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RESEARCH PAPER

The Effects of Practice Variability on the Acquisition of Bilateral Dart-Throwing Skills

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ABSTRACT

The study compared random versus blocked practice schedules in learning bilateral dart-throwing skills from three different distances (290 cm, 350 cm, and 410 cm). One hundred eight healthy non-athletes (12-18-year-old male students) volunteered for the study. The participants were split into six groups (n=18 in each group. Two groups had blocked practice with the dominant and non-dominant hand, two groups had random practice with the same, and two control groups with the dominant and non-dominant hand. First day: 81 acquisition trials (3 blocks, 27 trials in each block) were given to the participants. A 24-hour retention test consisted of 27 trials (03 blocks, nine in each block) in serial order. After an hour of retention, 18 trials (2 blocks, 09 trials each) are completed from unique distances (250 cm, 430cm). Results indicated that blocked practice with the dominant hand differs from other groups in skill development and retention. According to the results, random practice is superior to blocked practice and thus recommended for bilateral learning for dart-throwing.

KEYWORDS Bilateral Transfer, Contextual Interference, Dart Throwing, Motor Learning, Practice

Introduction

Learning how to move about is a vital part of growing up. From infancy to old age, human beings acquire and perfect a wide range of motor abilities that improve their quality of life. The acquisition of motor skills and the coordination of movements is challenging for someone just starting, and the development of skilled athleticism requires significant training (Liefeith, 2019). Adequate motor skills development is necessary for participation in physical education, coaching, physical rehabilitation, and service in the military, police, or special forces (Callary & Gearity, 2019). Most human movements can be learned, as demonstrated through motor learning. The central nervous system (CNS) is responsible for all the body's movements, and the skeletal and neurological systems collaborate to ensure these movements are coordinated. Both systems are necessary for coordinated motion (Wiegel & Leukel, 2020).

In the Handbook of Clinical Neurology (Kitago & Krakauer, 2013), motor learning is "a loosely defined term that encompasses motor adaptation, skill acquisition, and decision-making." It can be explained as the cumulative effect of a person's internal body processes and the practice itself, leading to more permanent changes in that person. Motor learning and practice are intermittently linked, and this term illuminates the relationship between training and performance (Schmidt & Lee, 2005). In the acquisition phase, a motor skill is practised, and the improvement shown after exercising a motor skill is measured (Dayan & Cohen, 2011). Evaluating performance at the end of the practice is essential to measure any shifts in responsiveness. Motor skill retention or the ability to simplify a new or current skill are two ways performance can be measured (Schmidt & Lee, 2005).

The most crucial aspect of learning motor skills is deliberate practice. Skilled behaviour is characterized by performance improvements with experience. The acquisition of motor skills occurs because of learning, which happens through experience and practice (Savion-Lemieux, Bailey, & Penhune 2009). The understanding of this principle is demonstrated by gains in both the accuracy and speed of motor exercises. As a result of the fact that more repetitions might lead to the automation of motions, less training is required to control their execution (Doyon et al.,2009). The acquisition of a taught motor skill increases movement precision, speed, and accuracy of the first ballistic module, reducing the time spent on the correction module (Elliott et al., 2010). The neurological properties of the brain go through irreversible change when a person learns new motor skills. Some things are simple to understand, while others are more difficult. Physical education and sports teachers are constantly looking for the most effective training to assist pupils in rapidly mastering motor skills.

Literature Review

Random Versus Blocked Practice

Motor learning uses the term "variability," which refers to the exercise but takes on different meanings under different settings. It was at first one of the ideas derived from Schmidt's schema theory (Schmidt, 2003). The concept of practice variability accounted for the motor learning process. Variability in training was essential for motor skill acquisition (Boyce, Coker, & Bunker 2006). It has long been speculated that groups conducting variable versus continuous practice in motor learning will exhibit different behavioural outcomes. The theory is that when an experimenter introduces variability into one aspect of a task during practice, the participants learn to adapt their movements to that variable, leading to better performance than when the experimenter does not introduce any variability (Pacheco & Newell, 2018). The study of motor learning has resulted in several studies investigating the influence of practice routines. Magill and Hall (1990) provided specific information regarding the two different philosophies of practice and how each one affects motor learning. The one-of-a-kind nature of the learning principle is investigated first, which elucidates that motor skills are distinct even though they appear to be related to other skills. According to Schmidt and Lee (2005), any modification to a motor skill leads to developing new motor skills, which necessitates producing a new motor model.

One learning phenomenon recognized as the "contextual interference effect" explains how some forms of distraction during practice can actually be helpful for the development of a skill. Contextual interference (CI) is what Lee and Simon (2004) refer to as the stress placed on participants' performance when they are trained to accomplish numerous tasks simultaneously. Following these characteristics, CI was established as a practice program that included blocked and random practice with substantial interference (low interference). It was determined that interference negatively impacted an athlete's performance during acquisition practice; however, this effect was neutralized when the athlete's performance was examined on transfer and retention tests (Magill & Hall, 1990). Within the high variability group, typically the topic of discussion, authorization for training trials is granted randomly. Low variability is another precondition, and this one requires a consistent routine of practice tries (Fazeli, Taheri, & Kakhki 2017). The participants in that study were required to finish all the trials for one skill variant before moving on to another, such as AAA or BBB and low-interference blocked practice.

Alternatively, the random condition (high interference) may produce superior results if the changes are carried out in an unfixed order, e.g., ACB, BCA, and the like, as indicated in Fazeli et al.'s (2017) study. When describing the outcomes of a random or blocked learning exercise in applied motor skills, some academic studies have opted to use the term "contextual variation" rather than "intra-task interference." Magill and Hall (1990) stated that a practitioner's level of competence, the frequency with which they practised, and the amount of information they had to process were all possible sources of interference that may either increase or inhibit learning.

Bilateral Transfer

A bilateral transfer is a phenomenon that occurs when an individual engages in repeated practice with a task while simultaneously learning it with a different organ, as described by Magill and Richard (2011). It may be helpful to know about bilateral transfers while making decisions. It enables one portion of the brain to take over some functions from the other part of the brain, such as in the case of invertebrate handedness, vision, and movement asymmetries, Anfora et al. (2011). In motor behaviour investigations, the brain's hemisphere is examined, which helps determine which side of the brain is dominant.

To be able to move one's body denotes that the dominant hemisphere of one's brain, the left hemisphere, has a more remarkable ability to exert control over the bodily side that is on the opposite side, with a faster rate of movement and a better quality of movement than the other, non-dominant hemisphere of the brain (Teixeira, Silva, & Carvalho, 2003). A bilateral transfer established that the activity could be finished utilizing an arm or leg that was not generally used for or contributed to the activity. Compared to the dominant, the non-dominant limb receives a lower level of support from the participants. According to Kidgell, Frazer, and Pearce (2017), mobility occurs in everyday life and the context of athletic competition.

There is a beneficial bilateral transfer of power, stamina, and muscular performance from one limb to the other, as indicated by several studies. This is an example of a bilateral transfer when athletes transition between using their non-dominant (left) and dominant (right) limbs while competing. Consider a situation in which athletes or players are forced to go up against other competitors. According to Liu and Wrisberg (2005), in this scenario, they need to be able to switch between their dominant and non-dominant (ND) limbs to complete a specific task at various points throughout the course of practice or a game. This is required for them to complete the task successfully. As Stockel and Wang (2011) discovered, with basketball dribbling and ball tossing, training for one specific task with one hand leads to improvements in the motor function of the opposite hand. This was the finding of the researchers who conducted the study.

Hypothesis

H_0: There are no differences between the performance of the random practice group and the blocked practice group.

H_1: Regarding bilateral learning transfer, the performance of the random practice group is significantly higher than that of the blocked practice group.

H_2: Learning transfer from one hand to the other is more pronounced when the non-dominant hand is used.

Materials and Methods

Participants

Male students from a local high school between 12 and 18 years were chosen randomly for this research. Everyone who participated in the trial had no prior experience with the tested activity. Participants in the study were provided with informed consent. And ethical standards flowed at each stage of the research procedure, following the "Declaration of Helsinki."

Experimental Task

The following is a sample of the learning tasks assigned to participants. In the BD and BND groups, the practice was blocked with the dominant hand switching to the non-dominant hand, while in the RD and RND groups, the dominant hand was alternated with the non-dominant hand during the random practice sessions. Finally, in a randomized order, the CD and CND (no practice) groups were required to do the dart-throwing activity using their dominant and non-dominant hands. Each group contained eighteen people (n = 18 participants). Self-reporting of the participants' handedness was used to confirm the dominant hand.

Procedure and Design

The participants received explanations of the task before beginning the tests. They received information on the entire study process and other pertinent information. The task of tossing darts is performed to gather data. Instead of a typical dart board, a dartboard with regular concentric circles is utilized. The dartboard consisted of 10 concentric circles, the innermost of which had a radius of 1.27 cm and a width of 2.54 cm. The participant shot a dart at a board with a series of concentric circles on it from three different work areas at various distances of 290 cm, 350 cm, and 410 cm. The target was in the centre of the board, and the other concentric circles served as scoring zones for accurate throws.

Random selection placed each participant in one of the six experimental conditions. Participants were instructed to toss a dart across their arms to hit the target in front. All terms, conditions, and instructions were explained to the participants by the researcher before the experiment's conduct. Before starting the experimental trial, the researcher demonstrated by throwing a dart himself. Before the trials began, each competitor made a warm-up throw. The experiment had three phases, i.e., acquisition, retention, and transfer.

Participants were instructed to practice throwing darts in the acquisition phase in either a blocked or random practice setting. Participants in the blocked group practised 81 trials in three blocks, consisting of 27 trials of the experimental task "A (290 cm)," 27 trials of the task "B (350 cm)," and 27 trials of the task "C (410 cm) (27 trials per block). All participants completed the three tasks in the blocked condition in a counterbalanced order. They completed the same activities in the random group in the same three blocks as they did in the blocked group. However, the trials' ordering was determined randomly, as in (ABB, CAB, and CCA). Every experimental block of 27 trials was conducted according to a random schedule, and it was required that no activity be done more than twice.

After the acquisition phase, 24 hours was used to conduct the retention phase. The task "A (290 cm)" was given to participants in nine trials in serial order (ABC, ABC, ABC), followed by nine trials in serial order (ABC, ABC, ABC) for the task "B (350 cm), and nine trials in serial order (ABC, ABC, ABC) for the task "C (410 cm)," totaling 27 trials over three blocks (9 trials per block).

A transfer test was administered during the transfer phase, which began one hour after the retention phase ended, to evaluate the consistency and long-term learning. Each participant conducted 18 trials with an untrained hand task "D (250 cm)" and task "E (430 cm)" in alternating order, nine trials from each of the two novel tasks.

Data Collection

In this experiment, if the dart hit the centre circle, which was the target, the thrower received 10 points. To others, 9, 8, 7, 6, 5, 4, 3, 2, 1, and 0 points were awarded when the dart landed on any circle or the outer side of the indicated target. If the dart dropped after striking a circle on the dartboard, a score of 0 was also given. In this study, metal darts were utilized, the time between trials for data collection was 5 seconds, and all groups received a 1-minute rest period between each experimental block. Following the conclusion of each experiment, verbal Knowledge of Results (KR) was given. The participants received no additional comments. Every trial was videotaped.

Results and Discussion

Acquisition Phase

The results of the ANOVA revealed that the BD group learned significantly more during the acquisition phase (F (3, 71) = 106.76, P = (0.000). The statistics in the table below (Table 1) indicate that the mean values for each group were as follows. The BD group's mean value (4.6111) was higher than the RD group's (4.2222), while the RND group's (1.1667) was higher than the BND group's (0.6667). During the acquisition phase, those who practised under overcrowded conditions (BD group) outperformed those who practised under random conditions (RD group).

Table 1.
Statistics describing the individual groups who participated in the acquisition phase

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	coefficient of variation
					Lower Bound	Upper Bound			
BD	18	4.6111	0.97853	0.23064	4.1245	5.0977	3.00	6.00	21.2211
BND	18	0.6667	0.68599	0.16169	0.3255	1.0078	0.00	2.00	102.8992
RD	18	4.2222	0.87820	0.20699	3.7855	4.6589	3.00	6.00	20.7996
RND	18	1.1667	0.78591	0.18524	0.7758	1.5575	0.00	3.00	67.3633
Total	72	2.6667	1.95729	0.23067	2.2067	3.1266	0.00	6.00	73.3984

Retention Phase

According to the ANOVA results, the performance of the RD group significantly improved (F (5, 107) = 25.883, P = 0.000). Table 2 below demonstrates that RD's mean value (3.833) was higher than that of all other groups, including BD (3.722), CD group (2.611), RND (2.000), CND (1.000), and BND (0.778) proving that the random practice group with the dominant hand produced better performance than the other groups during the retention phase. The results show that participants in the RD group perform significantly better than those in the blocked practice (BD, BND) and the control group (CD, CND).

Table 2
Statistics describing the individual groups who participated in the retention phase

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	coefficient of variation
					Lower Bound	Upper Bound			
BD	18	3.722	1.127	0.266	3.162	4.283	2.00	6.00	30.291
BND	18	0.778	0.878	0.207	0.341	1.214	0.00	3.00	112.912
RD	18	3.833	1.150	0.271	3.261	4.405	2.00	6.00	30.012
RND	18	2.000	0.970	0.229	1.518	2.482	1.00	4.00	48.507
CD	18	2.611	1.378	0.325	1.926	3.296	1.00	5.00	52.772
CND	18	1.000	0.970	0.229	0.518	1.482	0.00	4.00	97.014
Total	108	2.324	1.605	0.154	2.018	2.630	0.00	6.00	69.063

Transfer Phase

The results of the ANOVA point to the main effect caused by the RND group F (5, 107) = 24.555, p = 0.000. According to the table below (Table 3), RND's mean value (4.2778) was higher than that for the categories CND (3.1667), BND (2.7222), CD (1.2222), BD (1.5000), and RD (0.8889) demonstrating that the random practice group using the non-dominant hand produced superior results than the other groups during transfer. Participants (RND) who practised under the random condition outperformed participants (BD, BND), control groups, and those who practised under the blocked condition (CD, CND).

Table 3
Statistics describing the individual groups who participated in the transfer phase

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	coefficient of variation
					Lower Bound	Upper Bound			
BD	18	1.5000	0.51450	0.12127	1.2441	1.7559	1.00	2.00	34.2997
BND	18	2.7222	1.44733	0.34114	2.0025	3.4420	0.00	6.00	53.1673
RD	18	0.8889	0.90025	0.21219	0.4412	1.3366	0.00	3.00	101.2786
RND	18	4.2778	1.22741	0.28930	3.6674	4.8882	1.00	6.00	28.6927
CD	18	1.2222	1.11437	0.26266	0.6681	1.7764	0.00	4.00	91.1761
CND	18	3.1667	1.29479	0.30518	2.5228	3.8105	1.00	6.00	40.8880
Total	108	2.2963	1.63066	0.15691	1.9852	2.6074	0.00	6.00	71.0126

Discussion

The effectiveness of a random vs. blocked practice schedule on the bilateral transfer of learning was examined in the current study. During the acquisition phase, it was expected that performing random practice with the dominant hand (RD) would result in superior learning when compared to the other groups. The findings from the retention phase showed that the same group, RD, did significantly better than the other groups by a significant margin.

The results of the transfer phase showed that the scores of participants in the random practice with the non-dominant hand (RND) group were significantly different. Previous studies conducted by researchers have conclusively shown that random practice is substantially superior to blocked practice (Dayan & Cohen, 2011; Fazeli et al., 2017; Schmidt, Lee, Winstein, Wulf, & Zelaznik, 2018). (BP). The results of a few other research studies (such as Hall et al., 1994 and Schack and Mechsner, 2006), which further confirm these findings, indicated that random practice (RP) provided better results in the acquisition, retention, and transfer phases of the learning process. The findings of the subsequent trial, in which RP showed significant results compared to BP, were validated by the findings of a second investigation (Meira & Tani, 2001; Broadbent, Causer, Ford, & Williams, 2015; Medina, Baba, & Thomas, 2019). As a result, this study's outcomes supported the hypothesis that the retention and transfer phases of motor learning are when random practice is the most beneficial for developing a particular skill.

The current study also discussed how random practice helps facilitate knowledge transfer between bilateral partners. The research findings indicate that the random practice group with the non-dominant hand (RND) group is essential, and the finding shows that there has been a transfer from the non-dominant hand to the dominant hand. The results of this study indicated that it was possible for the trained hand that was not the dominant hand to transfer part of its knowledge to the trained hand that was the dominant hand (Kidgell et al., 2017). In addition, the research that Stockel and Wang carried out (2011) found that when the participants changed tasks bilaterally, the non-dominant hand typically became the dominant hand. This was discovered because of the findings of the previous point. The findings of this research project make it possible to conclude that random practice is more successful than blocked practice in increasing the bilateral transfer of newly acquired abilities. Additional evidence of the bilateral transfer of motor control from the hand that is not dominant to the dominant hand has been revealed based on this study.

Conclusion

According to the findings of this research, there are statistically significant differences between random practice and blocked practice when it comes to the transmission of bilateral learning. According to the statistical findings, learning and memory are improved with random dominant hand practice (RD). The outcome of RND's transfer test demonstrates bilateral transfer from the individual's non-dominant hand to their dominant hand. This research can be helpful for trainers, coaches, and physical education teachers in teaching sports motor skills.

Recommendations

Based on the findings, it is recommended that random practice schedules be prioritized over blocked practice for developing bilateral dart-throwing skills. This approach enhances skill retention and adaptability, especially when learning tasks from varying distances, making it a more effective method for motor learning in similar contexts.

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