	O	O
2. Een training draait vooral om het aanleren van de meest ideale techniek (CBA)	O	O	O	O	O
3. Ik geef zo min mogelijk expliciete feedback (bijvoorbeeld: '*leun een fractie verder naar voren tijdens je onderhandse pass*') op de uitvoering van een beweging tijdens een training (DSA)	O	O	O	O	O

4. Ik geef bij het trainen van de pass zoveel mogelijk feedback op de houding van de speler (bijv. goed door de knieën en gestrekte armen) (CBA)	O	O	O	O	O
5. Het variëren van de veldgrootte zie ik (potentieel) als een nuttige oefenvorm (half veld, heel veld, badminton veld) (DSA)	O	O	O	O	O
6. Om een beweging goed aan te leren leg ik de beweging eerst stap voor stap uit (CBA)	O	O	O	O	O
7. Ik laat mij spelers bewegingen droog oefenen (zonder bal) (CBA)	O	O	O	O	O
8. Een speler is erbij gebaat om veel op verschillende posities te trainen (libero, aanvaller, spelverdeler) (DSA)	O	O	O	O	O
9. Het is belangrijk voor een speler om een beweging te automatiseren (bijvoorbeeld doormiddel van het slijpen van die beweging) (CBA)	O	O	O	O	O
10. Tijdens een training staat het effectief reageren op een spelsituatie voornamelijk centraal (DSA)	O	O	O	O	O
11. Ik denk dat het nuttig is om de reactietijd van mijn spelers te meten en te trainen (CBA)	O	O	O	O	O

Volgend scherm

Voor een volgende stap in mijn onderzoek zoek ik nog een aantal trainers die bereidt zijn deel te nemen aan een (digitaal) interview over de oefeningen die ik heb ontwikkeld. Zou ik u mogen benaderen voor een interview? Indien u op ja klikt zal ik u onder andere om uw email adres vragen.

- Nee
- Ja

Volgend scherm (indien NEE)

Hartelijk bedankt voor het deelnemen aan de enquête!

U kan de enquête sluiten.

Volgend scherm (indien JA)

Omwille van de beperkte tijd zal ik voor de interviews een klein aantal trainers selecteren die aan bepaalde voorwaarden voldoen. Om deze selectie te maken moet ik mij beroepen op de door u gemaakte keuzes in de enquête die u zojuist heeft ingevuld. Gaat u ermee akkoord dat ik uw resultaten inzie, om op basis daarvan te bepalen of ik u wel of niet uitnodig voor het interview? Als u akkoord gaat gebruik ik uw resultaten dus enkel voor de selectie, de resultaten worden vervolgens wel geanonimiseerd verwerkt.

- Nee
- Ja, mijn email adres is: […]

Volgend scherm (indien NEE)

Hartelijk bedankt voor het deelnemen aan de enquête!

U kan de enquête sluiten.

Volgend scherm (indien JA)

Fijn dat u bereid bent mee te werken aan de interviews die ik voornemens ben om af te nemen. Ik zal spoedig contact met u opnemen.

Hartelijk bedankt voor het deelnemen aan de enquête!

U kan de enquête sluiten.

Appendix E – Results Kolmogorov-Smirnov Test (non-significant)

When testing the data (percentages found of the times CBA-statements are chosen) using a Kolmogorov-Smirnov test (non-significant), the null-hypothesis is not rejected. This indicates that the distribution of the responses (the data) is normally distributed. Visual inspection of both figure E.1 and figure E.2 conforms this.

Figure E.1: Plot of the cumulative probability density function for the responses on the first type of question in the questionnaire of chapter 6. Visual inspection conforms that the data is normally distributed.

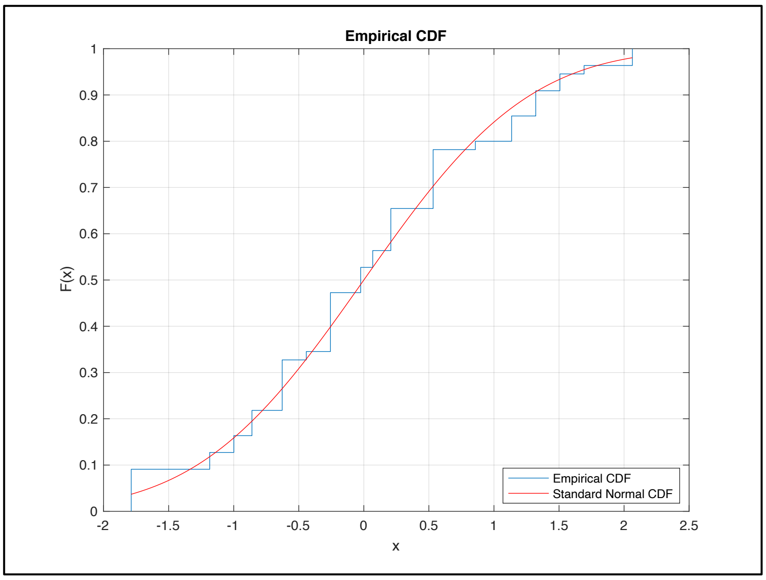
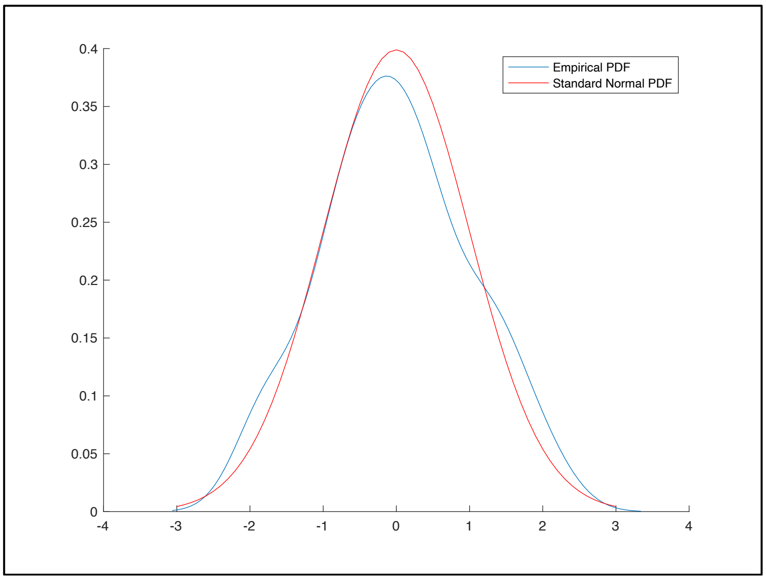


Figure E.2: Plot of the probability density function for the responses on the first type of question in the questionnaire of chapter 6. Visual inspection conforms that the data is normally distributed.



Appendix F – Designing the Smart Sport Exercises

Cognitive Based Approach – Novice

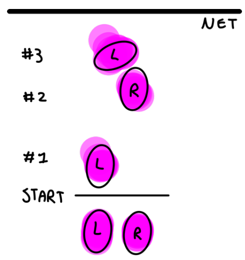
Goal:

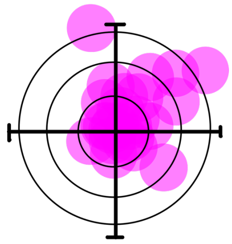
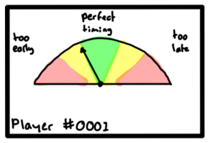
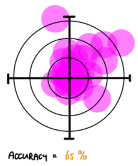
- Result of the exercise is learner who are performing an idealized form of the spike (Edwards, 2010, pp. 123 & 268) → Learner understands *how* to execute the movement
- Learner should grasp the basic idea of the movement (Edwards, 2010, p. 252)

Manners to achieve the goal:

- **Task decomposition**, practice components of the movement in isolation (Davids, Button, & Bennett, 2008, p. 167; Renshaw, Chow, Davids, & Hammond, 2010, p. 124)
- Split task into body functional units (Van Dijk, Van der Sluis, Bongers, 2017: Reductive and Emergent Views on Motor Learning in Rehabilitation Practice)
- Explicit Learning / internal focus of attention (manipulation of declarative knowledge in working memory) (Steenbergen, Van Der Kamp, Verneau, Jongbloed-Pereboom, & Masters, 2010, p. 1510) → Visual and verbal instructions, experts in the field showing the idealized movement

The exercise:

	What?	**Why**	**Usage digital floor**
1	Explain the goal of the exercise: learn how to spike	**Explicit learning**, state explicitly what is expected	
2	Show the execution of a perfect spike by a professional	Show the idealized state	Show video of the attacker spiking a ball
3	Explain the different steps of the spike executed by the professional (freeze frames e.g.)	**Explicit learning** and altering the declarative memory	Show frames of the attacker spiking a ball
4	Break the spike down in different movements and explain the idea of each of these movements. These movements are the ones executed by the learners in the following steps	**Task decomposition** to practice in isolation, split the task into body functional units → step 4-8	
4a	Practice the step sequence (for right-handed learner this is small left, big right, small left)	Learn step sequence in order to maximize the height when jumping	Project the steps on the floor. Measure how accurate the steps are taken. Give feedback about accuracy (Knowledge of Results, KR), how much cm the steps are 'off' 

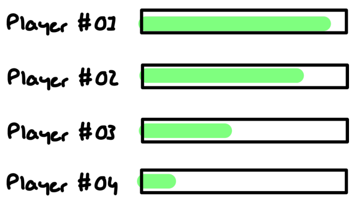
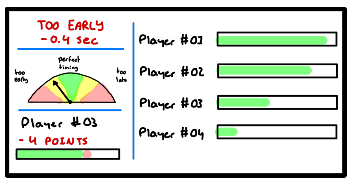
4c	Practice hitting the ball. Learner throws the ball and hits it aimed at a target on the floor. The ball bounces via the floor against the wall, back to the player. He catches the ball and start again.	Practice hitting the ball aimed at a target	Target are projected. Measure the accuracy of hitting the targets 
5	Combine all separate parts and perform a complete spike. The ball is tossed/shoot, and the learner should hit the ball by performing a complete spike. In order to increase the consistency of the set, a ball shooting machine could be used. Additionally, targets could be added on the opponents' field which the learner should hit.	Practice the combination of all separate parts of the spike.	Measure the timing of the learner and provide feedback in the form of a visual.  
	Additionally, a progression measure could be added which allows the learner to progress to the next step, only after his performance exceeds a certain threshold over the course of X tries. Step 4: average amount of max. X cm off, over 15 attempts Step 6: learner has to be within green area for 15 attempts Step 7: timing in green for 15 attempts, and an average amount of max. X cm off, over 15 attempts Step 8: average amount of max. X cm off, over 15 attempts Step 9: timing in green for 15 attempts, and an average amount of max. X cm off, over 15 attempts		Visual clues to tell the learner at which step he is, when to move on to the next step, how many attempts he made before moving to the next step. Also, his performance could be visualized compared which the performance of other players.

Cognitive Based Approach – Expert

Goal:
- *Goal: an idealized state (how? Is central)* (Edwards, 2010, pp. 123 & 268)
- Keep high motivation (Edwards, 2010, p. 260)
- The aim is to increase the generalizability of internal models/schemas (Schema theory Schmidt)

Manners to achieve the goal:
- Lots of repetition with concrete and concise feedback (Edwards, 2010, p. 387)
- Variability of practice principle (Edwards, 2010, p. 142)The aim is to increase the generalizability of internal models/schemas (Edwards, 2010, p. 142)

The exercise:

	What?	Why	Usage digital floor
1	Explain that the goal of the exercise is to improve the moment of hitting the ball when spiking	**Explicit learning**	
2	Introduce a game in which players of a team are battling to be in the game as long as possible. Explain the game (steps 4-7)	**Explicit learning**	Project the main rules on the floor
3a	Every player starts with a 'health bar' of a certain number of points. Points will be subtracted when the timing of a spike is off. When a player's 'health bar' reaches zero he is out of the game. The player that remains in the game longest wins.	Keep high motivation by starting a competition between the players	Project all players' health bars on the floor 
3b	The number of milli-seconds the attack is off, is the amount of points subtracted from the 'health-bar'. Feedback is given whether the hit was too early or too late.	Focus on a single part of the whole movement, **decouple** one part of the whole by explicit focus on this timing element.	Expanding the novice dashboard. Giving more details about the timing being off. Average could also be projected to get insight in the personal bias. 

Dynamical Systems Approach – Novice

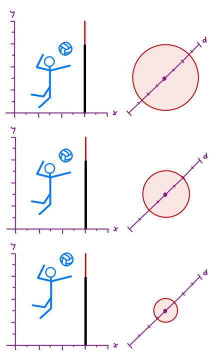
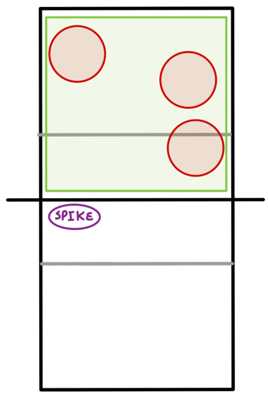
Goal:

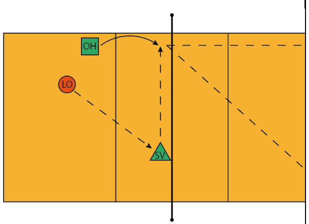
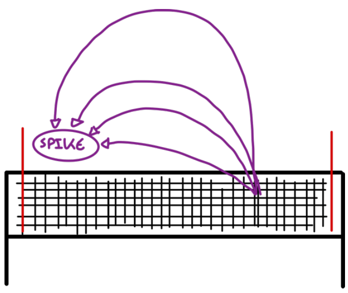
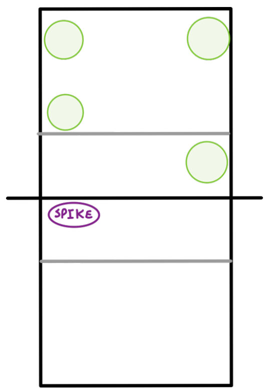
- Result of the exercise is that the learner has gone through the learning process (Edwards, 2010, p. 269) → he understands *why* to execute the movement
- Maintain the connection of information and movement intact throughout the whole exercise (Davids et al., 2008, p. 167; Renshaw et al., 2010, p. 124), the context should not be lost

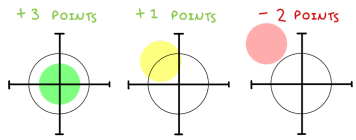
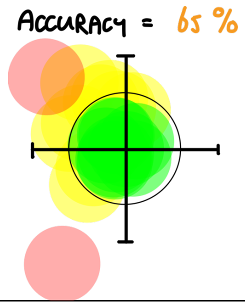
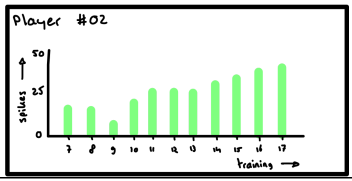
Manners to achieve the goal:

- A learner is an active seeker of information (Edwards, 2010, p. 268) → he should be provided with an incentive environment which holds learning opportunities
- Allow the learner to repeat the process of finding solutions for a motor problem (Bernstein, 1996, p. 205)
- Task simplification (Davids et al., 2008, p. 167; Renshaw et al., 2010, p. 124) by splitting the task into functional units (Van Dijk, Van der Sluis, Bongers, 2017: Reductive and Emergent Views on Motor Learning in Rehabilitation Practice) and by freezing degrees of freedom (Edwards, 2010, p. 146)
- Implicit Learning / external focus of attention (the acquisition of a new motor skill without a corresponding increase in verbal knowledge about the skill.) (Steenbergen et al., 2010, p. 1510) → show the learners a potential solution executed by someone who has a skill level which is achievable by the learners themselves

The exercise:

	What?	Why	Usage digital floor
1	Based on the acceleration of the learner, the size of the digital opponents varies. The smaller the acceleration, the smaller the opponents, the greater the area to score is.	The size of the virtual opponents is correlated to the acceleration of the learner. The smaller the acceleration, the closer the learner is to his highest point (where he should hit the ball), the smaller the projected opponents are, **environment-constraint**. This stimulates the learner to hit the ball at the highest point of his jump (where the acceleration is zero). 	Project opponents which must be avoided. The opponents' sizes are correlated to the acceleration of the learner. 

2a	Learner stands still on one position and has to toss the ball for himself, jump and hit the ball at its highest point. When hitting the ball, he must try to avoid virtual opponents on the opponents' field and hit the ball on open spots on the field.	**Simplification** of the task, yet, a strong connection to the complete movement of a spike is present. **Agent-constraint**	Display (virtual) opponents which must be avoided.
2b	Again, the learner stands still on one position. The ball is tossed by someone else and he has to jump and hit the ball at his highest point. Opponents must be avoided.	Again **simplification**, expanding the movement, and **agent-constraint**	Display (virtual) opponents which must be avoided.
2c	The learner starts a few meters behind the place where the ball gets tossed by a second person. So, he has to run towards the ball, jump and hit the ball at his highest point. Opponents must be avoided.	Expanding the movement, still **agent-constraint**	Display (virtual) opponents which must be avoided.
2d	Same as step 2c, now the ball is set instead of tossed.	Expanding the movement	Display (virtual) opponents which must be avoided.
3	Throughout step 2a-2d the learner can obtain points for hitting the ball with a good timing. Scoring on the opposing court gives an extra point, but most points can be earned by having a good timing.		Register proper timing and project points
3c	Player LO passes the ball to the setter, SV. SV then gives a set to OH, who spikes the ball. He has to aim for projected target-areas 	**Lots of repetition**. Yet, some **variability because** the sets differ a bit due to human error. Variability in sets increases the generalizability of internal schemas for spiking. 	Project targets/target-areas where the spiker has to aim for. This could result in additional points (health regeneration e.g.) 

3d	Hitting target areas results in ‘health regeneration’.	Next to training the timing, the proper timing can be used to improve accuracy (which is one of the benefits of a proper timing)	Hitting a target area regenerates health. The accuracy of the shots aimed at target areas is also measured and fed back.  
4	Show at the end of the game the results, and compare it with previous results	Make the progress explicit to maintain high motivation Goal is to achieve the most **ideal movement**, being closer to a perfect timing represents a better movement	Show stats of previous games and show for example the number of spikes one has made before he dropped out. Also show the average milli-seconds off. Make progress more insightful using the floor 

Dynamical Systems Approach – Expert

Goal:

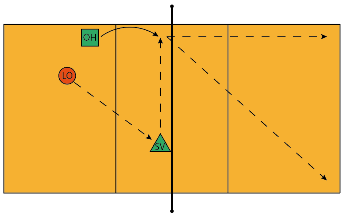
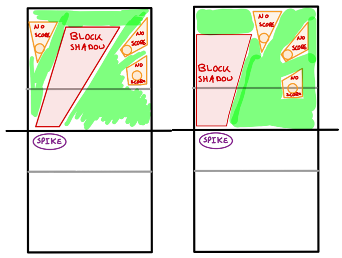
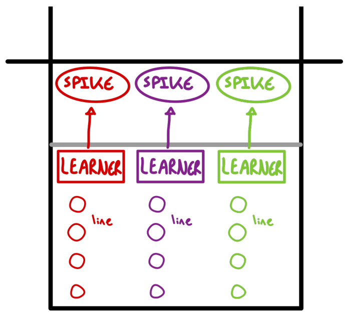
- To go through the learning process (Edwards, 2010, p. 269)
- Become more adaptive and increase movement effectiveness (Edwards, 2010, p. 266)
- Provide learners with opportunities for self-discovery of movement options (Edwards, 2010, p. 161)

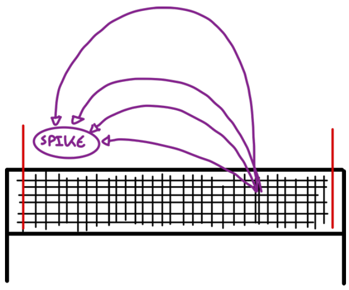
Manners to achieve the goal:

- Variability of practice, allows for exploitation and exploration in skill learning (Renshaw & Chow, 2018, p. 11)
- Repetition without repetition, by Bernstein (Renshaw & Chow, 2018)
- *"Bernstein, breaking with cognitive theorists, saw human movements as emerging from the interaction of many systems and subsystems, including both biological and environmental systems, which were both connected, interdependent, and adapting."* (Edwards, 2010, p. 150) → use environment to allow for movements to emerge
- The use of environmental constraints, task constraints, and organismic constraints (Edwards, 2010, pp. 152–153)
- Tasks should be fun and challenging to ensure active engagement of learners in the learning process (Edwards, 2010, p. 269)

The exercise:

	What?	**Why**	**Usage digital floor**
	Learners have to perform a spike in different variants. Points can be obtained by hitting targets and avoiding obstructions. The goal is to gain as much points as possible.	To **provide the learners with learning opportunities** and to make them more adaptive. By adding points, the exercise can be made more challenging and fun in order to make it more engaging and to motivate the learners to participate	Projection of obstructions to avoid.
	Every variation and/or combination is based on the following principles: 1. The learner starts at a certain position, the other players form a line behind him 2. Pass to the setter (at position 2/3, near the net), either this ball is tossed or played to the passer (resulting in variation of passes) 3. The setter gives a set 4. The learner spikes the ball 5. During his spike he has to avoid obstructions (e.g. team-players standing in	**Implicit learning** by presenting the learner with varying situations. Spike is treated as a **whole**, not highlighting separate parts of the complete movement	

	the way of the learner when spiking) 6. He also has to aim where he hits the ball on the opposing field 7. Points are assigned for avoiding obstructions and hitting targets 		
1	Learner has to hit the ball at the opposing field on locations where no virtual players are standing. Also, a virtual block can be added, which is displayed by projecting the area behind the block where the ball won't land when a block is formed.	The need to avoid players on the opposing field requires the player to observe the opposing field during his spike and decide how he need to hit in order to avoid the players. This makes him more adaptive	Project players and register whether or not the learner misses the projected players. Missing the players is good and results in points. Project 'block shadow', the no-hit zone. Different layouts of the opponents' field can be configured to create game-like scenarios. 
2	The starting position can differ based on the position where the attack is (outside-hitter, middle-blocker, or weekside-hitter)	**Variation** in starting-position to stimulate adapting to varying situations	Project starting point 
3	The ball played to the libero (located at position 6). A played ball results in a more variable pass. The pass is directed towards the setter		

4	The setter gives a set. Due to the variability in passes the quality of the set will be variable.  	Variation in quality of sets to stimulate adapting to varying situations	
5	The learner spikes the ball. He either can make his step-sequence without obstruction, or he has to run around projected obstructions (representing team-mates standing in the way e.g.)	Variation in step-sequence to stimulate adapting to varying situations	Projection of obstructions on the field which must be avoided by the learner. Crashing into obstructions results in more challenging situations.