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The Impact of Skill Level Matching in Cooperative Dyadic Interaction on Learning Table Tennis Forehand Skills among Adolescent Girls

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Abstract

Background: Dyad training is one of the new practicing methods which has received growing attention due to its increasing practice efficiency in skills.
Objective: The present study aims to investigate the impact of skill level matching in cooperative dyadic interaction on learning forehand table tennis skills in adolescent girls.
Methods: Participants were selected based on convenience sampling from among 24 junior high school girls in Nahavand city, and were randomly divided into two groups of Novice-Novice and Novice-Expert. Both groups performed six sessions of participatory dyad training with their respective arrangement (novice- novice, novice- expert), each session consisting of 20 sets of 3-minute with a 1-minute rest time between the sets. Using table tennis forehand shot accuracy test, the motor performance was measured in the pre-test, post-test, retention and transfer stages (merely forehand performance with increasing throwing speed of ball launcher machine).
Results: The results revealed that both Novice-Novice and Novice-Expert groups displayed significant progress learning of table tennis forehand skills. Moreover, the Novice-Expert performed better in the post-test, retention and transfer stages in comparison to the Novice-Novice group.
Conclusions: As a result, Novice-Expert arrangement facilitates learning table tennis forehand skill more than Novice-Novice arrangement during participatory dyad training.

Introduction

Studies conducted on skills learning and acquisition mainly seek to answer the question of what teaching methods and approaches can be both effective and efficient (e.g., in terms of time, cost, equipment, and other sources). One of the new practicing methods which has received considerable attention due to its increasing practice efficiency is dyad training (Shea, Wulf, & Whltacre, 1999). Inspired by Shebilske, & Regian (1992), Shea, Wulf, & Whltacre (1999) proposed dyad training. In Shebilske, & Regian (1992), subjects played video games in pairs, each party undertaking half of the complex task (space fortress); for example, controlling a keyboard or joystick, whereas the other group worked individually. Although the dyad training did not lead to more learning in that study, it was proven to be more efficient than the individual practice. In other words, two individuals practiced simultaneously over the same period of time, which was naturally twice as long as in individual practice, and required more practice time. In another study conducted by Arthur et al. (1997), it

was demonstrated that the re-acquisition of a task after 8 weeks of non-practicing was the same in both the individual and dyad practice groups. In this study, too, although dyad training was not more effective, it was more efficient than the individual practice. A large number of studies have proved the efficiency of dyad training in various sport and non-sport exercises, including: Reed, Fraser & Dougill (2009) in speed; Feth et al. (2009) in tracking precision; Wulf et al. (2001); Tolsgaard et al. (2015) in simulation-based skills; Granados (2013) and Ko & Hall (2017) in golf-playing; Darnis & Lafont (2015) in Basketball and Handball; Karlinsky & Hodges (2018) in balance training; Siavashi, Zareian and Daneshfar (2017) in roping and Parvinpour, Balali and Karimi (2017) in swimming. There are, however, several other studies which failed to verify the effectiveness of dyad training compared to individual practice, including: Crook (2008); Rader et al. (2014); Den Hartigh et al. (2018) and Lamotte et al. (2017).

Dyadic turn-taking practice and dyadic concurrent practice are two examples of dyad training, during which physical practice alternates with observational practice; the same intervals between trials recommended in practicing complex skills (Wulf and Shea, 2002). Through these intervals, learners can look at their training partner; an act believed to involve processing activities that affect acquisition and retention. Although at first glance the superiority of these practices is attributed to individuals' opportunity for practicing and observing, this seems to originate from something more important. In fact, the interactive and dynamic nature of the alternation between physical practice and observation seems to be the cause of this superiority. For example, the alternation between observation and physical practice in the first half of the exercise and partners replacement in the second half will not be helpful. However, research on dyadic turn-taking exercises is scarce, and only one uni-skill learning has been taken into consideration so far (Karlinski and Hodges, 2018). In behavioral sciences, individual (asocial) learning and social learning are distinguished from each other (Whitten et al., 2004). Social learning is a type of learning facilitated by observation or interaction with another partner, and involves multiple processes (Hoppitt & Laland, 2013). Relying on Vygotsky's view, the advocates of socio-constructivism promoted cooperative learning (CL) and acknowledged that adults or peers play a vital role in the development and growth of an individual. CL is now a fully-recognized teaching method in educational institutions. Johnson and Johnson (1989) held that there are 5 crucial components in CL: 1) Positive internal correlation (connection between group members), 2) Individual accountability, 3) Face-to-face interaction, 4) Interpersonal and group skills and 5) Group processing According to Deutsch (1949), CL is a collaborative and participatory game in which the achievement of a goal by one partner has a positive and significant correlation with the achievement of the goal by the other partner. Interpersonal interactions in real-world situations basically depend on predictions about how and when the practicing partner acts. These predictions rely on the observation of the practicing behavior of the

partner (Sebanz and Knoblich, 2009), and can be supported by invoking the sensory motor network and parietal forehead in the simulation of actions (Urgesi et al., 2010). In this way, we represent not only the actions we have to perform, but also the actions of our partner (Sacheli &Aglioti &Candidi, 2015). Forbes and Hamilton (2017) showed that participants tend to imitate the kinematics of others' actions, even when this imitation is detrimental to the efficiency and effectiveness of their own actions. In general, research has shown that pair-performance improves when subjects are able to perceive their partners' actions during collaborative and participatory motor interactions (Moreau et al., 2016).

One of the issues that has been taken into account in optimizing observational learning is paying attention to the skill level of the expert and the observer. In general, it has been shown that the more similarity there is between the observer's skill and the expert, the greater the possibility of optimal transmission and learning is (Pollock and Lee, 1992). In other words, the skill level of the expert affects the observer's cognitive load. In the expert model, although the individual receives a perfect motor pattern, this does not help the person involved in problem solving procedure, as he wants to first go through the basics and cognitive stages of learning and later fulfill error identification and correction. (McCullagh and Caird, 1990). Mireles et al. (2016, 2107) and Kager et al. (Panzer et al., 2019) have recently addressed the skill level of participants in training pairs and dyadic practices. Specifically, they sought to determine whether the level of skill, i. e. the similarity and skill matching can affect the performance and learning of those involved. Results of the study conducted by Mirales et al. (2017) on accessibility and stability tasks revealed that in dyadic practices in which an expert person and a novice attended, the task was performed better than when both parties were novice. However, the rate of transferability of the acquired skill to individual skill performance was higher in the novice pair. Simply put, the rate of transfer was higher when individuals practiced with similar skill levels (Mirales et al., 2017). Table tennis builds on the proper performance of the two partners. In other words, the skill is formed properly when the parties can act in a constructive partnership so that the desired skill is achieved. Whenever one of the parties makes a mistake in a sequence of repetitive skills such as forehand drive, the possibility of sequencing and learning the skill will be challenged for both parties.

Despite the studies conducted so far on dyadic practice, it is still necessary to investigate the skill levels of individuals involved in pair performance as well as its impact on the acquisition and learning of sport skills. What the present study is concerned with is the challenge that while numerous studies have shown the effectiveness and especially the efficiency of dyadic practice, and state that this training method leads to better learning and transfer, especially in skills requiring coordination, how can the efficiency of such practice be improved by making changes in its components? Emphasizing on skill arrangement, dyadic groups in this study were arranged in novice-novice and novice-expert arrangements to investigate the impact of skill arrangement on the novices'

learning. Given that one of the components of dyadic training is observation (Panzer et al., 2019), through observation, general rules of behavior are formed, and this coded information will turn into a pattern of behavior in the future. That is why individuals learn what to do by looking at an expert performer before doing anything. As a result, it enables individuals to save time and effort (Panzer et al., 2019). In the literature on observational learning, emphasis has been placed on observation of the expert performer which can develop the representation of correct movement, and that the observation of the novice's performance can help identify and correct their errors (Schmidt and Lee, 2018).

In many sports, individuals are exposed to both motor and cognitive challenges. During a tennis match, for instance, the athlete has to focus on the position of his opponent's body, and follow the path of the approaching ball while at the same time running towards the correct position to return the ball, which in this situation requires more cognitive effort. Relevant scholarly literature has also revealed that novice performers tend to keep their cognitive effort at a low level, and use the same strategies in their practice, while expert performers show more flexibility and make more cognitive efforts for themselves (Panzer et al., 2019). In other words, expert performers attempt to create more cognitive challenges in their training by hitting different targets. It seems that in a dyadic practice protocol, the expert's practice and his observation create more motor and cognitive challenges for the novice partner and lead to better learning. Therefore, due to the observational nature of these practices, the effects of skill arrangement in cooperative dyadic practices on learning the table tennis forehand skill can be addressed.

Method

The present study is a quasi-experimental research with repeated measures design, involving two experimental groups of dyad practice. In terms of results, it is an applied study due to the presentation and use of its scientific results. Initially, the sample size for each experiment was calculated using G * Power 3.1 software. Based on previous research (Karlinski and Hodges, 2018), the average effect size (f = 0.25) for intergroup-intragroup design which included 2 groups and 4 measurement stages with an alpha level of 0.05 and a test power of 0.80 was estimated at 24 subjects. Therefore, 24 junior high school girls from Nahavand schools were selected based on convenience sampling, and were later randomly divided into two groups of novice-novice (14/0 +- 66/65) and novice-expert (15/16 + 0/83 years). Moreover, 12 expert table tennis players who had at least 3 years of experience in this field were conveniently selected from among the players. These had referred to the Nahavand Table Tennis Board, had participated only in the practice sessions of the novice-expert group, and had received no motor evaluation. The inclusion criteria of the study were lack of training experience in racquet sports, especially table tennis, being right-handed (self-report), having a natural eyesight (self-report) and falling within the age range of 14 to 16 years. Exclusion criteria, however, was failure to complete training and evaluation sessions.

A personal characteristics questionnaire was used to collect the participants' basic information, including questions such as age, weight, medical records, previous sports records, and level of education. A consent form was also used to obtain written permission from participants and their parents to participate in this study. Information about the participants' performance during the evaluation process was entered on the scorecard. Due to the Covid-19 conditions, the study equipment was completely disinfected, participants' fever degree was measured, and all executive members used gloves and masks during the study.

The task which was measured in this study was table tennis forehand skill, performed on a standard table with a length of 274 cm, a width of 152.5 cm, a height of 76 cm and a net height of 15.25 cm (Figure 1). Further, a Table Tennis RoBoT ball launcher (made in Taiwan) was used in the tests that threw tennis balls at a 30-degree angle. In the pre-test, post-test and retention phases, the ball speed was set to 3 degrees and about 45 km / h, and in the transfer phase to 4 degrees. Throwing speed was identical for all hits and subjects. Accuracy of table tennis forehand skill was calculated using the table tennis forehand shot accuracy test, which was a five-point scale (sum of trials) whose scores were calculated sequentially (Liao and Masters, 2001).

Results

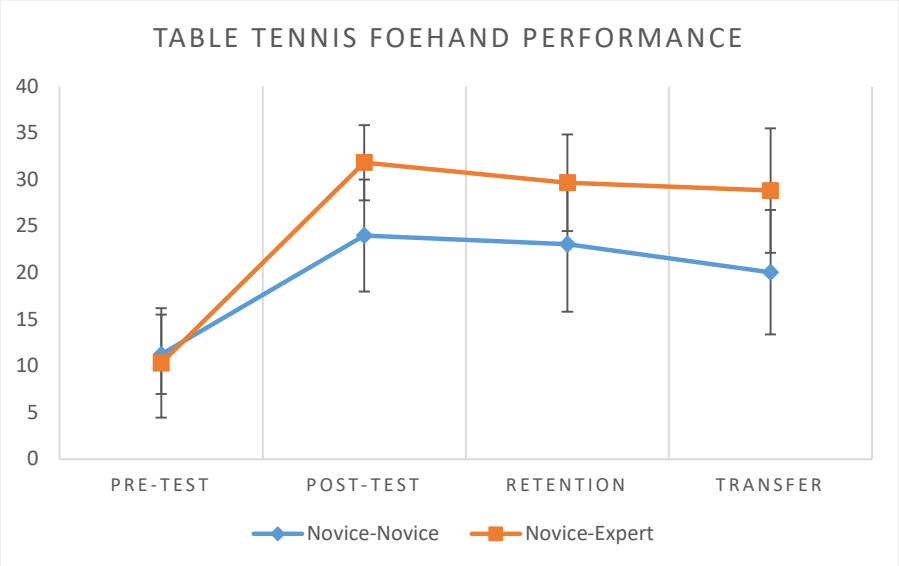

Figure 1. Mean and standard deviation of table tennis forehand skill performance in research groups.

Results of combined ANOVA test with Mauchly's Sphericity test ($P \leq 0.05$) demonstrasted that the main effects of stage ($F = 53.59$, $P = 0.0001$, $\eta 2 = 0.70$) and group ($F = 16.94$, 0.0001) $P = =$, $\eta 2 = 0.43$) and the interactive effect ($F = 4.22$, $P = 0.01$, $\eta 2 = 0.16$) are significant. To better understand the results, the independent t-test was used to observe the inter-group differences in each step (by adjusting the significane level at 0.012 to reduce the probability of type 1 error) and

Bonferroni post hoc test was used to track the results of the effects of the measurement steps.

Results of independent t-test showed that in the pre-test stage (t = 0.43, P = 0.66), there was no significant difference between the forehand performance of groups. However, in the post-test stages (t = -3.74, P = 0.0001), retention (t = -55.5, P = 0.01), and transfer (t = -3.65, = 0.0001) P), the novice-expert group performed significantly better than the novice-novice group.

Results of Bonferroni post hoc test revealed that the subjects of both groups performed table tennis forehand shot better in the post-test, retention and transfer stages than in the pre-test stage. There was, however, no significant difference between post-test, retention and transfer stages (Table 1).

Table 1: The dyadic comparison of the study phases.

Phase (i)	Phase (j)	Mean difference	Significance level
Pre-test	Post-test	-17/12	*0/0001
	Retention	-15/58	*0/0001
	transfer	-13/66	*0/0001
Post-test	Retention	1/54	0/88
	transfer	3/45	0/27
retention	transfer	1/91	0/99

Discussion and Conclusion

The present study aimed to investigate the impact of skill matching in cooperative dyadic interaction on learning table tennis forehand skill among adolescent girls. According to the findings, both novice-novice and novice-expert groups showed significant progress from the pre-test to the transfer stages. In other words, training in general, regardless of the skill level of the training partner, led to the learning of table tennis forehand skill, a finding in line with the results of most studies conducted on dyad practice (Shea et al., 1991; Tolsgaard et al., 2015; Granados, 2010; Co and Hall, 2017; Darnis and Lafonte, 2015; Karlinsky and Hodges, 2018; Siavashi et al., 2017; Parvinpour et al., 2017; Panzer et al., 2019; Granados et al., 2007). In general terms, the progress of individuals after each type of training can be justified using the power law of practice, according to which at the beginning of training, a significant improvement is seen in the performance of new learners (Schmidt and Lee, 2018). One of the possible reasons for the effectiveness of dyad practice is expert observation. For years, researchers in the field of observational learning have shown that observation in the early stages of skill acquisition leads to a richer practice environment (Ste-Marie et al., 2012). The nature of the task in the present study only allows intermittent (not simultaneous) dyad practice,

which enables one party to observe the other party between physical trials. However, according to the perceptual needs of the task for spatial and temporal adaptation of the rocket movements with the ball, the subjects have probably paid more attention to the movement of the ball than to the movement pattern of the opponent. But it is not possible to separate the amount of attention to the ball and the opponent's movement. It is suggested that future studies investigate glaring behavior in dyad practices using an eye tracker. It also seems that dyad practice increases the motivation of learners as a result of adding competition to the training situation. Thus, the competition may cause learners to choose higher-level goals (36). The scholarly literature on goal setting has shown that specific and short-term goals lead to more performance and learning of motor skills (Weinberg and Gould, 2018). Another advantage of dyad training is the constructive interaction which is created between the training partners after each trial or training block. It is likely that after each trial or group of trials, the expert partner has given the observing partner feedback on their performance, which contained both information and motivational load. Moreover, both partners may have shared different strategies to solve the motor problem, which led to their greater involvement in problem-solving processes (Shea et al., 1999). In this study, due to external pase of skills and performance speed and its alternation between two parties, there was no opportunity to interact and provide feedback during the practice, but it is possible that the two parties, especially in novice-expert group, may have involved in interaction and information sharing after the exercises in each session. However, as mentioned earlier, certain studies (Crook, 2008; Rader et al., 2014; Den Hartigh and Marmelat, 2018; Lamotte et al., 2017) failed to demonstrate the effectiveness of dyad practices compared with individual ones, possibly due to methodological differences between them and the present study such as the type of skill, the subjects, number of sessions and the nature of task. In Crook (2008), subjects practiced a computer software program individually and in pairs, and the results revealed that when individuals are trained individually, learning duration lasts longer. Räder et al. (2014) also displayed that there was no significant difference between the two groups of dyadic and individual practices in learning a complex medical skill. Therefore, dyadic practices are probably more effective in coarse motor skills than in fine and cognitive motor skills. In a review study, Lamotte et al. (2017) also showed that there is insufficient evidence to support the benefit of dyad practice interventions on cognitive function and behavioral and neuropsychological symptoms in participants suffering from Alzheimer's disease. Thus, dyad practice is likely to be more effective in individuals with relative health than in individuals with cognitive impairment (Lamotte et al., 2017). Den Hartigh et al. (2018) also indicated that adaptation complexity cannot be attributed to rowers' imitation behavior or adapting to each other after a training session. Therefore, the effectiveness of short-term dyadic practices cannot be demonstrated in relatively complex skills (Den Hartigh and Marmelat, 2018). Further, the novice-

expert group performed better in the post-test, retention and transfer stages than the novice-novice group, which was consistent with the results of studies conducted by Mirales et al. (2016, 2017) and inconsistent with the results of studies conducted by Kager et al. (2019). Few studies have examined the skill level of participants in training pairs and dyad practices. The difference of the present study and other consistent studies with other non-consistent studies may be attributed to the different nature of the tasks measured. Some scholars believe that training with the same skill level (novice-novice) is more beneficial than training with unequal skill level (novice-expert) due to error correction for rehabilitation protocols, especially for low-power training pairs (Kager et al., 2019). According to the results of the present study and, to some extent, Mirales et al. (2016, 2017), it can be said that playing with expert partners may be more beneficial for novices in sports skills such as table tennis. Given that a crucial part of dyad practices is observation, the results of this study can be interpreted from the perspective of the observational model. Demonstrating an expert pattern in the process of practicing motor learning is the most preferred method, and helps the learner to create a correct pattern of how to perform the skill properly. In addition, this pattern is subsequently used as a resource for detecting and correcting errors in performance, providing a stronger mental display of skill (Rahbanfard and Proteau, 2011). Thus, as long as the subject acquires a proficient pattern of the skill, the benefits of individual learning increase through observing the correct source criterion (Este Marie et al. 2011; Lelievre et al., 2021). To justify the superiority of the novice-expert dyad training, theoretical mechanism of coadaptation can be referred to which means the rearrangement of the system's components in order to adapt to the environmental changes. The presence of continuous rearrangement capacity in the system components (degrees of freedom in a complex adaptive system) allows functional variability to the two training parties who need to adapt to changes in the performance environment. Successful performance in sports relies on the fine combination of stability and change to achieve the desired outcomes, which are based on synergy formation. The balance between stability and functional variability in two training partners can result from degeneracy (in other words, where coordinated structures are called to achieve the same or different performance results) within the system (Smith and Lane, 2016).

According to the results of the present study, novice-expert dyad practice is a representative learning scheme. Representative learning schemes build on the key principle that movements should usually be linked to the perceptual variables which determine the practicing tasks simulating a competitive environment. Ecological dynamics argues that in designing tasks in individual and team sports, training simulators are needed that are designed for athletes based on accurate sampling of information variables in specific performance environments so that athletes are able to use them for regulating their behaviors. Representative training tasks allow athletes to use their cognitive, perceptual, and action processes in a fully

integrated manner during performance (Pinder et al., 2011). However, given that in the present study, forehand skill has been assessed in a quantitative and result-based manner, it is suggested that future studies also examine the movement process. In addition, measuring glaring behavior using an eye tracker can provide more information about the visual attention of the two partners in pair arrangements in terms of skill level and effect mechanism.

In general, results of the present study, like those of the previous studies, substantiated the effectiveness of dyad practices. This study was also the first attempt to examine the skill arrangement in cooperative dyad practices in a sport skill. It revealed that novice-expert arrangement is more efficient in comparison to novice-novice arrangement as the former enjoys the benefits of using the optimal observational pattern (seeing an expert person), and offeres various challenges and strategies for the novice partner as a result of exercising with an expert partner. To conclude, novice-expert dyad practice promotes the speed of learning among table tennis learners.

The message of the article: cooperative dyad practice in novice-expert pairs is more effective than in novice-novice pairs in learning table tennis forehand skill for novices.

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