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Massive Amount of Practice and Special Memory Representations, "Special Motor Program Hypothesis"

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Abstract

The purpose of this study was investigating the contradiction between different types of memory representations. These viewpoints are based on generality and specificity of motor skill learning and the practice outcome. Sixteen players, divided into different groups of less- experienced group (less than six-month experience) to well- experienced group (at least eight years of experience) participated in this study. Each player performed 147 shoots in 3 sets and 21 blocks. The results of the current study showed that, in well-experienced group, there was a significant difference between predicted and actual free throw performance in the foul line. However, in less-experienced group, no significant difference was observed between predicted and actual free throw performance in the foul line. Significant differences were observed between predicted and actual free throw performance in the foul line may be explained by different reasons such as visual context, specific motor program, specific parameterization, etc. Further studies need to be conducted in order to explain them. However, many concepts of schema theory such as variable exercise, the storage problem and generality of the schema should not be viewed as certain. A New theory is needed in motor control in order to explain the special effects and specific memory representations in the massed practiced skills.

Keywords: Motor control, Schema Theory, Specific memory representations, Highly practiced skills

Introduction

The concepts of specificity and generality of motor skill learning have long been discussed in the field of motor control and learning. Many researchers have considered two basic ideas for motor learning. Some researchers believe that people learn a broad range of activities as non - specific way. In contrast, some others believe to the specificity in motor skill learning. Many years ago, Lashley, [1] investigated the generality idea with the writing pattern of alphabets with different effector systems. He asked the participant to write some words with closed eyes, using different effector systems such as preferred hand, non-preferred hand, and feet. Analyzing participants' writing revealed that there is a significant similarity between writings, when participant used different effector systems. Bernstein and others [2, 3] conducted similar study. They confirmed these results. Researchers concluded that handwriting skill is controlled by the general memory representations. Schmidt [4, 5] formulated these findings via Schema Theory and proposed the generality in motor skill learning. Based on this theory, people have skillful performance in different conditions, and these conditions are not specific to the practice condition.

Therefore, each practice attempt (for example throwing from different distances) provides brief information that could be applied for similar conditions. They have not been practiced before, and this supports the schema. In summary, schema consists of two basic parts in memory: the first part is GMP which is required for covering features of a group of movements (invariant features include the relative timing and force), and another part is recall schema which can support GMP during performing the particular action. Therefore, these two parts are interrelated and confine the need to separate program for each particular action. This feature of GMP resulted in solving storage problem [4, 5]. Many researchers have also showed that having different parameters in training results in generalizability to the conditions which have never been practiced before [6, 7, 8]. All these findings emphasize on the generality of motor skill learning

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and general memory representations.

On the other hand, specific viewpoints in motor skill learning proposed that when skill is learned, it would be sensitive to the practice "conditions". If the practice conditions in transfer test are changed, performance is disturbed and if the practice "conditions" and the transfer test are similar, the person's performance will have optimum quality. Researchers believe that "conditions" may be provided due to context specificity, processing specificity and sensory–motor specificity. These are three kinds of information, each of them resulting in the dependence of the learner, and consequently leading to specified learning for those conditions [9]. Sensory-motor specificity refers to the involvement of the information gained from the human senses (audition, kinesthetic, vision, etc) and the dependence of the learner. Poteau [10, 11] studied these findings: participants aimed a lever toward a target and different conditions (from complete vision to complete deletion of visual feedback) were tested. In other experiments, other conditions were applied. For most of them, the results were the same [12]. The results showed that if the transfer test is done without visual feedback, those get the best performance in transfer test that has learned with the least visual feedback during practice conditions. Ultimately, Proteau and other researchers proposed the sensory-motor specificity hypothesis, which states motor learning includes sensory–motor representation, in a way that sensory and motor information are joined and specify the learning. In this case, where sensory and motor specificities (such as vision) are similar in practice and transfer sessions, memory representation is to be specified, and this issue leads the skill to be performed in optimal way.

Context specificity (context-dependant learning) states that several environmental factors including the context with an action (environment's temperature, color, etc) affect the performance in transfer test. In transfer session, when the performer attempts to remember the information from practice conditions, if context information is similar, the performer will represent practice context information more easily [13]. In addition, the "home field" idea is the kind of specific context information [14].

Processing specificity is also another kind of them, which is sensitive to practice and transfer conditions. Processing specificity suggests that, if these processing are similar during practice and transfer test, participants will perform the best in transfer test. In other words, conditions that are effective for one transfer test may not be effective for another. In addition, Concepts such as superiority of constant practice over variable practice [15], random practice over blocked practice [16], and predominance of observing a learning model over a skillful model in observational learning of novice learners [17] emphasize the specificity of memory processing. Ultimately, this hypothesis proposes that similarities between involved processing in practice and transfer sessions are the most important factor in the performance of the learners.

Adams [18] formalized the findings related to the specificity of motor skill learning as a theory: closed loop theory. This theory suggested that learning motor skills is due to the specific memory representations. He proposed that all of the movements are performed by comparing response-produced feedback with a correction reference, which he called "Perceptual Trace". In addition, closed loop theory has many restrictions that are pointed out in several researches [9]. Recent researches have provided instances that imply the existence of specific memory representations. Keetch et.al [19] studied this hypothesis, using experienced basketball players (more than 10 years experience in basketball). They asked players to perform the free throws from the foul line and other six locations. Statistical analysis based on prediction of regression equation, showed that performance in the foul line (4.5-meter from basket) was higher than performance in other locations and the regression predictions. Schema theory- even with massive amount of practice- predicted no specific effects for any locations. However, the results of the research were contrary to the principles of schema theory. Simons et al [20] also studied the existence of special memory representations in college baseball players. They asked them to perform baseball throws from different distances. Baseball players always throw from standard distance, which it is 18.75 meters (or 61.5 feet) from goal - the so-called Pitch throw. They allocate most of practice for throwing from the 18.75 distance. Researchers evaluated accuracy in throwing from 18.75 meters and other eight locations (30cm distant between them). Data analysis revealed that pitch throw executed from the 18.75 meters distance was 42% more accurate than regression prediction. These results and similar findings in the basketball show the existence of the special skills. It has confirmed the specific memory representations. Hence, a new approach is founded in literature of motor control and learning. These new findings are very interesting, but the results will be trusty if they are tested in many different conditions and so verified. Otherwise, these results does not provide strong basis for new viewpoints in motor control and learning. In order to do further investigations, we provide this experiment to explore the type of memory representations in the skilled and novice basketball players. In comparison with previous researches, this study is conducted with different participant and scoring system, which is presented in next session.

Methodology

Participants: sixteen qualified players were chosen for this study (based on the inclusion criteria), and were divided into experienced (8 player) and novice groups.

All Participants were male and between 17-22 years old. The participants in the novice group were freshman students in physical education, having the least experience (less than 6 months) in basketball skills. In experienced group, participants had at least 8 years experience in professional basketball. They have experienced the different posts. All of them have already been a member of Iran national basketball team or have been invited to the national basketball team in recent years. The task used for this study was the free throw in basketball, which should be thrown only from the foul line. The reason for selecting this task was extensive practices in this location and the little variability in designing of practice conditions [19]. Therefore, a target skill is chosen that the experienced players have practiced for many years (more than 8 years), with massed and constant practices.

Equipments: The experiment for this study was performed in a standard basketball court, with standard floor. Ring diameter was 45 cm; the height was 3.05 meter, with a standard net. A Molten ball that is used for international competitions was chosen for the experiment. Players performed throws from seven locations that were measured as making right angle with the board, toward the center of the court. The distance between each location was 60 cm so that the first location placed on 2.70m and the final location was on 6.30m far from the center of the ring [19]. Special tapes (5×25 cm) marked throwing locations. Throws were recorded by Sony camera (Sony-CCD-TRV238E-PALLHI8-3352553), and then were reanalyzed. When participants perform the experiment, with the exception of experimenter 1 (supervisor), experimenters 2 and 3 (responsible for returning the ball), experimenter 4 (recording scores) and the participant, no one was present in the court. Experimenter 2 and 3 returned the ball to the participants in a same way, after each throwing (chest pass without ground contact).

Procedures: Before starting the experiment, participants admitted their satisfaction by filling an informed consent form. Players executed free throwing from the foul line and six other locations with right angle toward to basket. Seven locations were marked on the floor: 2.70, 3.30, 3.90, 4.50 (foul line), 5.10, 5.70, and 6.30 meters (shape 1). Each player performed 147 throws in three sets (7 blocks per set). Participants were asked to perform seven throwing from each location. The players rest for five minutes after each set and then prepared to perform next set. Experimenters 2 and 3 (figure 1) were responsible for returning the ball to the players.

Five seconds rests were allowed for the participant between each trial. The players were required to finish a block of 7 throwing and then move to the next block. The experimenter 4 who recorded the scores, announced moving from one block to the next block (experimenter 4) by announcing the number of the distance (distances were numbered from 1 to 7). In order to remove the sequence effect, the sequence of throwing in each group was done counterbalance: Participants were randomly divided into two groups. In the each one, half of them executed their throwing from far to near locations, and other half from near to far (from the location 7 to 1 and vice versa). No emphasis was for any particular locations. Throwing from all locations was executed with the same effort. No dribbling or any other movement was done before throwing. the experimenter 4 recorded players' scores in the individual score table. Scoring was done based on a four-value system. Three scores were given, if the throwing turned into a goal with no ring contact. Two scores for turned into a goal with ring contact, if it hit the top of the ring, not turning into a goal, one score, and if it hit the bottom of the ring or did not hit it, 0 score was given to it [19, 21]. All participants were allowed to use visual feedback, (for example, they could see the ball flying), but they did not receive any other feedback Such as verbal or augmented one.

Results

The information from 147 throws executed was collected. In subsequent analysis, mean value of throwing scores for each distance was calculated. In addition, the average values of the performances were calculated for each player and for the distances of 2.70, 3.30, 3.90, 4.50 (foul line), 5.10, 5.70, 6.30 from the basket, for novice and experienced groups. These data were used to calculate linear regression equation. Then, individual regressions were used to calculate predicted performance in the foul line. Using average amounts of intercept (a) and slope (b), regression equation was calculated for each group.

The amounts of actual and predicted performance in the foul line were compared using paired-samples t test. Results revealed that for the experienced group the predicted performance was 72.87 and the actual performance was 80.21 in the foul line. For the novice group the predicted performance was 42.30, and the actual performance in the foul line was 46.58. Analysis comparison of the results was done independently for each group. Results showed no significant difference between predicted and actual performance in the foul line, in the novice group, for $t(7)=0.58$, $p>0.05$; but there was a significant difference between predicted and actual performance in the foul line, in the experienced group, for $t(7)=4.43$, $p<0.05$.

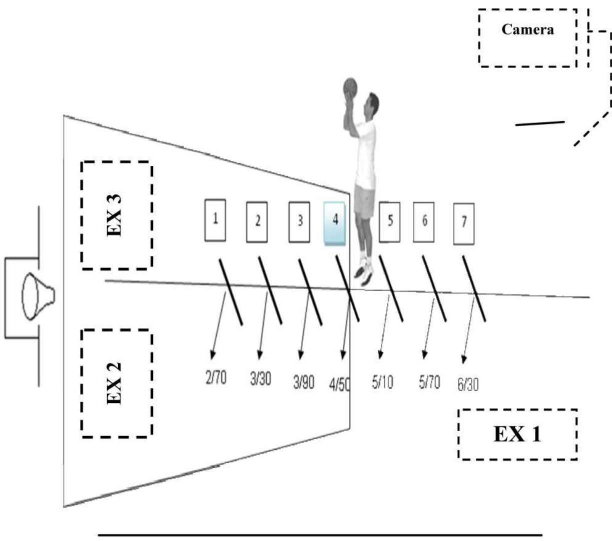

Figure 1: illustration of the court in during the experiment.

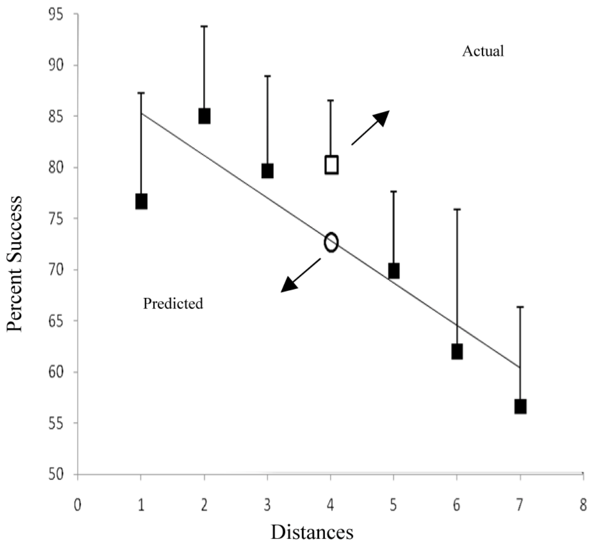

Figure 2*:* Comparison of actual and predicted performance in the foul line in experienced group (The filled squares represent the actual performance at the non-foul line distances; the unfilled square represents the actual performance at the foul line (4.5 meter); and the unfilled circle represents the predicted success at the foul line (4.5 meter).

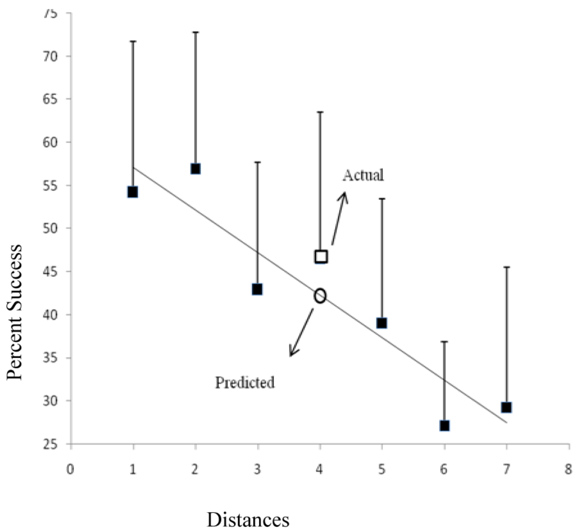

Figure 3*:* Comparison of actual and predicted performance in the foul line in novice group *(*The filled squares represent the actual performance at the non-foul line distances; the unfilled square represents the actual performance at the foul line (4.5 meter); and the unfilled circle represents the predicted success at the foul line (4.5 meter).

Discussion

Specific memory representations are evident in the performance of the experienced group in the foul line, and general representations are clearly observed in other locations (all distances except for the 4.5-meter distance) both in the experienced and novice players. Apparently, all the findings for the novice group and six locations for the experienced group confirm the general memory representations and general views in motor learning and result in representing general effects in all locations. Which factors cause this specific performance? Indeed, based on our current understanding of motor control and learning, these findings are challenging. However, specific memory representations and the simultaneous occurrence of the general effects would be related to the potential factors. New structures in memory are the probable factor that we will discuss it in the next paper that is performed on experienced dart player. However, some other factors can be the causes of the special effects in the 4.5 meter from basket. Also, these results would have subsequent effects in the motor control and learning principles. First, we refer to dynamical systems approach.

Dynamical systems approach

According to Dynamic Systems Approach, motor system tends to perform movements or actions as superior conditions and with minimum energy. These conditions are called stability. When an attractor state (this factor destructs system stability, for example Massive amount of practice) modifies the stability, motor system transitions to the new stable conditions [22, 23].

In the present conditions, massive amount of practice in the experienced basketball players works as attractor that disarranges stability of motor systems. But before and after the transition stage, the performance should be stable and fix (performance in 1 location called "closer area" and performance in 5, 6 and 7 locations called "further area") (figure 4). The expected stability in further area is quite logical, but condition in the closer area is challenging. Based on Fit's low [24] and principles of visual system, this state (closer area) is not considered as stability. It is expected that all experienced players perform the best own performances in the nearest location but we do not see any signals. Therefore, we see two critical stages:

1-First, the weak performance in the closer area

2-Second, the destruction related to massed practice in the transition stage.

This challenge is confirmed if we accept that dynamic systems approach principles support the class of skills (i.e. throws from different locations, as motor pattern do not alter). we discussed less about this issue in the literature. Now, how can we explain these two “consecutive unbalanced conditions” by Dynamic Systems Approach? We wait for the thoughts of motor control and learning scientist and theoreticians.

Visual context hypothesis

This probability considers that massed practices in the foul line have acquired specific visual capabilities that are specified to this location, such as visual context or sight angle. Many researchers have confirmed the importance of visual cues in target skills [10, 11, 25, 26, 27]. Some of recent researches have studied visual attention in basketball throws [28, 29, 30]. Most of them have studied the importance of the online visual information during performing the movement. It has clarified that among visual variables, the experienced players learn the method of using the online visual information well, during performing the movement. Keetch et al [21] examined visual context hypothesis in another way. They asked experienced basketball players to execute free throws from seven locations that were 4.5 meters away from the basket (foul line distant). Results revealed that the performance of the players was better in the foul line (90') as compared to the locations with other angles. They discussed that a weaker performance in other locations might be due to a change in visual context and shoot angle. However, this hypothesis has not been considered yet. Based on the present finding, we propose “optimal visual area”. As it is seen in the figure 2, massed practice causes in special performance in the foul line and nearest locations (2 and 3 locations). This hypothesis reveals the existence of visual area (not one special distance or degree) in the experienced players. Perhaps, investigation on this hypothesis is provided by the comparison of the experienced players’ performance in the nearest environment of the foul line.

Gradual specification hypothesis

Memory representations are general in lower skill levels. Improvement in skill level cause in specialize memory representations [31, 21]. Several researches have studied the role of massed practices in memory representations. Some of these have supported this hypothesis [32, 33, 34]. In addition, in the novice players we can see general memory representations because of not enough practice in the foul line. However, considering immense complexities in human and central nervous system, and based on the existence of unlimited movements in the environment, it seems that memory representations are related to different mechanism (combination of two kinds of them in different conditions). Therefore, variations in memory representation seem to be clear. It is probable that there are different combinations of memory representations and different practice outcomes in different skill levels, different ages, and different development stages. This hypothesis is discussed in the next section.

Covariance Model of Memory Representations

What could we say about a covariance between memory representations and motor learning steps in different skill levels? Based on present findings and recent researches [19, 20, 21], there is probably a covariance between memory representations in motor skill performance and motor learning steps (and maybe individuals skill level and even their age) (figure 5).

In other words, at the first level of learning the motor skills, the high percentage of memory representations is general. With improving in the skill level, specific memory representations would enlarge in share, and general representations (represent as performance outcome) would be decreased. There is always a logical combination of general and specific memory representations, which is invariant in all motor learning conditions and steps. Also, other factors such as detraining, aging, physical injuries, damages, and similar factors reverse this process and contribute to increasing the share of general representations in memory. This model could be evaluated by examining the learning high practiced skills in retention and transfer test at different motor learning steps and other factors.

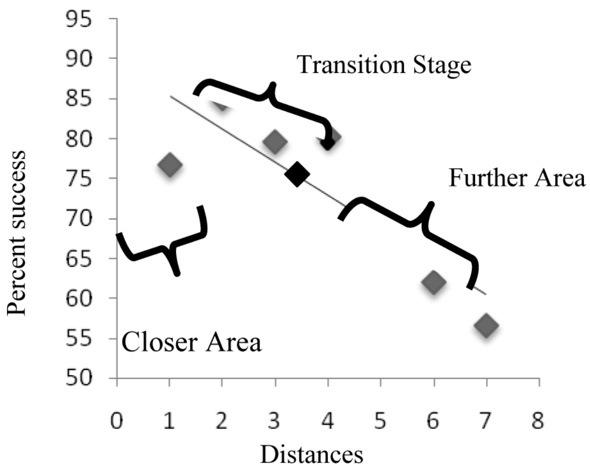

Figure 4: divided performances of experienced players in 7 locations to 3 sections based on dynamic systems approach.

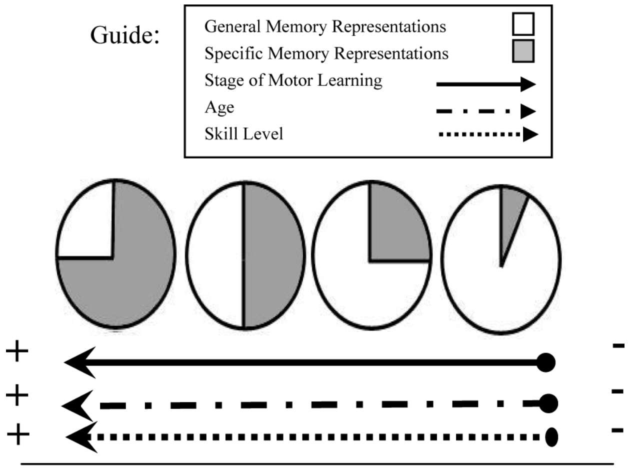

Figure 5: Possible relation between skill level, high level of practice and age with the type of memory representations

Which one: Variable or constant practice?

Priority of variable practice (even in close skills), has been described in many literature related to organization of practice for many years [4, 5, 7, 35, 15]. However, it is clear that due to restrictions in the basketball rules, and also because of the special conditions in performing the free throws (feet are not separated from the ground); basketball players rarely execute this throwing from other distances and angles (except for 90 degrees and 4.5 meters distance). This means the experienced players have practiced the free throws in a constant way through several years, and have no (or very little) variability during practices. Constant practice is probably more useful than variable practice for closed skills. However, how condition and context is the best choice for motor skill learning? This question will be answered in the future work, related to the organization of the practice session.

Special Motor Program hypothesis

Is it probable that there are the “special motor programs”? In relation to this issue, Keetch et.al [21] referred to "Special GMP" hypothesis, which this suggestion needs revision. It seems the name of this hypothesis raises some important questions. Schmidt [4, 5], by introducing Generalized Motor Program (GMP) instead of Motor Program (MP) proposed that storage problem and novelty problem could be answered. The reason for this claim is the great usage of GMP in a wide range of movements (a category of actions) and incredible generality, in comparison with the limited usage of MP in a particular action or movement. Now, is there the special GMP? This statement violates the basis of the GMP. It is better to refer to "special motor program" (or new structures in memory that differ from GMP), as the potential reason for the development of special effects in the players. However, proposing the "special motor program" hypothesis increases the probability of emersion of the motor programs. In addition, important challenges penetrate on general views, including schema theory.

Storage Problem, Forgotten or emerging again: "special motor program" hypothesis is an assumption now, and needs supplementary studies. If future researches confirm this hypothesis, it may result in the emergence of the problems such as "storage problem" and "novelty problem" again. This hypothesis would be tested by recording the brain activities before and during executing movements by the experienced players or recording the kinematics (i.e. relative timing) of free throwing performance in different locations (includung the foul line). If it is clarified in the future (existence the specific motor program), we hope that a new approach is formed in motor control and learning and indeed, many current concepts of general view will query.

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