MASTER THESIS

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Variability versus specificity of practice in training basketball putting

Date: 15.05.2017 Total number of pages: 43

NORD University

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ABSTRACT

Veronika Myran Wee: Variability versus specificity of practice in training basketball putting

Master thesis in physical education and sport science. Nord University, 15.05.2017

Purpose: The aim of this experiment was to examine the effect of variable versus specific practice in basketball set shot training upon transfer and retention performance. **Methods:** 36 subjects with limited previous basketball experience were randomly assigned to two experimental groups and one control group. During a three-week training period, the variable practice group trained from four different shooting positions, while the specific practice group trained from one specific shooting position. The relationship of the subject to the target was varied between shooting positions in terms of angle size. To adjust for attention, the control group conducted the same amount of practice on a different task; football penalties. A post-test was conducted right after the end of the training period, and a retention-test four weeks after.

Results: No significant group difference was found in pre-test performance. Both the variable and specific practice group increased performance significantly from pre-test to post-test, with no significant difference found between group. However, only the specific practice group maintained this performance on the retention-test, whereas performance for the variable practice group decreased significantly from post-test to retention-test. Control group showed no significant differences between tests.

Conclusion: The hypothesis that variable practice would facilitate transfer to novel responses on a post-test to a larger extent than the specific practice was not supported, as the variable and the specific practice group experienced transfer to the same extend on the post-test. Nor the hypothesis that the variable practice group would perform better on retention-test compared to the specific practice group was supported. This is however not to say that variable practice is not suitable for learning, as different results might have been found if the training period was extended.

Key words: Variability of practice, specificity, transfer, motor learning, basketball

SAMMENDRAG

Veronika Myran Wee: Variabel versus spesifikk praksis i trening av basketball putting. Masteroppgave i Kroppsøving og idrettsvitenskap. Nord Universitet, 15.05.2017

Hensikt: Hensikten med dette eksperimentet var å undersøke effekten variabel versus spesifikk praksis under trening av grunnskudd i basketball har for transfer- og retention-prestasjon.

Metode: 36 forsøkspersoner med begrenset basketball erfaring ble tilfeldig fordelt i to eksperimentelle grupper og en kontrollgruppe. Under en tre uker lang treningsperiode trente variabel praksis-gruppa fra fire ulike skuddposisjoner, mens den spesifikke praksis-gruppa trente fra én spesifikk skuddposisjon. Skuddposisjonene var ulike på bakgrunn av forskjellig vinkel mot basketkurva. En post-test ble gjennomført like etter fullført treningsperiode, og deretter en påfølgende retention-test fire uker etterpå.

Resultater: Det ble ikke funnet signifikante forskjeller i pre-test prestasjon mellom gruppene. Både variabel og spesifikk praksisgruppe hadde en signifikant økning i prestasjon fra pre-test til post-test. Kun den spesifikke praksisgruppa vedlikeholdt denne prestasjonen på retention-testen, mens den variable praksisgruppa hadde en signifikant nedgang i prestasjon fra post-test til retention-test. Ingen signifikante forskjeller mellom tester ble funnet for kontrollgruppa.

Konklusjon: Hypotesen om at variabel praksis ville føre til større grad av transfer til post-test sammenlignet med spesifikk praksis ble ikke støttet, siden den variable og spesifikke praksisgruppa oppnådde transfer i like stor grad på post-testen. Heller ikke hypotesen om at den variable praksisgruppa ville prestere bedre på retention-test sammenligned med den spesifikke praksisgruppa ble støttet. Det er imidlertid viktig å påpeke at disse resultatene ikke indikerer at variabel praksis ikke er passende å benytte i læring av ferdigheter, siden ulike resultater kanskje hadde blitt oppnådd dersom treningsperioden hadde lengre varighet.

Nøkkelord: Variabilitet i læring, spesifisitet, transfer, motorisk læring, basketball

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Introduction

Transfer of learning appears whenever antecedent experience influences acquisition, relearning or performance of new experience (McGeoch & Irion, 1953). As a learning phenomenon, transfer has widespread significance in a variety of different fields, e.g. education, motor learning, rehabilitation, and sport specific learning (Magill, 2001). In sports, transfer is seen as the effect, positive, negative or neutral, previous experience has upon learning a new skill or performing a skill in a new context (Magill, 2001). An athlete has a limited number of hours available for practicing and improving their sport performance. This calls for a tough prioritising of what training to engage in, as it is of great importance that the training conducted is effective and suitable, providing the greatest amount of positive transfer to the athlete's future competitive performance. The question of transfer of skills is however a complex one.

Historically, a major challenge in transfer research has been to evaluate precisely what features in the task conditions of the training and transfer situations are responsible for the experienced transfer (Speelman & Kirsner, 1997). Various different theoretical approaches have been proposed in order to explain what is transferred from the training situation that either facilitate or infer performance in the transfer situation. Transfer of training has traditionally been both executed and examined with an underlying faith in common factors. The big question in this regard is: What is the nature of these common factors? Is the communality a question of kinematic building blocks, is it a common neural area that is activated, or is it common neural patterns? For the last centenary several theoreticians have proposed explanations of the nature of these common factors.

Cognitive theories of traditional motor control describe learning processes based on the formation of representations, schemas and generalised motor programmes (Estil & Ingvaldsen, 1995). Richard Schmidt's *Schema Theory* (1975; 1976) is a modern version of this, and has given considerable impact on the understanding of motor behaviour. The foundation of the schema theory is that motor control and learning occur on the basis of general motor programs or motor response schemes. A generalized motor program stores the invariant features[1] that control the production of a movement (Schmidt, 1975; 2003), e.g. overarm throwing, while a motor response schema is responsible for providing parameters,

[1] Invariant features is defined as the common but unique set of features present in the set of different actions which represents a particular class of actions (Magill, 2001)

i.e. skill specific features, to the generalized motor programs (Magill, 2001). Parameters are applied to specify how a particular movement pattern is to be expressed, e.g. in relation to overall duration of the movement, the force needed to accomplish the movement, which muscles to use and in what order (Rose & Christina, 1997; Magill, 2001). In regards to transfer of skills, the parameters found in a general motor program can be applied to a skill of movement for different effectors[2] or skills of movement found in the same class of movement or response[3] (Rose & Christina, 1997). Thus, an athlete can perform a previously inexperienced skill successfully by applying the motor response schema rules generating appropriate parameter characteristics to the general motor programme for that skill. After the proposal of the Schema theory, several studies have found support for the theory in transfer experiments (Newell & Shapitro, 1976; Kerr, 1977; Kerr & Booth, 1977; Landin, Herbert & Fairweather, 1993). However, other studies have reported no support for Schema theory (Reeve, 1977; Zelaznik, 1977; Johnson & McCabe, 1982).

Schmidt's approach to the transfer question is based on an idea of transfer as some sort of general competence that can be applied in a variety of circumstances and contexts. Other theories utilize a more specific explanation of transfer. Edward Thorndike was one of the first to experimentally study transfer, and his theory of identical elements was the first prominent behavioural theory of transfer (Oxendine, 1984). The Identical Elements Theory was further developed and labelled a stimuli-response (S-R) theory, arguing that transfer of skills is determined by the level of similarity in the stimuli (S, i.e. perceptual aspects, context characteristics) and/or in the response (R, i.e. the motor execution), or in the connection between S and R (i.e. the association) between training and performance tasks or contexts (Holding, 1976). Thus, Thorndike's "elements" embraces a variety of components, as it can refer to general characteristics of both the skill and the performance context where the particular skill is executed. For the stimulus dimension, examples of these general characteristics might be the shape or speed of an object which guides the response action, and for the response dimensions, the kinematic features of a movement (Holding, 1976). Thus, within the Identical elements perspective, transfer is perceived as relatively specific, as the more similarities found between the initial task and the transfer task or the two contexts in

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[2] An effector is defined as a component unit of the motor system that is involved in performing a movement. An effector is thus a muscle-joint system (Vangheluwe, Puttemans, Wenderoth, Van Baelen & Swinnen, 2004)

[3] A class of movements or responses is defined as a set of goal-directed actions that share similar underlying characteristics (Schmidt, 1975)

terms of stimuli, responses or stimulus-response pairs, the more transfer will be experienced (Oxendine, 1984; Holding, 1976). After the proposal of the Identical elements theory, several studies have found support for the theory (Seefeldt, 1979; Rose and Heath, 1990; O'Keeffe, Harrison, Smyth, 2007; Kovacs, Sztruhar Jonasne, Karoczi, Korpos & Gondos, 2013). However, some studies detected no transfer, but rather found skills or variations of skills to be highly specific (Oxendine, 1967; Giboin, Gruber & Kramer, 2015)

In line with the thoughts of Thorndike are those of Burrhus Skinner and his *Theory of Operant Conditioning*. In Skinner's theory (1965), behaviour is viewed as a class of actions or responses, called an *operant,* with *behavioural atoms* being the building blocks of behaviour. The theory of operant conditioning is an S-R-S theory where the connection between elements in stimuli, responses and reinforced stimuli, i.e. the operant, is formed through what Skinner refers to as "contingencies of reinforcement", i.e. shaping of behaviour and behavioural preferences based on the individual's history of reinforcement. Common elements in the perception of the situation, S, the action itself, R, and the reinforced consequences of action that reciprocate on the individual, S, make it possible for an operant (i.e. an action) to be generalised in different ways. In regards to the action itself (R), Skinner refers to these "elements" as common behavioural atoms, which in the training and transfer task response must have similarities in order to achieve transfer. Transfer of learning can be achieved through varying levels of similarity, as a response can be evoked by a stimulus sharing some of the properties (elements) of the stimulus which the response normally is appropriate to. Thus, only a single identical property of a stimulus can be effective in the meeting of a new stimulus (Skinner, 1965).

The traditional explanation of transfer emphasises that the strengthening of the transfer response occurs only insofar as the training response and transfer response "possess identical elements". According to Skinner (1965), to say that the elements are strengthened wherever they occur is a more useful approach as it identifies the element rather than the response as the unit of behaviour. Here Skinner differs from Schmidt in that the focus is not on any underlying mental entities, but on the performance itself and the constraints which bring it about (Ingvaldsen & Whiting, 1997).

From a Dynamic System Approach (DSA) on motor control, the interaction between the athlete and the context is essential. Actions appear due to a complex, self-organising system where physical, biological and psychological facilitating or limiting factors are included

(Tetzchner, 2001). Learning is influenced by an interaction between properties within the athlete and the environment or context, but what is common lay within the movements. Contrary to the Schema theory, where behaviour is based on the intention of the movement, the DSA view seeks to see the pattern in the behaviour itself, described as behavioural information by Kelso (1981).

Turvey (1990), amongst others, has suggested the nature of the patterns of behaviour. He implies that humans are organised on the basis of the natural laws as proposed in the hierarchical structure called the *Farey tree* (Treffner & Turvey, 1993; appendix 2). Farey's tree comprises branches of rational ratios (e.g. 1/1, 1/3, 2/5), which, mathematically speaking, belong to each other. These rational ratios are ultimately thought of by Turvey as a kind of "omnipotent natural patterns" basic to nature. They are therefore also important for understanding all kinds of self-organised patterns, not at least human motor actions. This is readily observed in movements, referred to as oscillators (Schmidt, Beek, Treffner & Turvey, 1991). Coordination and the coordination dynamics in movements are determined by the relations between these oscillators. These self-organised coordination dynamics, with the basis in rational ratios, are effector independent, meaning that coordination dynamics is learned regardless of the specific effectors involved in the training (Bardy, 2004; Fauglorie, Bardy, Merchi & Stoffregen, 2005; Kelso & Zanone, 2002). Different actions can in this way hold similar patterns of movement, i.e. through similar rational ratios, which therefore also will function as a basis for transfer. And as Levitov (1991) points out, unimodular shifts[4] (i.e. 1/2) may provide a means of accessing states of dynamical optimality.

Through the experience one has on the rational ratio 1/3, one can achieve transfer on other tasks with the same rational ratio. For instance, one can learn a 1/3 rhythm in the basketball lay-up, and this particular effector-independent 1/3 rhythm can be transferred to other skills, e.g. to a leap in a football heading. Additionally, in the Farey tree, the branches divide further, with 1/3 dividing into 1/4 and 2/5 ratios. A potential thought is thus that experience on 1/3 facilitates transfer to 1/4 or 2/5 to a larger extent compared to the 3/5 ratio, which is located

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[4] Unimodularity refers to the strong relation between any two adjacent ratios. In relation to the Farey tree, 2/3 and 1/2 are unimodular ratios (|2*2 – 3*1|=1), whereas 2/3 and 4/5 are non-unimodular (|2*5 – 4*3|l=2) (Treffner & Turvey, 1993). Experiments with physical dynamical systems indicate that bifurcations follow a route satisfying unimodular relations rather than a more arbitrary sequence of shifts (Maselko & Swinney, 1985)

on a different branch. The experience one has on 1/3 can in this way be extrapolated further down the branches, to other tasks with different ratios, in this case 1/4 and 2/5.

Extrapolation and interpolation between training and performance can be viewed as two different types of generalisation, and thus transfer, of training experience. Considering Schmidt's schema theory of motor learning, extrapolating and interpolating is two different ways of picturing how the formation of a scheme can take place. As abovementioned, extrapolation as a transfer phenomenon can also be explained by the Farey tree. If athletes need to perform something that they have little or no former experience with, they must extrapolate relative to the experience basis they already have. For instance, if their training has been conducted with relatively low variability, the athletes have to perform outside this one area of acquired experience. Interpolating is necessary if the variability of the training conducted leads to the athletes having several smaller areas of experience surrounding the performance task. As when extrapolating, the performance task is outside the athletes' experience basis also when interpolating, but with this kind of variability of practice they must interpolate between the surrounding areas of experience in order to perform the task. If athletes extrapolating relative to their experience basis perform better on a test than athletes that need to interpolate in order to conduct the task, this will be an argument for very specific training. However, if interpolating between several smaller areas of experience yields the best results, this advocate for a lot more variability in training.

Variation is considered one of the key factors in order to achieve learning of motor skills. This is highlighted by the status of variation as an explicit training principle. An important question is what amount of variability in training provides the most positive transfer from training to performance? Since the proposal of the schema theory of motor learning (Schmidt, 1975; 1976), researchers have shown interest in its variability of practice hypothesis. This hypothesis states that increased practice variability will enhance transfer of learning between variations of skills that is governed by the same motor program (Ingvaldsen & Whiting, 1997). Thus, practicing many variations of a skill will lead to a more effective performance of novel versions of that particular skill, and thus enhance transfer. This is justified by practice variability leading to an optimal schema development and better defined parameters (Estil & Ingvaldsen, 1995), something a repetitive practice of the specific skill would not.

A significant amount of research has been conducted with the purpose of testing the variability of practice hypothesis. Many studies are conducted with one group of subjects practicing a single form of a task and another group practicing several variations. In a subsequent transfer-post-test, performance between groups is tested with subjects conducting a novel variation of the task not previously practiced. Results from some initial investigations using fine, laboratory tasks supported the variability of practice hypothesis (McCracken & Stelmach, 1977; Newell & Shapiro, 1976; Wrisberg & Ragsdale, 1979; Catalano & Kleiner, 1984; Lee, Magill & Weeks, 1985), while others did not find variability of practice to enhance transfer (Zelaznik, 1977; Johnson & McCabe, 1982). More sport specific experiments using throwing tasks have mainly yielded support for the variability of practice hypothesis when varying weight of the object being thrown (Carson & Wiegand, 1979), distance to target (Kerr & Booth, 1978; Landin, Herbert & Fairweather, 1993) and target angle (Moxley, 1979). However, Memmert (2006) did not find any transfer effect for basketball shooting in the variable practice group when varying distance to target.

Moxley (1979) tested the variability of practice hypothesis by having subjects conduct a throwing task from either four locations (high-variability group) or one location (low-variability group). The distance to the target was the same for all locations, as well as the distance between each location. In the first experiment, subjects were allowed to reorient themselves to face the target from each location. Since the target was a circle on the floor, the angle between the target and the subject was thus the same for all locations. In the second experiment, however, the line of direction of the subjects was constant for each location, i.e. reorientation was not allowed. This led to dissimilar angles between the target and the subject for the different locations. The first experiment produced no difference between the high- and low-variability groups, as the conditions were essentially the same for all locations, and no varying of the actual response was thus necessary. The second experiment found that practice from a variety of locations facilitated performance on a novel location compared to practice from one specific location. This is explained by the altered relationship of the subject to the target for the different locations, inducing the need to vary the response between the different locations (Moxley, 1979).

Schmidt's Schema theory and the related variability of practice hypothesis do not directly predict what impact variable practice will have upon retention results. Thus, experiments testing the variability of practice hypothesis, typically test transfer but not retention performance (Shea & Kohl, 1990; Memmert, 2006). Indirectly, Schmidt (1975) suggests that all practice within the same class of movement or response enhances retention. Some experiments have found support for this view in throwing tasks (Carson & Wiegand, 1979) and basketball shooting (e.g. Landin, Herbert and Fairweather, 1993), but this kind of research is limited.

To further examine the impact variable practice has upon learning, as done by Carson and Wiegand (1979) and Landin, Herbert and Fairweather, would thus be relevant. Additionally, examining two different kinds of generalisation; extrapolation and interpolation, in relation to the variability of practice hypothesis, would also be of interest.

The purpose of this experiment was to evaluate the effect of variable versus specific practice in basketball set shot training upon transfer and retention performance. It was hypothesised that variable practice more than specific practice would facilitate transfer to generation and execution of novel responses on a post-test. In regards to learning, the hypothesis was that the variable practice group would perform better on the retention-test due to a more optimally developed schema and better defined parameter.

Methods

Experimental approach to the research question

To compare the effect of two different training protocols; specific practice and variable practice upon basketball shooting performance, a pre-test post-test control group design was used. The independent variables were type of training regime (specific, variable and control group), and the dependent variable was shooting performance.

Subjects

36 subjects were recruited to participate in the present study. The group of subjects consisted of 15 females and 21 males. All subjects reported being right handed and had limited previous basketball experience (no organized basketball background). Moxley (1979), amongst others, highlights that, for some of the tasks and subjects used in earlier experiments testing the variability of practice hypothesis, the schema has probably already been well developed, hence finding no support for the hypothesis. Thus, for this experiment, novice athletes without previous experience in basketball were chosen to participate. After the pretest, three and three subjects were matched and then randomly assigned into two experimental groups (specific practice group and variable practice group), and one control group. Subjects were matched based on their gender, height, and pretest score, ensuring an even distribution across groups. Each group consisted of 5 female and 7 male subjects, giving a total of 12 subjects in each of the three groups.

Table 1. Subject characteristics

	Specific practice (N=12)	**Variable practice** (N=12)	**Control group** (N=12)
Age (years)	20.8±1.3	21.1±3.7	20.1±2.1
Body height (cm)	176.8±9.6	175.5±9.6	177.2±9.2
Body mass (kg)	76.0±7.3	70.4±8.2	69.7±8.2
Pretest score	1.9±0.6	1.8±0.5	2.0±0.5

Notes: Data is presented in mean±SD (Standard deviation).

The study was conducted in accordance with the principles outlined in the Declaration of Helsinki and the Declaration of Toronto. Before signing a written consent form to participate, subjects were informed of experimental procedures and the fact that they could at any time withdraw from the study without giving any reasons and without facing any consequences (appendix 1).

Apparatus

Subjects used a standard basketball, size 7 for men and size 6 for females. The basket used had standard dimensions according to the International Basketball Federation (FIBA, 2010). The backboard measured 180 cm horizontally and 105 cm vertically. The basket ring had an inside diameter of 45 cm, with the top of the ring being located 305 cm above the ground. The specific shooting positions during tests and training were marked with tape on the floor. In front of the tape was a printed sheet with the name of the spot (A, B, C, D, E, 1, 2, 3 or 4) to guide the subject to the designated spot when the experimenter was calling out the next shooting point (figure 1).

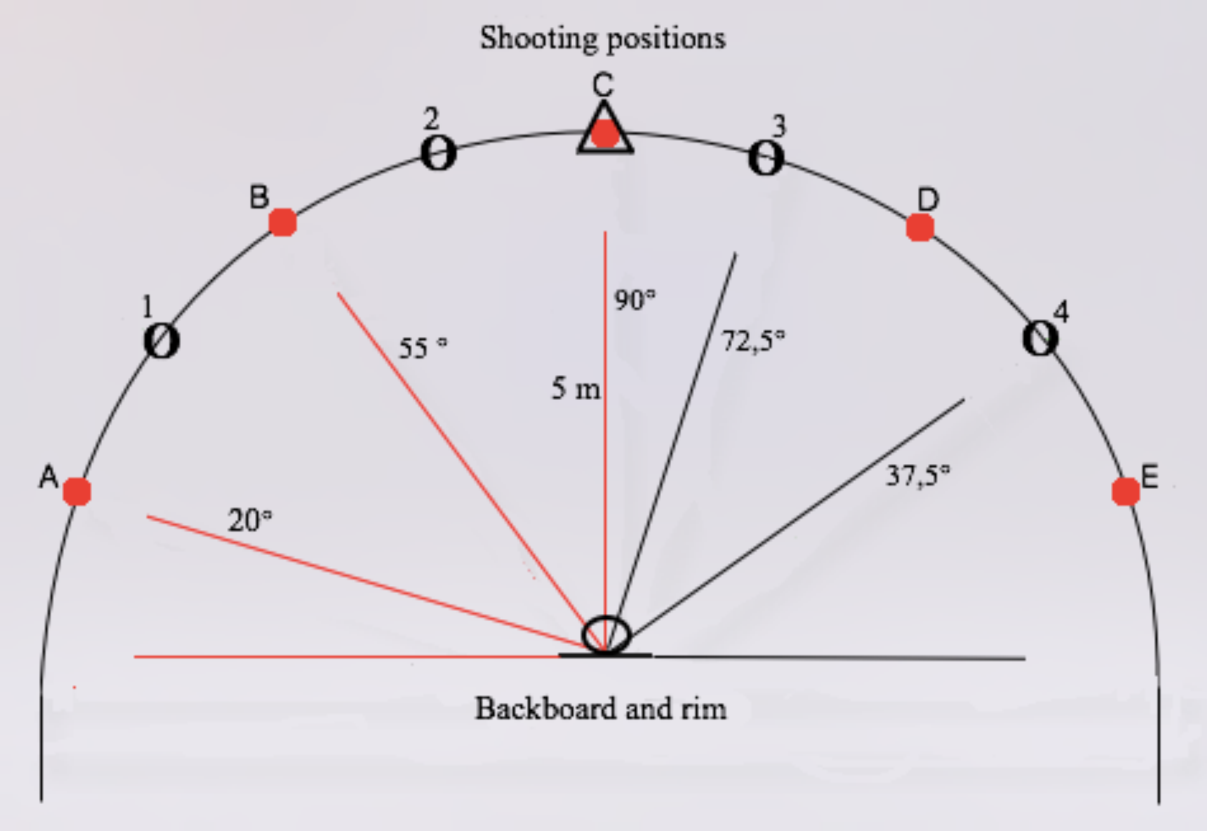

Figure 1. Experimental set-up. The red dots A, B, C, D and E show the positions of shooting at the pre-, post- and retention-tests. The training positions for the specific practice group were at the black triangle in front of the basket (position C), and the training positions for the variable practice group were at the black circles 1, 2, 3 and 4. All shooting positions were located 5 m from the backboard, and the respective angles between the shooting position and the basket shown in this figure.

A Sony video camera (HDR-CX240E Handycam®, Sony Inc., Tokyo, Japan) was used to record each test and training session. The Sony camera was zooming in on the basketball backboard and ring in order to catch the outcome of each shot. Using the videotapes from one of the subjects, two other researchers would independently score all shots from the filmed pre-, post- and retention-tests based on the scoring system for this experiment. A Spearman's rank-order correlation was run to test the inter-rater reliability, yielding a strong, positive correlation between the experimenter and the first external researcher (r_s=0.971, n=150, p=0.000), and between the experimenter and the second external researcher (r_s=0.951, n= 150, p=0.000).

Scoring system

The scoring system used was adapted from a scoring system developed earlier by Wallace and Hagler (1979), and adjusted to fit the present research question. Wallace and Hagler's (1979) scoring system, including similar systems, have been reliable in previous basketball shooting studies (e.g. Keetch, Schmidt, Lee & Young, 2005; Hardy & Parfitt, 1991). For this experiment, the scoring system was a measure of how close the ball came to swishing trough the basket after hitting the backboard first (table 2). Hitting the backboard first was crucial in regards to the present research question, as it would lead to dissimilar perceptual features for the different shooting positions (figure 1), whereas straight hits towards the basket would not. All variations of the task had dissimilar angles towards the backboard and basket, increasing variability of practice for the training group conducting shots from distributed positions (variable practice group).

Subjects were familiar with the nature of the scoring system. The outcome of all shots was registered in a scheme (see appendix 2) during all tests and training sessions.

Table 2. Scoring system (partly modified after Wallace and Hagler, 1979)

Score	Description
0	Ball misses backboard or rim completely
1	Ball hits backboard only or rim only and bounces away from the basket OR ball hits rim first and then backboard* OR ball passes cleanly through the basket without touching the rim without hitting backboard first
2	Ball hits backboard first, then outside of the rim and bounces away from the basket
3	Ball hits backboard first, then top of the rim - would fall in or out of the basket
4	Ball hits backboard first, then inside of the rim and - would most often fall through the basket, but sometimes rolls out
5	Ball hits backboard first and passes cleanly through the basket without touching the rim

*A ball hitting the rim first and then the backboard was given a score of 1, regardless of the ball hitting the rim again or not

Shooting technique

The chosen type of shot for this experiment was the set shot. Prior to the pre-test, subjects watched a videotape with five slow motion demonstrations of a traditional set shot from both anterior and lateral view. Subjects were not able to see the outcome of the shot, as only the shooting motion was shown on the tape. The model was a female expert basketball player and subjects were encouraged to mimic the model's movement pattern. During the video demonstrations the experimenter gave the following instructions of key elements of movement:

- Preparation phase: Feet shoulder width apart, knees bent, elbow bent to 90 degrees.
- Shooting phase: Extend knees, raise arm keeping elbow at 90 degrees, extend elbow as extending knees, flick wrist when releasing the ball, feet go into plantar flexion.

The following principles were mandatory in order to conduct a valid shot:

- Shoot the ball with their dominant hand using the non-dominant hand as support (i.e. not allowed to use both hands equally in performing the shot).
- Feet need to be in contact with the floor (in order to control for potential differences in jump height), plantar flexion allowed.

Following these instructions, subjects were given five shots to standardize the valid shooting technique. During standardization shots, corrections were given if the technique was not in line with the valid principles. During the training sessions and tests, if the subjects did not follow the standardized shooting technique, e.g. performed a jump shot instead of a set shot or conducted the shot with equal force from both hand, another shot had to be conducted and the results from the wrongly performed shot was not registered. All shots were conducted with the subjects being stationary, i.e. run-ups were not allowed.

Procedure

Initially, the height (KaWe PERSON-CHECH® height measuring device) and body weight (Soehnle Professional 7730) of each subject were measured. Subjects were instructed to wear clothing allowing them to move freely during the tests and training sessions. The experimenter was present during each test and training session and provided verbal commands about the subsequent shooting position after each conducted shot. No additional verbal or other feedback was given.

Test protocol involved a pre-test, a 3-week training period, a post-test and a retention-test. Pre-test was conducted two days before the start of the training period, and the post-test maximum three days after the end of the training period. The retention test was conducted four weeks after the post-test. An experimental session lasted for approximately 30 minutes with two subjects being tested together. Test partner varied for each test or session.

Prior to each test and training session subjects were given a one-minute warm-up to familiarize themselves with the ball (weight, shape and surface) and tune into the testing situation. During this period no shots towards the basket were allowed, but subjects could throw the ball towards a wall, up in the air, or bounce it. After warm-up the first subject shot his/her first block of ten shots, followed by first block of ten shots from the second subject. This order was repeated until all blocks were completed for both subjects. In order to avoid observational learning[5] the non-shooting subject was not allowed to view the other subject executing his/her shots.

Pre-test, post-test and retention-test

Procedure was similar for pre-, post- and retention-test, and all three groups conducted the same three tests. Each test involved five blocks with ten shots in each block, giving a total of 50 shots per test and 150 shots per subject in the test period altogether. Shots were conducted from five different shooting positions (A, B, C, D and E, figure 1). Subjects shot ten shots from each of the five positions in a random order (for an example, see Appendix 2).

Training period

The training period consisted of two training sessions per week for three weeks. Each session consisted of six blocks with ten shots in each block, giving a total of 60 shots per session and 360 shots per subject in the training period altogether. Combined with shots from all three tests subjects shot 510 shots combined.

Specific practice group performed shots from one specific position perpendicular to the backboard (position C, figure 1). Variable practice group performed fifteen shots from each of the four positions 1, 2, 3 and 4 distributed across the line. The order of shots from the four positions was randomized for each of the six blocks (for an example, see Appendix 2). Shooting angle for these positions were 37,5° for position 1 and 4 and 72,5° for position 2 and 3 (figure 1).

Control group was conducting football penalties on a 2mx5m football goal at a 7-meter distance. Their procedure involved the same number of sessions, blocks and shots as the two experimental groups.

The curve of all shooting positions was following the standard 3-point line (6m from the basket), but results from a pilot study indicated that the line should be abridged 1 meter. The distance to the basket was thus 5 meters for all shooting positions (figure 1). The shooting positions was moved closer so that all subjects had a chance of making contact with the

[5] Observational learning (or modelling) is defined as learning that occurs through observing the behaviour of others (Bandura 1963; 1977)

basket on their first test, but no further than 1 meter in order to avoid making the task too easy for some of the subjects.

Statistical analysis

Statistical analysis was performed using SPSS (version 23.0; SPSS, Inc., Chicago, IL). Aggregated results (mean and standard deviation) were compiled and used to analyze differences within and between groups. Differences in performance between tests within each group individually were examined using a Friedman Test, and between groups using a Kruskal Wallis H test. Post hoc analysis with Dunn-Bonferroni correction of *p*-values was applied for all multiple comparisons. Statistical significance was accepted at $p \leq 0.05$.

Results

The first section of this chapter presents performance results within the specific practice group, variable practice group and control group separately. In the second section, comparisons of performance between the three groups are presented. All subjects completed the study as planned.

Variable practice group

Mean results from pre-test, post-test and retention-test are shown in table 4. Performance increase or decrease between tests for the five different shooting positions are shown and illustrated in the middle part of figure 2. Friedman test demonstrated a significant difference in overall performance between pre-test, post-test and retention-test (p=0.000). Post hoc comparisons showed a significant increase in performance from pre-test to post-test (difference: +0.48, p=0.000), with a subsequent significant decrease in performance from post-test to retention-test (difference: -0.28, p=0.008). No significant difference between pre-test and retention-test was found (difference: +0.20, p=0.653).

Table 4. Mean pre-test, post-test and retention-test results for overall performance and for all five shooting positions for variable practice group

	Pre-test	**Post-test**	**Retention-test**
Overall (N=60)	1.90±0.70	2.38±0.64	2.10±0.62
Position A (N=12)	1.81±0.52	2.23±0.59	2.08±0.75
Position B (N=12)	2.10±0.72	2.44±0.63	2.28±0.63
Position C (N=12)	1.99±0.90	2.53±0.64	2.08±0.48
Position D (N=12)	1.88±0.63	2.51±0.67	2.17±0.57
Position E (N=12)	1.73±0.72	2.18±0.71	1.92±0.67

Notes: Data is presented in mean±SD (Standard deviation). N=60 [5 positions x 12 subjects], N=12 [1 position x 12 subjects].

In regards to performance on each of the five different shooting positions, a significant difference between tests was found for position C (p=0.044), D (p=0.024) and E (p=0.038), whereas no significant difference between tests was found for position A (p=0.241) or B (p=0.534). For position C, performance increased significantly from pre-test to post-test (p=0.048; difference: +0.54), before significantly decreasing from post-test to retention-test (p=0.048, difference: -0.45). For position D, pre-test performance was significantly higher compared to post-test performance (difference: +0.63; p=0.032). Rank values for Friedman test comparisons between pre-test, post-test and retention-test are shown in table 6 and 7.

Specific practice group

Mean results from pre-test, post-test and retention-test are shown in table 3. Performance increase or decrease between tests for the five different shooting positions are shown and illustrated in the upper part of figure 2. A Friedman test demonstrated a significant difference in overall performance between pre-test, post-test and retention-test (p=0.000). Post hoc comparisons showed a significant increase in performance from pre-test to post-test (difference: +0.50, p=0.000), whereas no significant difference in performance between post-test and retention-test was found (difference: -0.01, p=1.000). Retention-test performance was however significantly higher compared to pre-test performance (difference: +0.49, p=0.000).

Table 3. Mean pre-test, post-test and retention-test results for overall performance and for all five shooting positions for specific practice group

	Pre-test	**Post-test**	**Retention-test**
Overall (N=60)	1.83±0.64	2.38±0.65	2.37±0.54
Position A (N=12)	1.59±0.51	2.15±0.55	2.16±0.44
Position B (N=12)	2.05±0.63	2.54±0.71	2.50±0.52
Position C (N=12)	2.00±0.55	2.85±0.63	2.66±0.51
Position D (N=12)	1.88±0.66	2.21±0.64	2.40±0.45
Position E (N=12)	1.62±0.77	2.16±0.51	2.14±0.64

Notes: Data is presented in mean±SD (Standard deviation). N=60 [5 positions x 12 subjects]), N=12 [1 position x 12 subjects]

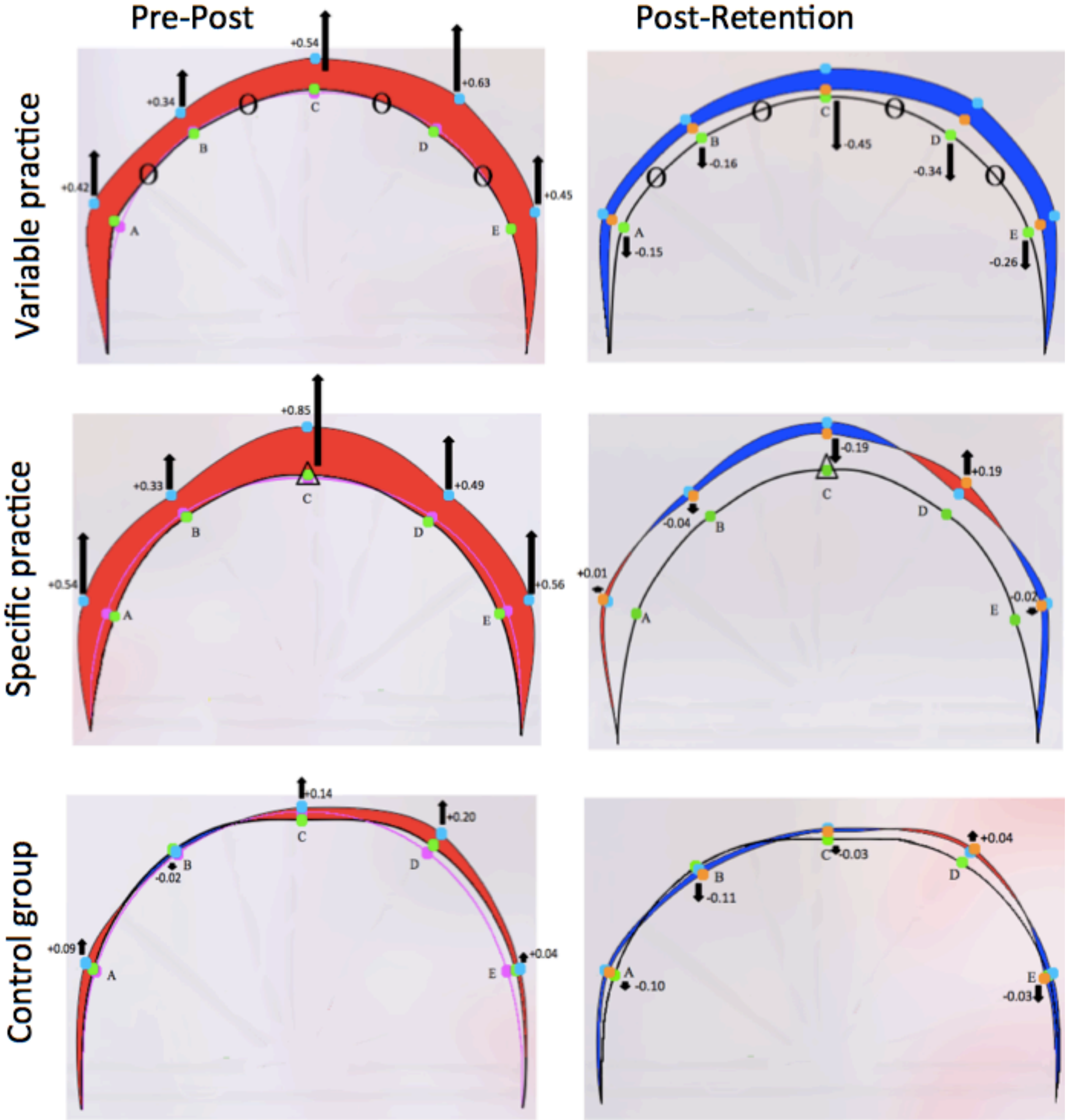

Figure 2. Illustrates results from pre-test to post-test (left panel) and post-test to retention-test (right panel) for specific practice group (top figures), variable practice group (middle figures) and control group (bottom figures). Red colour indicates an increase in performance compared to the result from the previous test. Blue colour indicates a decrease in performance compared to the previous test. The deviation is illustrated by the size of the red/blue area and the size and direction of the arrows affiliated to each shooting point. Additionally, the actual deviation size is shown in numbers next to each arrow. The bold black curve with green dots represents the pre-test result for the present group, and is shown in all figures.

Left figures: The pink curve with pink dots represents mean pre-test results for all three groups combined

O = Represents the shooting positions for the variable practice group during the training period

Δ = Represents the shooting position for the specific practice group during the training period

= Pre-test score **= Post-test score** **= Retention-test score**

In regards to performance on each of the five different shooting positions, no significant difference between tests was found for position B (p=0.266). A significant difference between tests was found for position A (p=0.015), C (p=0.004) and D (p=0.044) and E (p=0.028). For position C, post hoc comparisons showed that both post-test performance (difference: +0.85; p=0.007) and retention-test performance (difference: +0.66; p=0.043) were significantly higher than pre-test performance. For position A and D, retention-test performance were significantly higher compared to pre-test performance (A: difference: +0.57; p=0.032; D: difference: +0.52; p=0.043). Rank values for Friedman test comparisons between pre-test, post-test and retention-test are shown in table 6 and 7.

Control group

Mean results are shown in table 5. Performance increase or decrease between tests for the five different shooting positions are shown and illustrated in the bottom part of figure 2. Friedman test demonstrated no significant difference in overall performance between pre-test, post-test and retention-test (p=0.320). In regards to performance on each of the five different shooting positions, no significant difference was found between the three tests for any of the five positions (A: p=0.517; B: p=0.754; C: p=0.353; D: p=0.218; E: p=0.406). Rank values for Friedman test comparisons between pre-test, post-test and retention-test are shown in table 6 and 7.

Table 5. Mean pre-test, post-test and retention-test results for overall performance and for all five shooting positions for control group

	Pre-test	**Post-test**	**Retention-test**
Overall (N=60)	1.91±0.59	2.01±0.62	1.96±0.58
Position A (N=12)	1.71±0.56	1.80±0.53	1.77±0.62
Position B (N=12)	2.15±0.67	2.13±0.70	2.02±0.51
Position C (N=12)	1.86±0.60	2.00±0.65	1.97±0.48
Position D (N=12)	2.01±0.53	2.21±0.58	2.25±0.62
Position E (N=12)	1.84±0.56	1.88±0.62	1.78±0.60

Notes: Data is presented in mean±SD (Standard deviation). N=60 [5 positions x 12 subjects], N=12 [1 position x 12 subjects].

Group comparison

Table 8. Mean pre-test, post-test and retention-test results for specific practice group, variable practice group and control group.

	Pre-test score	**Post-test score**	**Retention-test score**
Specific practice group	1.83±0.64	2.38±0.65	2.37±0.54
Variable practice group	1.90±0.70	2.38±0.64	2.10±0.62◆
Control group	1.91±0.59	2.01±0.62*	1.98±0.58◆

Notes: Data is presented in mean±SD (Standard deviation). N=60 [5 positions x 12 subjects]

* Indicates significant different in post-test score compared to specific (p=0.013) and variable practice group (p=0.004)

◆ Indicates significantly lower retention-test score compared to specific practice group (p=0.001, p=0.028 for control group and variable practice group, respectively)

Mean results are presented in table 8. Performance increase or decrease between tests for the five different shooting positions are shown and illustrated in figure 2 for specific practice group, variable practice group and control group. Kruskal Wallis H test demonstrated no significant difference in pre-test performance between the three groups ($p=0.725$), whereas a significant difference in post-test performance ($p=0.002$) and retention-test performance ($p=0.001$) was found. Post hoc comparisons showed that for post-test, both the specific practice group (difference: +0.37, $p=0.013$) and the variable practice group (difference: +0.37, $p=0.004$) performed significantly higher compared to control group. For retention-test, both the control group (difference: -0.39, $p=0.001$) and the variable practice group (difference: -0.27, $p=0.028$) performed significantly lower compared to the specific practice group.

In regards to performance on the five different shooting positions, no significant group difference was found for pre-test results. For post-test and retention-test performance, only results from position C were significantly different between groups (Post-test: $p=0.012$; retention-test: $p=0.006$). Post hoc showed that for post-test, specific practice group performance on position C were significantly higher compared to control group only (difference: +0.85, $p=0.010$). For retention-test, specific practice group performance on position C was significantly higher compared to both control group (difference: +0.69, $p=0.010$) and variable practice group (difference: +0.58, $p=0.030$). Rank values for Kruskal Wallis H test comparisons between specific practice group, variable practice group and control group are shown in table 9 and 10.

Discussion

The purpose of this experiment was to evaluate the effect of variable versus specific practice in basketball set shot training upon transfer and retention performance. It was hypothesised that variable practice more than specific practice would facilitate transfer to generation and execution of novel responses on a transfer-post-test. In regards to learning, the hypothesis was that the variable practice group would perform better on the retention-test due to a more optimally developed schema and better defined parameter.

Variable practice group

The variable practice group experienced a significant increase in performance from pre- to post-test (difference: +0.48). These results are in line with earlier studies testing the variability of practice hypothesis when varying weight of the object being thrown (Carson & Wiegand, 1979), distance to target (Kerr & Booth, 1978; Landin, Herbert & Fairweather, 1993) and target angle (Moxley, 1979). All studies found support for the view that variability of practice enhances transfer. As expected for the variable practice group in this experiment, the scores from the five positions contributed equally to the mean score. The curve of the generalisation effect was thus in line with the theory of interpolation.

The effect of variable practice upon retention performance was not included in the original schema theory predictions, but has been studied later on. For this experiment, the variable practice group performed significantly poorer on the retention-test compared to the post-test (difference: -0.28), leading to a small but not significant increase in performance from pre-test to retention-test (difference: +0.20). Even though not significant, these results indicate a learning effect from variable practice to variable performance for basketball shooting. This is in line with Carson & Wiegand (1979), Landin, Herbert and Fairweather (1993) and Memmert (2006), who found support for variability of practice in their experiments on throwing tasks and basketball.

If one looks at the results of the variable practice group independent of those of the specific practice, they yield support to the variable practice hypothesis. Schmidt (1975) states that high practice variability will enhance transfer of learning between variations of skills that are governed by the same motor program, due to a more effective performance of novel versions of that particular skill (Ingvaldsen & Whiting, 1997). The results of the post-test for the variable practice group imply such an effect. Additionally, the retention-test results also yields support to the variability of practice hypothesis as a facilitator of learning.

Specific practice group

The specific practice group experienced a significant increase in performance from pre- to post-test. As expected, post-test performance on position C, the concurrent training and transfer-test position, was considerably higher compared to the adjacent positions. Nevertheless, a performance increase was also seen in all other positions (see figure 2). This indicates a generalisation effect extrapolating from the concurrent training and transfer position onto the adjacent positions.

The specific practice group's post-test and retention-test performance were almost identical (difference: -0.01). This lead to retention-test performance being significantly higher compared to pre-test performance (difference: +0.49). These results indicate transfer and learning from specific practice to variable performance for basketball shooting.

Thorndike's Identical Elements Theory might explain the positive results for both transfer and learning in the specific practice group. As will be discussed later, one can question how dissimilar the different variations of the performance task really are. A high level of similarity between the perceptual features of the task variations appears to have lead to a high amount of perceptual transfer from the concurrent training and transfer position to the adjacent positions.

Control group

Attention might serve as an important factor affecting the results of an experiment. Thus, the control group in this experiment conducted the same amount of training as the two experimental groups, although on a completely different task: Football penalties. This type of training did not have an effect on post-test or retention-test performance, as no significant differences was found between tests for any of the shooting positions.

Group comparison

There was no significant difference in pre-test performance between the specific practice group, the variable practice group and the control group, illustrating that all groups started out on the same baseline. For the variable and specific practice group, no significant difference was found in post-test performance. These results are not in line with previous research comparing variability of practice and specific practice in similar matters (one group practicing a single form of a task and the other practicing several variations). Experiments using throwing tasks, both varying weight of the object being thrown (Carson & Wiegand, 1979), distance to target (Kerr & Booth, 1978; Landin, Herbert & Fairweather, 1993) and target angle (Moxley, 1979) found variability of practice to lead to better transfer effect compared to specific practice. This experiment, varying the relationship of the subject to the target in a similar way as in Moxley's (1979) experiment, did however not find support for the variability of practice hypothesis to the same extent. These results are thus of interest.

In relation to the Dynamic System Approach, one can argue that the shooting action for this experiment is the same for all groups, e.g. in terms of force required (determined by distance to target) and rhythm, and that the difference lies in the angle towards the basket, and thus the perceptual features of the task. In other studies, varying distance to target rather than angle, the different variations of the task are clearly dissimilar due to the increased levels of force as distance to target increases (Schmidt, Zelaznik, Hawkins, Frank & Quinn, 1978). In Schmidt's (1975) terms, the different variations of the task require application of novel parameters for the same motor program. For this experiment, however, the results might indicate that the differences in perceptual features of the task were not as prominent as was first expected, yielding a large level of similarity in the stimuli as well as the expected similarity in response between training and transfer-tests. With Thorndike's Identical elements theory as a basis, this might explain why both experimental groups performed well on the post-test, as the level of similarity between practice and performance was high for both experimental groups.

The specific practice group experienced a superior increase in performance on the concurrent training and post-test position, and this learning effect seems to generalise itself just as good as the generalisation experienced for the group conducting variability of practice. By varying shooting positions, performance was lowered, generally. This seems to have affected the amount of transfer. By increasing the intensity on one variation of a skill, in this experiment through becoming better and better on one particular version, generalisation became better than variable practice.

For this experiment, the main distinction between the variable and specific practice group lies in their retention-test performance. Both the specific practice and the variable practice group experienced an increase in performance from pre-test to retention-test, which means that both specific and variable practice facilitated learning. However, retention-test performance for the specific practice group was significantly higher compared to variable practice performance. This is contradictory to the results of Carson & Wiegand (1979) and Landin, Herbert and Fairweather (1993), which found loss in performance on retention-test to be significantly less for the variability of practice compared to specific practice. The latter results are contradictory to Schmidt's Schema theory, as the variability of practice hypothesis argues that a strengthening of schemas occurs due to diversity of experience rather than repetition (Ingvaldsen & Whiting, 1997). Results from this experiment indicate that these strengthening effects induced by variability of practice are not as effective as specific training, where the subjects reach a higher quality of performance.

One explanation to these results might be that varying training positions as done in this experiment can be perceived as a dual-task. The need to adjust to different perceptual demands for each position, and thus for each new shot, might have had a detrimental impact on the variable practice group and their capacity to achieve learning. As the specific practice group only had one variant of the task to focus on during training, their learning was not affected in the same way as the variable practice group. This might challenge the dominant view as represented by Whiting, Savelsbergh and Pijpers (1995). They state that a system, i.e. the human body, can operate effectively under changing informational constraints due to a flexibility of the system operation. Results from this study contradicts this notion, as the variable practice, operating under changing informational constraints, performed less on retention compared to the specific practice group, which conducted training under the same informational constraints.

The significant decrease in performance from post-test to retention-test for the variability of practice group might indicate an attunement to the testing situation rather than adaptation, to apply Whiting's (1984) terms. He explains skill differences through the use of these two terms. When acquiring a new skill, attunement describes the ability to adjust movements relative to immediate variations of a given situation. Adaptation, on the other hand, describes stable, long-term changes in a movement or movement pattern in the acquiring of a new skill or in the built up on an already taught skill to make it more complex (Ingvaldsen & Whiting, 1997). In line with the thoughts of Skinner (1965), a development of both function and structure (action and perception) is necessary in other to learn new motor skills. The results from this experiment indicate that adaptation (Whiting, 1984), i.e the development of function and structure in Skinner terms, was strengthened to a larger extent by the specific practice compared to the variable practice. However, this kind of hypothetical speculation can only be confirmed by further studies.

Extrapolation and interpolation between training and performance was the two types of generalisation for this experiment. Considering Schmidt's schema theory of motor learning, extrapolating and interpolating is two different ways of picturing how the formation of a scheme can take place. For this experiment, in line with the variability of practice hypothesis, we would expect the interpolating mechanism to result in learning of a generalized schema, and thus better transfer and learning, as extrapolation was based on specific rather than variable practice. The results indicate that this might not be the case. One possible explanation to this might be that the similarity between task variations resulted in the variable practice group not applying novel parameter setting of the same motor program during practice, as they would have engaged in had the task variations been dissimilar. Performing several variations of the task is necessary to develop a more precise schema and better defined parameters, according to Schmidt (1975). As this is the basis for experiencing a high amount of transfer and learning, the similarity between variations of task might in this way influenced the results for this experiment.

David A. Rosenbaum suggests a possible explanation that can apply to these results (in: Keetch, Schmidt, Lee & young, 2005). Performance of actions within the same class is governed by a schema-rule, but an additional component of accuracy, which is a function of the proximity of the highly practiced skill, is added to the performance. Thus, effects of high amounts of practice on one particular skill should transfer to its nearest neighbours and create a generalisation effect. Rosenbaum's ideas was originally linked to massive amounts of practice of one particular skill, e.g. the basketball free throw in skilled athletes. This might, however, also be seen as a kind of ad hoc hypothesis to rescue Schmidt's Schema theory from contradictory results from both Keetch et. al's (2005) study and the present study.

However, one cannot conclude that the specific practice is the only solution. For this experiment, both experimental groups trained for three weeks, and each subject conducted 510 shots in total. We cannot be certain how the results would turn out if instead 1000 shots were performed, or if the training period lasted for eight weeks. For instance, the dual-task nature of the variable practice and the subsequent need to always readjust to the perceptual demands might interfere the learning process in the short run, but not necessarily on a long term. Maybe, if this experiment continued for a longer period, the variability leading to the need to relate to several tasks at the same time might have induced a better learning compared to the specific practice.

Implications

Regarding the application of the present study, the effect of variability in training upon later performance is an issue of theoretical and practical significance. Theoretically, as it challenges the variability of practice hypothesis as proposed by Schmidt in his Schema theory (1975). As previously stated, Schmidt (1975), in his Schema theory, does not directly predict what impact variable practice will have upon retention, but for the practical use of this theory, it is an important issue to take into account. Knowledge about this issue is vital because it facilitates the understanding of processes underlying the learning and control of motor skills (Magill, 2001).

In regards to practical significance, what amount of variability to employ, and how to employ it, is essential for athletes and their limited number of hours available for practicing and improving their sport performance.

Other experiments can be instigated to further test the variability of practice hypothesis, both in comparison to specific practice, or alone. For instance, to adjust for the perceived dual-task for the variable practice group, one could design the experiment in such a way that the specific practice group was given a second task as well, e.g. problem solving.

Conclusion

The major goal for coaches and athletes is to create a practice environment that will promote learning during practice, which ideally transfers to later performance enhancement. Both specific and variable practice lead to enhanced transfer on a post-test, where all variations of the trained task were new for the variable practice group, and four out of five were new for the specific practice group. Specific group experiences a superior increase in performance on their concurrent training and post-test shooting point, and this learning effect seems to generalise itself just as good as that experienced for variability of practice.

The specific practice group experienced learning from pre-test to retention-test to a larger extent than the variable practice group. Such results challenge the variability of practice hypothesis.

Most game situations in sports call for random responses. The results from this experiment indicate that both specific and variable practice enhances transfer to novel responses of a trained task, but that specific practice enhances learning to a greater extent compared to variable practice. However, as the duration of this experiment was limited to three weeks, one cannot conclude that specific practice is in favour over variability of practice.

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Appendix

Table of contents

A1. Consent form

Informasjonsskriv

Deltagelse i forskningsprosjekt

Forskningsprosjektet vil foregå i Løa ved Trønderhallen på Levanger. Protokollen involverer en treningsperiode på 3 uker, med 3 økter hver uke. I tillegg vil det bli gjennomført en pre-test rett før treningsperioden starter, en post-test like etter endt treningsperiode, samt en retention-test ca. en måned etter endt treningsperiode. Totalt tolv økter på hver person. Dere kommer to og to sammen til øktene, og hver økt vil ha en totalvarighet på ca. 35 min. Øktene er ikke fysisk krevende eller anstrengende. Per økt er oppgaven å skyte 80 skudd med en basketball, hvor målet er å treffe oppi kurva så mange ganger som mulig. Under de tre testene er oppgaven den samme, men da med noen færre kast.

Under øktene vil det bli tatt i bruk videokamera for å kunne dokumentere kastutførelse og type treff. Videoopptakene og eventuelle andre personopplysninger vil ikke være med i den ferdige oppgaven, og vil bli slettet etter at masteroppgaven er levert. Dette gjøres senest i juni 2017. All innhentet informasjon vil også bli anonymisert slik at ingen enkeltperson skal kunne kjenne seg igjen i den ferdige oppgaven.

Det er frivillig å delta og man kan som forsøksperson trekke seg fra deltagelse underveis, uten å måtte begrunne dette. Dersom noen velger å trekke seg vil all informasjon om den aktuelle forsøkspersonen slettes umiddelbart.

Veiledere for mitt masterprosjekt er Professor Rolf P. Ingvaldsen og førstelektor Tore Kristian Aune. Masteroppgaveprosjektet gjennomføres i henhold til Helsinkideklarasjonens forskningsetiske retningslinjer. Som prosjektleder har jeg taushetsplikt, noe som betyr at all informasjon som innhentes i forkant og underveis i prosjektet vil behandles konfidensielt.

Har du spørsmål er det bare å ringe eller sende en melding til meg på telefon 99 58 32 98, eller sende en e-post til veronikamyranwee@gmail.com

Med vennlig hilsen

Veronika Wee

Samtykkeerklæring

Jeg har mottatt informasjon om eksperimentet og ønsker å delta

Signatur student: …………………………………………………………………….

A2. Test protocol and registration schema

Table A2.1 Test protocol and registration schema for pre-test, post-test and retention-test.

Subject: ______________ Test/session: ______________ Date: ____

Nr.	Position	Result	Nr.	Position	Result
1	C		1	E	
2	D		2	A	
3	C		3	C	
4	E		4	A	
5	C		5	B	
6	B		6	C	
7	D		7	E	
8	A		8	A	
9	C		9	B	
10	A		10	D	
11	C		11	E	
12	E		12	D	
13	C		13	A	
14	B		14	B	
15	E		15	D	
16	A		16	C	
17	E		17	A	
18	B		18	D	
19	A		19	E	
20	D		20	B	
21	E				
22	D				
23	A				
24	B				
25	D				
26	E				
27	C				
28	B				
29	D				
30	B				

Table A2.2 Test protocol and registration schema for training sessions.

Subject: Test/session: Date:

Nr.	Position	Result	Nr.	Position	Result
1	3		1	1	
2	4		2	3	
3	1		3	1	
4	2		4	2	
5	1		5	3	
6	2		6	2	
7	1		7	3	
8	4		8	4	
9	3		9	3	
10	2		10	4	
11	3		11	2	
12	4		12	3	
13	2		13	2	
14	4		14	1	
15	3		15	2	
16	4		16	1	
17	2		17	2	
18	1		18	1	
19	3		19	4	
20	1		20	1	
21	2		21	4	
22	3		22	2	
23	1		23	4	
24	3		24	3	
25	2		25	1	
26	4		26	4	
27	1		27	3	
28	4		28	4	
29	1		29	3	
30	2		30	4	

A3. Farey tree

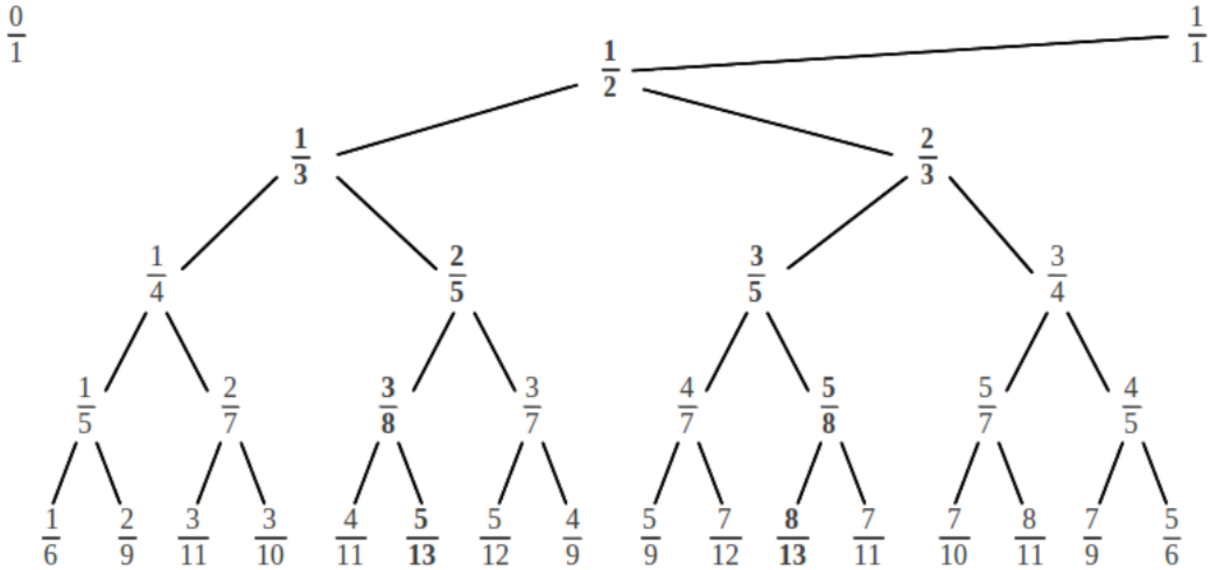

Figure A3.1 Farey tree

A4. Mean rank values for Friedman tests and Kruskal Wallis H tests

Table A4.1 Friedman test rank values for comparisons between tests within specific practice group, variable practice group and control group.

Rank values						
	Specific practice		**Variable practice**		**Control group**	
	Number of observation	Mean rank	Number of observation	Mean rank	Number of observation	Mean rank
Pre-test	60	1.43	60	1.67	60	1.90
Post-test	60	2.27	60	2.44	60	2.15
Retention-test	60	2.30	60	1.89	60	1.95
Total	180		180		180	

Notes: N = 180 [5 positions x 12 subjects x 3 groups]

Table A4.2 Friedman test rank values for comparisons between performance on five different shooting positions (A, B, C, D, E) for pre-test, post-test and retention-test within specific practice group, variable practice group and control group.

Rank values																
		Specific practice					**Variable practice**					**Control group**				
	Number of observations	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
Mean rank pre-test	12	1.33	1.63	1.25	1.50	1.46	1.67	1.88	1.71	1.58	1.50	1.96	2.13	1.67	1.63	2.13
Mean rank post-test	12	2.29	2.17	2.50	2.00	2.38	2.33	2.25	2.58	2.63	2.42	2.25	2.04	2.13	2.17	2.17
Mean rank retention-test	12	2.38	2.21	2.25	2.50	2.17	2.00	1.88	1.71	1.79	2.08	1.79	1.83	2.21	2.21	1.71
	36															

Notes: N=36 [12 subjects x 3 groups]

Table A4.3 Kruskal Wallis H test rank values for comparisons between tests within specific practice group, variable practice group and control group.

Rank values						
	Pre-test		**Post-test**		**Retention-test**	
	Number of observations	Mean rank	Number of observations	Mean rank	Number of observations	Mean rank
Specific practice	60	86.16	60	98.38	60	110.23
Variable practice	60	93.29	60	101.84	60	85.48
Control group	60	92.05	60	71.28	60	75.80
Total	180		180		180	

Notes: N = 180 [5 positions x 12 subjects x 3 groups]

Table A4.4 Kruskal Wallis H test rank values for comparisons between performance on five different shooting positions (A, B, C, D, E) for pre-test, post-test and retention-test between specific practice group, variable practice group and control group.

Rank values																
		Mean rank pre-test					**Mean rank post-test**					**Mean rank retention-test**				
	Number of observations	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
Specific practice	12	16.96	17.88	18.79	17.00	17.04	19.71	20.33	24.29	16.46	19.88	21.42	22.17	26.33	21.17	21.92
Variable practice	12	20.50	18.13	20.21	18.29	18.88	21.75	19.67	19.58	22.88	20.00	18.96	19.08	15.29	15.54	17.58
Control group	12	18.04	19.50	16.50	20.21	19.58	14.04	15.50	11.63	16.17	15.63	15.13	14.25	13.88	18.79	16.00
Total	36															

Notes: N=36 [12 subjects x 3 groups]