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Research Article

Transfer of Motor Skills from Virtual Reality to Real Environment

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Abstract

Aim: the aim of the present study is to evaluate the transfer of motor skills from Virtual Reality (VR) to Real Environment (RE).

Methodology: participants included students who were divided into two groups of VR and RE according to their pre-test scores.

Findings: The results of ANOVA with repeated measurements and MANOVA depicted significant improvement is both groups at the learning phase. Moreover, the positive transfer and lateral transfer from right hand to the left hand in table tennis were happened in both groups.

Conclusion: sometimes, even better than the "RE", VR can be an efficient tool in learning and teaching motor skills as it acquires easy modifiable setting.

Keywords: Motor skill; Virtual reality; Real environment; Learning

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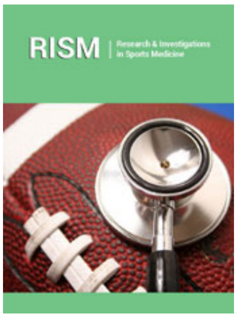

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Introduction

The aim of Virtual Reality (VR) is to allow individual(s) to perform a cognitive-motor activity such as cognitive activity in a simulated unreal world. A practical ground in VR is education that has been drawn great attention to itself. Virtual environments include many aspects of an ideal average-level education. Application of virtual settings allows instructor to control stimuli and feedback patterns, provide the possibility of supervision on performance, and increase motivation. Finally, the final aim of education is to transfer newly learned materials into the new settings. Transfer is a key concept in learning theories. In fact, transfer is vital issue in learning. Transfer has been defined as the development of retention and knowledge, skills, and implementation of attitudes from practical setting to reality. It is also a touchstone in assessing virtual setting (including constancy, adaptability and technical dimensions like the size of scope), all of which are important underlying backgrounds for a positive transfer [1]. From this viewpoint, acquisition of the capability of knowledge and skill transfer is one of the main factors of learning economy which lowers down probable costs. Recent studies have provided evidence on the positive transfer of learning from VR to RE [2]. Also, the main subject of learning transfer is bilateral transfer. Theoretically, bilateral transfer happens when learning transfer consequences in the learning of a task with other parts being either symmetrical or asymmetrical. Symmetrical transfer is when transfer happens equally from right part to the left part or vice versa and asymmetrical transfer is when the level of practice causes the level of transfer to be higher in one side of the body when compared to the other side [3]. In sports, probably the first transfer study focused on the simulation of table tennis. It showed better performance of simulation group when compared to the controls. However, due to the lack of visual signs, skill transfer was not accomplished. By the advancement in technology Virtual Reality (VR) appeared. Applying VR and video games for education and training, rehabilitation, and mental fitness was greatly emphasized [4-6]. Moreover, simulation-based education along with Ludic-based approaches were designed for mental-outcomes learning such as cognitive, sensory, a motor skills that may be even harder/dangerous, or have difficult educational infrastructure e.g. [7-9]. It has been predicted that a true and comprehensive VR allow people to communicate with events and things via more novel and meaningful approaches and would get underlying data and integrate them with "knowledge of doing work" [10]. Furthermore, the open structure and inherent self-discovering information in VR can improve background learning and transfer of situational knowledge [10,11].

Given skill transfer from VR to RE, Larid, showed that utilizing VR is possible to promote walking skills in order to avoid collision with hurdles. It also potentially provides a new way to lower down the risk of falling [12]. On the other side, Router et al, in their study provided boating opportunity through VR and concluded that acquisition of motor skills was possible through VR settings and proposed that it can be transferred to RE [13]. Trip et al. [14] studied the transfer of training Darts utilizing Xbox along with kinect. Both real and virtual groups showed improvements in their throwing. In summary, their study showed partially acceptable results in presenting the advantages of training with VR [14]. Finally, Gray et al. [1] showed that the practice of VR is transferred to the real world specially when the administering background in VR was similar to the RE. VR has been used in a wide range of educational fields. However, up to the present moment, few studies have been carried out on the merits of using VR in education. Utilization VR for training cognitive-motor skills is rapidly growing in the field of different sports. Development of virtual environments as an E-learning tool can facilitate learning and task transfer. Therefore, the successfulness of these merits in the field of education and rehabilitation can be more interesting when it facilitates task learning and skill transfer. Nevertheless, lack of any investigation is highlighted here and thus, the present study has been conducted to investigate whether educating sport stimulation can be transferred to reality or not?

Methodology

Participants and method

The participants were 24 BS female students in different non-sport fields of study (age average was 20.31±0.72) who were voluntarily participated in the present study. inclusion criteria were right- handedness, lack of any experience in table tennis, and the absence of any visual impairment. In the present investigation, Xbox along with Kinect was used to transfer movements and to provide VR settings. For pre-tests and acquisition and retention tests 6.50cm×50cm squares in two rows and 3.25cm×25cm squares inside bigger squares of the first rows were specified on the surface of table tennis. The balls were thrown by NEWGY robo pong 2040 with no rotation toward participants with the intervals of 3 to 4 seconds and on the right end edge of table and then the participants responded. Ball hit to area No 5 was scored as 3, area No 2 scored as 2, and other areas scored as 1. Wrong hit was not scored [15]. To perform and assess this task, a standard tennis table, table tennis racket, 100 tennis table balls (diameter 40ml), and NEWGY robo pong 2040 was utilized. The present research had five stages of pre-test, acquisition, and post-test (retention, transfer, and lateral transfer). At the first stage, all participants were taught of forehand skill in table tennis. In the following, after ten hits in pre-test, the participants were divided into two groups of group 1 (RE practice group) (this group was trained by a professional instructor in terms of target skill) and group 2 (VR practice group). In this group, the participants learned the skill via a valid and approved training movie and were also asked to handle the racket in western manner (as if they shake hand with the racket) and they had five minutes to get familiar with racket and ball) (Figure 1). Acquisition stage was comprised of six sessions through which 360 hits were performed in a way that each session included 60 hits in 6 ten-blocks and then they took rest for two minutes between two blocks (Figure 2). After the practice sessions, the participants immediately entered the acquisition stage, and they were respectively entered retention, transfer, and lateral transfer stages 72 hours later and performed 10 forehand hits in each test. In transfer test the forehand hit was analysed and in lateral transfer test the participants performed forehand skill with their left hand. It must be noted that in all stages the balls were thrown with no rotation by NEWGY robo-pong with 20 balls per minute. Moreover, the participants performed all stages in a quiet environment, and all filed the consent form to participate in the study.

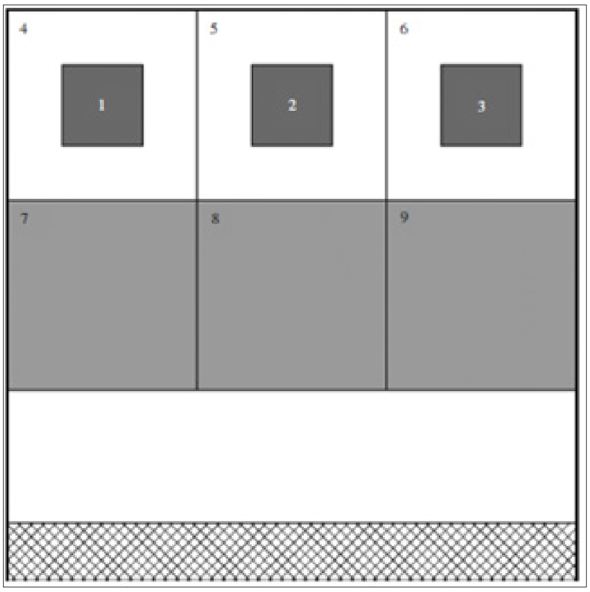

Figure 1: Divisions of tennis table for scoring.

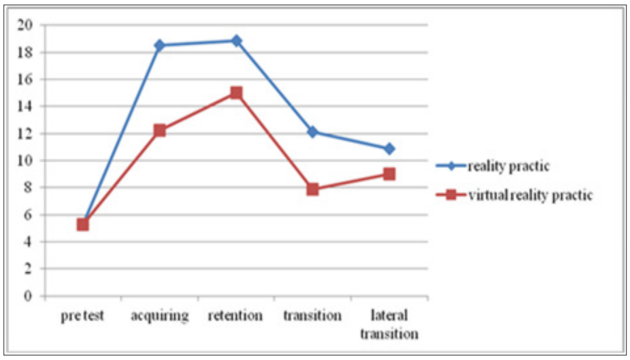

Figure 2: Mean of hits scores in different stages.

Statistical method

In the present investigation descriptive statistics were used to classify data, Shapiro-Wilk test was used to assess the normality of data distribution, ANOVA test with repeated measures, MANOVA, and LSD follow-up test was used for data analysis (Table 1). P>0.05 was considered to be statistically significant and thus, the normality of data distribution was confirmed. At first, pre-test was performed to place people in homogenous groups according to the score of pre-test stage (Table 2). Then, training sessions were held and after that acquisition, retention, transfer, and lateral transfer tests were respectively administered. Initially, the hypothesis of MANOVA test were evaluated and then the results from Levene's showed that the variance homogeneity hypotheses for the variables is true in the range of P=0.495 to P=0.543 (P>0.05). Hypothesis of Covariance homogeneity in variables was also confirmed (P>0.05). All stages were processed by SPSS software (version 18) and the level of significance was 0.05. As illustrated in (Table 3), the results of ANOVA with repeated measures test showed that both groups had improvements (real practice group: $F(4,44) = 74.44$, $p<0.001$, $\eta 2=0.871$) and VR group: $F(4,44) =38.88$, $p<0.001$, $\eta 2 =0.779$). In other words, Forehand skill was improved after training sessions in both groups. Moreover, as shown by (Table 4), there was no significant difference between retention and acquisition. It means that the intervening variable was learning variable. Also, as suggested by (Table 5), the results of MANOVA test revealed that there was no difference between two groups in all stages suggesting the fact that the considered skill was transferred (Table 6).

Table 1: Mean ± SD of participants' demographics in both groups.

Group	Age	Weight	High
Reality Practice	20.37(0.74)	55(8.7)	163.12 (7.1)
Virtual Reality Practice	20.25(0.70)	53 (9.6)	162.7(5)

Table 2: Mean ± SD of performed hits in each test.

Dependent Variable		N	Pre	Acquiring	Retention	Transfer	Lateral Transfer
			M (SD)	M (SD)	M (SD)	M (SD)	M (SD)
Group	Reality Practice	12	5.25	18.50 (2.33)	18.87 (1.7)	12.12 (1.2)	10.87 (1.02)
	Virtual Reality Practice	12	5.25	15.83 (2.54)	15.84 (3.38)	7.87 (1.38)	9 (1.19)

Table 3: Results of ANOVA test with repeated measures in all stages (pre-test, acquisition, retention, transfer, and lateral transfer).

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	
Group	Reality Practice	1560.375	4,44	390.094	74.449	0.001	0.871
	Virtual Reality Practice	696.75	4,44	174.187	38.885	0.001	0.779

Table 4: Results of Benferroni follow-up test in all stages (pre-test, acquisition, retention, transfer, and lateral transfer).

Group	Pre-Test				Acquiring			Retention		Transfer
	Acquiring	Retention	Transfer	Lateral Transfer	Retention	Transfer	Lateral Transfer	Transfer	Lateral Transfer	Lateral Transfer
Reality Practice	0	0	0	0.008	1	0.001	0	0	0	1
Virtual Reality Practice	0	0	0.01	0.037	0.105	0	0.018	0	0.001	1

Table 5: Results of MANOVA in all stages.

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Group	**Acquiring**	**234.375**	**1,21**	**234.375**	**43.885**	**0**	**0.676**
	Retention	90.094	1,21	90.094	11.964	0.002	0.363
	Transition	108.375	1,21	108.375	21.258	0	0.503
	Lateral. Transition	21.094	1,21	21.094	3.234	0.087	0.133

Table 6: Results of Benferroni follow-up test.

Dependent Variable			Acquiring	Retention	Transfer	Lateral Transfer
Group	Reality Practice	Virtual Reality Practice	0	0.002	0	0.087

Discussion

The present study showed that transfer and lateral transfer was happened from VR to RE. It was also confirmed that better transfer happened in RE to RE when compared to VR to RE. However, the difference was not significant and could be eliminated by small modifications of parameters in VR and also their more adaptability. Nevertheless, task stability tests were specifically selected as they can be depicted realistically in VR because the cognitive-motor properties of both virtual and real versions of the tasks are partially equal. These theoretical axioms can predict that the transfer of exercise from RE to its real performance is more than its transfer from VR to RE. In advocating these findings, it can be said that high levels of aerobic exercises during active sports can improve cognitive control and subsequently improve cognitive performance [16].

Inactive video games can significantly increase attention among player as they need to have control on some tasks to achieve success. When compared to non-professionals, young players of video games had more visual process and attention, more able to change the task, and processed more information over the longer period of time [17]. It was also revealed that attention was significantly increased in participants over a 10-days period of practical game [17]. Despite the fact that there is a lack of investigations on the relation between active games and attention, it can be suggested that based on the info taken from the players in active games their attention and transfer to another task were increased. Researchers suggest that in learning active games reminding spatial structure becomes possible. Also, people have more understanding of perception-action coupling and the relation between movements and visual entries. Therefore, better performance in learning active games is a modified interaction that happens even if other factors like enhanced motivation and engagement in performing the task caused by task interference (joystick) would exist [18]. Transfer of spatial knowledge from VR had been studied on different people in different settings. The results generally showed that going deep in VR can facilitate knowledge transfer when there is higher homogeneity between reality and game settings. The importance of background overlap between learning and task adjustment has been called close transfer in learning [19]. The results of the present study, in fact, confirm its preliminary findings suggesting that learning is possible through playing. Learning content and transferring situational knowledge can happen by more perception of spatial relations in an environment [20]. The fact that showed great success in transferring spatial data to real navigation tasks shows that subjective reflections are compatible with the spatial design of the target environment. Transfer of training depends on the number of shared cognitive-motor properties of environments that exist in practical/transfer tasks. It is also suggested that training happens through the relation between physical aspects of the task and cognitive orders meanwhile the task [21]. If the performance is based on virtual learning, then, compared to the real learning for special types of learning, there would be less need for cognitive performance. In its special terms, it shows that virtual learning can be utilized in some cases such as when to train people with complicated duties in which any possible error would be dangerous and expensive or in training people with cognitive impairments [21].

A general assumption during practice was that people understand relation that can be generalized to other fields, if these fields provide grounds for this relationship or properties. This relation assumes that the elemental variables of a needed task in specific situation are similar (e.g., the degree of available freedom among different people to perform similar task such as joints, muscles etc.). For instance, in throwing from top of the shoulders, several joints are involved, but each joint movement is coordinated with the other joints in a way that the collective movement pattern is depicted using less variables (joints performance) even when some parameters change (throwing distance, speed, etc.). Therefore, in learning the throwing, only the performance is learnt in which all joints' movements are related to perform the task in its specific way [22]. A common instance is the concept of structural learning [23,24]. The idea is that the learner, when he practices a task which include many elemental variables, finds a structure that coordinates all these variables. These variables are enough to reach the aim. If a new task is performed by low-dimension structure then, transfer happens. This idea is similar to the other concepts of transfer such as traditional structure [25], or the coordination tasks [26]. The common point of all these structures is the assumption that in similar tasks people learn similar relations during the practice. The also learn the situation through which they find solution to the task through movement facilities space (task space) (Pacheco & Newell, 2018). This search is shown at every moment of practice by changing task dimensions (e.g. effort to effort or intra-effort, etc.). In this approach, one of the two properties must exist for a similar task between task spaces to be transferred or the target space must exist, that is the limitation in which task learning is attainable by the availability of only one relation (coordinative performances, low-dimension structure), or very similar people that look for similarities among themselves and search for result in one relation Pacheco [22]. As revealed, the groups were successful in lateral transfer, and when compared to initial trainings, they did left-hand movement pattern better than the initial stage. Here, the lateral transfer is the result of cognitive- motor factors [27]. The previous investigations have shown that motor learning tasks probably include a visual distribution network and cerebral motor-related areas that undergo some changes Kidgell et al. [28].

Another explanation for lateral transfer is observational learning and improvement of data extraction to facilitate the control of movements' predictability [29]. In fact transfer happen by stimulating cerebral transmission [30], Using intra-hemisphere interaction concept, the stimulation of direct stream of cerebral transmission is done by facilitating the stimulation of primary motor layer or the inhibition of primary motor layer in hemisphere. It is recently suggested that stimulation of both hemispheres [31] or cerebellar cortex (in which the internal patterns are probably saved) are stimulated simultaneously [32]. In fact, using mainstream of cerebral transmission can stimulate the change of synaptic mechanism that is probably plays role in learning [33]. Lateral transfer is caused by the overflow of motor impulses in brain caused by increased workload in practicing part of the body [34]. Neurological pathways are intersected in Central Nervous System (CNS) lower centers. Some of them are unilateral. Even weak, neurological pathways emanate nerve impulses to the similar parts on the other side of the body. It is thought that these weak impulses means that the learner does not initiate learning with the opposite part [35]. The theories that propagate the transfer from dominant hand to non-dominant hand are fast skill model and crossover action model. Fast skill model proposes that the movement plan forms in the hemisphere that is opposite to the under-training hand, therefore, the non-dominant hand can benefit from the program which is being practiced by dominant one and then transfer happens to non-dominant hand. But this transfer does not happen vice versa. This model also proposes that learning with dominant hand is better than learning with non-dominant one. The crossover action model also suggests that during practice with dominant hand dual movement programs are established in each hemisphere, but the left hemisphere acts better in this regard Chase [36]. There were some limitations in this study despite its interesting outcomes on the relation between virtual training and real world. For instance, it was assumed that there was high similarity among the virtual and real tasks, but the future studies should be improved in two aspects of motor performance, such as identifying the type of ball spin in movement and showing the exact location of the ball's impact according to the direction of movement of the hand subject. The present study did not evaluate the kinematics; however, the direct observation showed that forehand pattern in table tennis was similar in both groups. Showing the exact location of the ball's impact according to the direction of movement of the subject.

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