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Influence Ability of Motor Learning from Laterality Using Mental Exercise in Right-Handed Children

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ABSTRACT

In the present study, we investigate laterality effects on motor learning based on motor imagery workout in childhood. Four children groups that were mentally and physically right hand performed reaching movement via upper and non-upper hand with speed and accuracy as possible. Before and after training session the movement time has recorded and analyzed. Results showed that mental and physical practices through similar learning processes (similar exponentially learning curves), have positive effect on both hand performance. But in comparison with mental imagery, motion time in post-test session became significant for both hands after physical practice. More importantly, in comparison with motor imagery with non-upper hand, mental imagery with upper hand leads to wider progress in motor speed. This kind of advances did not show up in control group. Findings of this study show priority of upper hand in motor learning via mental workout.

Keywords: Motor Imagery, Motor Learning, Mental Training, Internal Pattern, Reaching Movement, Children

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INTRODUCTION

During practice mental imagery, test subjects simulate the motions internally and without generating movement. This mental process refers that people recognize the implementation feeling of motion from first-person perspective. Psychological and neurophysiological studies show that mental states and real movement, cause imagery of similar movement and overlapping neural substrates (Gerardin et al., 2000). It is reported, for example, activation of the joint segments of the side and front of the prefrontal, supplemental motor area, parts of the original motion and the motion, cerebellum, basal ganglia and Cerebellum bars (freeman et al., 2003). In addition, during intellectual exercise by individuals, autonomic nervous system activation increases as heart rate and respiration and finally, mental activity keeps the same space-time features and obey the laws of motion are the same as their public counterparts. Mental workout by moving imagery techniques is considered as a potential tool in sports and motor rehabilitation because this method has been proven to improve motor performance (Lindvall et al., 1990). In particular, mental exercise in terms of kinematics causes increase muscle strength and improves movement. The concept of internal model provides theoretical basis for understanding the positive effects of mental practice on motor performance. Leading internal pattern, in anticipation of sensory-motor mode (position, speed), or according to the relevant version of the efferent nerve simulates the mandate of the current state, the causal physical process. During physical exercise, with producing an internal training signal can be used for fulfilled state motor system to correct gesture commands that modulates the neural processes plastic. In addition, it is assumed sensory delay and noise feedback combine with leading model output till provides accurate and true estimation (Jeannerod, 1995). During mental exercise, similar plastic neural mechanism can be used based on an estimated motor system state.

Learning motion through mental training is associated with changes in brain activation in healthy subjects and people with stroke. But, since during mental exercise to estimating the state originates only from the leading pattern, it is possible that workout signal has less accuracy and precision than physical exercise. This may partly explain why mental workout has generally less efficient than physical workout (Ranganathan *et al*., 2004).

Previous studies have shown that the control system's right-hand / left hemisphere, contributes in organize and navigate, view and learn moves, estimation posture which in turn refers to important role of pre-futurist control process. On the other hand, the right hemisphere / left hand control system, with preferential participation in the processes of feedback control, reduces more advanced planning functionality (Oztop *et al*., 2005). According to this advanced mechanism (dynamic hypothesis-dominant), to proportion of left hand, mental exercise of the right hand can be expected to have more learning, because, control procedures are based on pre-existing mental workout and there is no motor feedback. In learning movement through mental workout, laterality effects is opened as forecasts of upper hand control system due to lack of experience or application compared with the right hand It is somewhat awkward (experience dependent workout-hand top side)(Jackson *et al*., 2001). Previous theoretical studies that predicted state estimation during mental activities in comparison with the non-dominant hand should be more precise and more accurate for the upper hand led to faster and better learning at upper hand (saj *et al*., 2014). and they were investigated in adults. Gentili RJ *et al.*, (2010).

In the present study, we consider the effect of laterality on movement learning through motor imagery workout in children 7-12 years. We asked four right-handed children groups to perform mentally and physically as quickly and accurately as possible (balance of speed/accuracy of speed/accuracy) frequent reaching movement toward multiple targets and in a predetermined direction with an upper and non-dominant hand. Based on the previously mentioned motor laterality processes, we anticipated that the upper hand mental workout in comparison with non-upper hand should lead to increase the performance. Thus, this research helps to development of the basic processes of learning in upper and non-upper hand during mental workout.

EXPERIMENTAL SECTION

Participants

Sixty healthy, right-handed children (with mean score of: 83%, based on the supremacy of Edinburgh and a good illustration (with mean score of: 40.1 the maximum score of 51 on the Motion Imagery questionnaire) have participated in the experiment. The participants were randomly divided into five groups (table 1): i) pd group with upper hand physical exercise, with age average of 10.2 five boys and seven girls; ii)md group with upper hand mental exercise, with age average of 10.7 five boys and seven girls; iii) pnd group with non-upper hand physical exercise, with age average of 9.8 eight boys and four girls; iv) mnd group with non-upper hand mental exercise, with age average of 9.7 eight boys and four girls; v) The control group c, with an average age of 10.0 include six boys and six girls there were no difference between groups . All the parents had given their informed consent. The experimental group was approved by the ethics committee and it was agreed on the legal requirements and international norms.

Table 1: test charts - three sessions (pre-test, workout, post-test)

group	workout	pre-test	post-test
pd	60 real mental tests of upper hand	3 real tests of upper hand	3 real tests of upper hand
pnd	60 real mental tests of non- upper hand	3 real tests of non- upper hand	3 real tests of non- upper hand
md	60 real mental tests of upper hand	3 real tests of upper hand	3 real tests of upper hand
mnd	60 real mental tests of non- upper hand	3 real tests of non- upper hand	3 real tests of non- upper hand
c	60 mental tests of visual	3 real tests of upper and non- upper hand	3 real tests of upper and non- upper hand

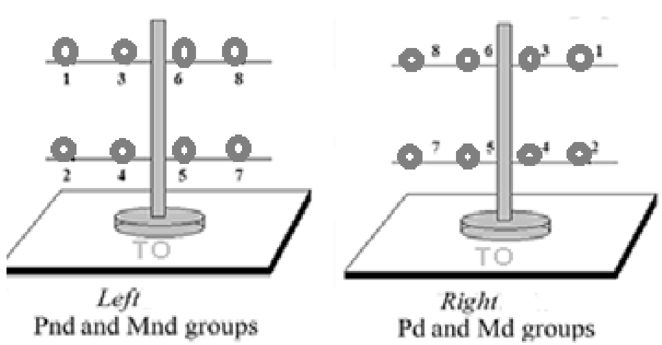

Figure 1: test structure

Experimental tool and motor task

Experimental tools which utilized were similar to that method that used by J.gentile et al.. Two aluminum corns (with a length of 75 and a diameter of 1 cm), were installed in a vertical bar (height 86 and diameter 10 cm) with a distance of 44 cm from each other. In each corns symmetrically goals were put, namely two vertical bars on the left and two on the right vertical bars. Horizontal distance that determines the proximity (3, 4, 5, 6) and far (1, 2, 7, 8) objectives of vertical bars were respectively 10 and 35 cm. Eight target Namely the keys (5 mm diameter) and every key had a lamp that when the child pressed the key, the lamp was turned on and all connected to one stopwatch. Another objective (target 0), also related to the same stopwatch and on the boards there was vertical bars with 20 cm distinct. The initial push button T0, enables end key and final pressure causes the stop and then total time was recorded the total moving time by chronometer. The pressure on other keys (T1 ... T8) causes recording time elapsed between two consecutive pressures. Participants sit in front of the device and with corresponding distance of 70% of their hand length and should cross the path according to their trained hand: we call right path he aims that follow md and pd group and left path is aims that follow pnd and mnd. In each path there is a label near the key for recognizing sequence of mentioned (see figure 1). Note that paths are mirror images and thus dynamic limitations during right and left hand moving are considered. Sequence of motions started and ended from T0. All participants should consecutively press the keys (0, 1, 2, 3, 4, 5, 6, 7, 8, 1, 7, and 0) (movement sequence of 11 means press 12). This sequence was as a test. Also note that participants must memorize consecutive of motions formerly. However our work emphasizes on treatment of velocity from one goal to another and regress reaction time doesn't need learning of sequence.

Experimental methods

This method consists of an orientation session, the pre-test session (three tests), training (60 tests) and post-test session (three tests).

Orientation session: Prior to test, all participants by pressing keys (with finger tips and each key twice) with upper hand (md and pd group) or with non-upper hand (mnd and pnd group) make themselves familiar with this structure. To avoid the potential effects of exercises that can improve the speed of hand movements, we asked participants to slowly move the left and right hand along the way. Then we asked them, to memorize the location and arrangement of keys. After ten to fifteen rounds, all participants memorized special paths (They mentally were able to visualize the desired direction and position of targets with closed eyes).

Pre-test session: Pre-test was the same for all participants. They were asked exactly to point physically and accurately and quickly as possible to 12 key-paths. Pd and md groups were working with right hand and mnd and pnd groups were working with left hand. It was while half of the participants in Group C were pointing to the keys with the right hand and the other half with left hand. Participants were aware that should reach all targets in a specific order. As a result, if they did not act in a valid goal and did not turn the light, should be pointed out that the aim again and then they began other goals. Three pretests were separated by the distance between the test of 10-s, and did not provide any information about the performance (time and speed) during and after the test to the participants. Total time, average time (when on hand moves from one goal to the other one), and the number of failed targets for each participant calculated and used as motor implementation basis.

Practice session. During the session, participants of pd and pnd groups, cross the path physically with right and left hand. They were encouraged to move carefully and quickly as possible in each test. Execute of any single movement (total motion time), was recorded at each test. Participants of pd and pnd groups simulate mentally referring to the objectives with right and left hand. Visualization of a motion in first person is a necessary condition for engaging in drive system. In each test ,participants encouraged to mentally move their hands along the path carefully and quickly as possible and in case of success they should run it physically also. Total travel time during mental test was recorded separately for each test. To do this, the participants were asked to press T0 key with left or right index and press the key again mean they mentioned the aims of path mentally. Using this method, we compared the progress of each test during mental tests measurement and physical test advance with the times. The participants in Group C were taught to view keys without moving in the direction. We also consider a control group because we observed that participants of other groups, their eyes are turning from one key to another with implementation of mentally or physically motion. With the help of the control group, we were hoping to separate direct and positive impact of mental practice on running movement from indirect effects.

Post-test session: post-test were similar to pre-test and held 2 minutes after training session. General time, recovery time, improve the physical / mental attributes of each hand, the average time (time moving from one target to another), the improvement of physical / mental average (improve the physical / mental for any hand movement of the goal for any purpose and other hand features) and the number of missed targets, calculated by analysis video records performed through tests and used as improved motor performance index.

Statistical analysis

For Statistical analysis normal distribution (Shapiro-Wilk, p> 0.05) and the same variance (Hartley, Coronel, and Bartlett test, p> 0.05), t test sequence (paired samples) were used.

Improve time (or speed) between pretest and posttest was calculated according to the following formula:

$$gain = \frac{Pretest - Postest}{pretest} \times 100$$

Required comparisons of Post hoc test using Tukey test was conducted.Statistical differences in average movement times between pretest and post-test were quantified by two-tailed t-test for each group.To assess the differences between the dominant and the non-dominant hand on motor learning by mental practice, we calculated the ratio (Mental speed gain/Physical speed gain) of the speed gain (see above) between mental practice and physical practice for each hand. Two-tailed t-test for assessment of any statistical differences between two ratios were used .The statistical effects conducted using Kruskal-Wallis ANOVA for between-group comparisons (Pd, Md, Pnd, Mnd, and C) and Wilcoxon tests for within-group comparisons (pretest versus posttest). For all statistical analyzes, significance, or p <0.05 was accepted.

Registration and analysis of EMG during mental practice

The main aim of EMG were controlling of arm muscle movement during mental training. EMG were recorded from Anterior Deltoid(AD), Medialis Deltoid (MD), Posterior Deltoid (PD),Pectoral Major Superior (PMS), Triceps Brachii (TB)

. signals at a frequency of 1000Hz, band-pass filter (10-600 Hz) were recorded and for offline analysis software BIOPAC, was saved. By calculating the root mean square (RMS), using the following formula EEG Patterns, were calculated:

$$RMS = \sqrt{\frac{1}{MD}\int_0^{MD} (EMG)^2 \, dt}$$

MD: time of movement

A one-way ANOVA was performed for each muscle (p<0.05) and we didn't found any differences in rest condition and the mental trials.

RESULTS

Place Accuracy

The number of missed goals for meeting pre-test and post-test were respectively 10 and 9 for pd, 9 and 10 for md, 10 and 11 for pnd, 9 and 10 for mnd and 10 and 11 for C group. Place accuracy between groups was same (Kruskal–Wallis ANOVA ، pretest h= 0.23 and p= 0.94 and posttest h= 0.60 and p= 0.90).and Wilcoxon tests in all cases between pretest and posttest were the same (z<0.55 , p>030)

Advance travel time between pretest and post test

Figure 2 describes average value of motion total time in the pre-test and post-test. ANOVA shows interaction between features and tests (p < 0.0002) and between hand a test (p< 0.0004). Post hoc analysis revealed that motion time obtained during the pre-test (p> 0.92) and between upper and non-upper hand (p> 0.06) are the same.

Interestingly, the increase in speed, between upper and non-upper hand, before viewing the entire path for upper hand in comparison with non-upper hand is significant in motor achievement and amounts were t= 3.61 ,p= 0.002 between goal 4 and 5, t= 3.14, p= 0.01 between goal 5 and 6, t= 2.97, p= 0.00, between goal 7 and 8, between goals7and 1 , t= 2.49, p= 0.02.

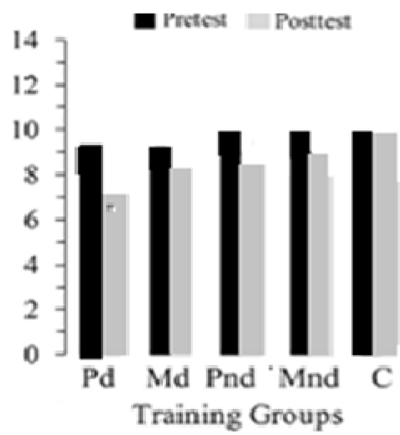

Figure 2: average value of moving time

Time performance during the training session
Trial-by-trial analysis during the training session shoed that total movement time decreased for all groups (Fig.2)
Time Performance during post-test
After physical exercise in post-tests (Figure 3, pd and pnd) performance was almost constant. Period of three post-tests was not statistically different (for pnd‹, p= 0.19 for Pd;, p= 0.13). But, after a mental workout, significant improvement in performance was observed. For md a decrease in progress time between first and third post-test observed (p= 0.018). For mnd between all post-tests time decreasing was highly significant (p< 0.0000).

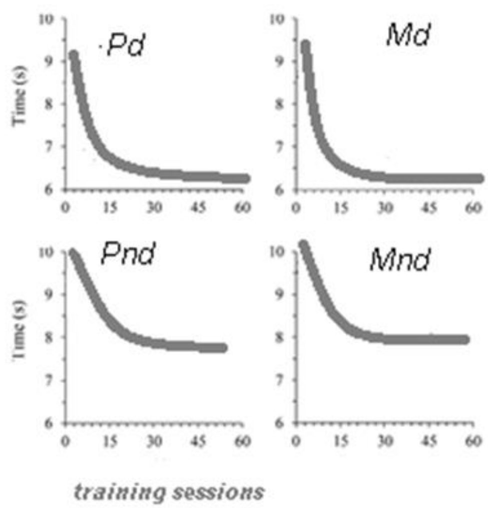

Figure 3: The learning curve during physical exercise and motor imagery that occurred during 60 runs.

DISCUSSION AND CONCLUSION

We examined the effects of laterality in motor learning through physical exercises and Motor imagery in right-handed children. In terms of quantity, we found that both of them, by the same learning methods have a positive impact on the implementation of the dominant and non- dominant hand (the same exponential curve learning). In terms of quantity, physical exercises were superior to visualize the movement in both hands. More importantly, compared to c with non-dominant hand, practicing of motor imagery with upper hand, lead to broader and more serious advance. Overall, our findings point to supremacy of upper hand in motor learning using mental imagery.

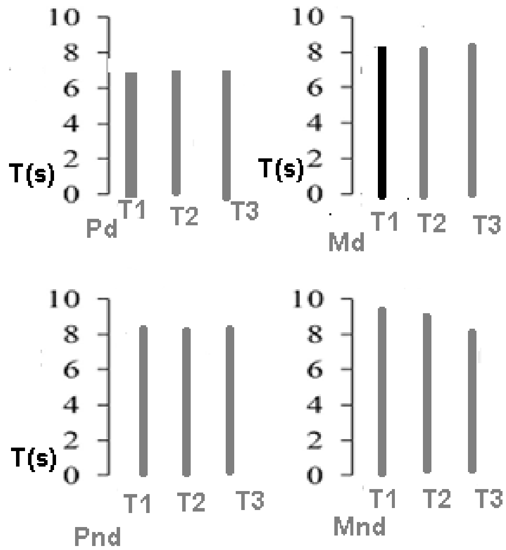

Figure 4: Average value (+S.D.)Three tests in the post-test sessions for all groups

Physical exercise with the upper and non-upper hand

Although physical exercise on motor performance achievement in both groups in terms of motion progress, in comparison with non-upper hand (pnd) was more extensive for upper hand (pd), in a further reduction in travel time and differences in learning were found during the test. Possible explanation could be that the effects resulting from laterality further specialization of the brain hemispheres is in learning and controlling of motion. The left hemisphere is often involved in motion planning, forecasting, and learning.

In contrast, the right hemisphere, with more constraints on the ability of scheduling, mostly can encrypt motion features that depend on Intermediaries impedance control mechanisms - peripheral feedback till to get fixed condition. However, in this study, end position was important, but improved performance was mainly dependent on the hand speed until quickly and accurately as possible to achieve the goals. So increasing the speed of test requires precise control of the dynamics of the hand (moment of interaction, inertia and gravity). Therefore, since the controller of the upper hand is good in the dynamic control, in comparison with pnd group, pd group has better physical training.

Mental workout with upper and non-upper hand

Reduce travel time, in post-test session, for all of the goals, refers to the positive impact of motor imagery workout on motor performance in mnd and md groups. In general, our findings confirmed earlier studies Notes that the non-dominant hand can get more advantages with precision balance - quickly achievement workout during motor imagery of hand movements.

The comparison between the physical and mental workout

By analyzing the physical and mental motion test during the training sessions, we found the learning curves during imagery (mnd and md groups) and physical practices (pd and pnd) follows the same exponential form. These findings indicate that physical exercises and imagery of motion provide a collaborative learning approach. A common underlying mechanism for these quantitative similarities in motor learning can be explained with the theory of internal model. In summary, during physical exercises, leading template of domestic recipient of a prescription is the current commands and the primary mode of hand and predicts the next state of hand (position, time, speed). During mental rehearsal, Gesture commands are prepared without access to the muscles. Therefore, a version of gesture commands and hand initial state is available for leading model that creates the next state predictions. We suggest, modes simulation be based on leading internal model output, a common method of physical and mental workouts.

However, we found quantity similarities between physical exercises and motor imagery learning curves, but significant quantity differences are also seen. For example, the learning proportion was lower in mental practice in comparison with physical exercises. As a result, the learning outcomes at the end of workout (a parameter) were lower in mental practice in comparison with physical exercises. In addition, between the physical exercises and motor imagery, there were important differences in the asymptotic learning. Perhaps these results suggest that mode simulation during mental practice is more changing than physical exercise. Because of the variability of test to test, in state estimation, internal training signal used for learning, is changing that may lead to lower update during mental workout in comparison with physical practice. According to speed of movement was still in progress at the post-test, for md and mnd groups, this idea is further confirmed (not for pnd and pd groups). This process shows that mental training sessions were incomplete. The actual movements looking for motor imagery workout can improve motor function because of state estimation updating (Through sensory information that provided during the execution of movements).

Framework of leading internal calculation model is made up from dynamic- upper hand hypothesis and for the laterality observed effects, provides required explanations. Upper hand hypothesis provides a combined control scheme that in it both hands can benefit from feedback and predictive mechanism in varying degrees, the left hemisphere system / dominant, much depends on the predictive control mechanism, while the right hemisphere system / non-dominant depends on the feedback - control mechanism is central impedance. As previously mentioned, motor advances in three-dimensional paths require complex dynamic control of hand. So upper hand that guides by effective preventive mechanisms gets more interest from motor imagery workouts. In particular, accurate and true state estimation during motor imagery workout can be used for trainer (by calculating the internal error signal) and an increase in neural commands up to improve motor performance. In contrast, the non-dominant hand controller, which is more dependent on feedback control, is less efficient in functions increasing, because there is no available peripheral feedback. For this reason, in study forward, function increasing in mnd group was lower In comparison with other groups. However, if the controller with non-dominant hand only engages in feedback control, and there be no increasing, presumably, the non-dominant hand controller has access to predictive mechanism. However, the estimation should be less accurate and thus leads to improved performance with low and medium stability.

Our findings suggest that beyond activation of same neural networks, motor imagery workout with upper hand in comparison with non-dominant hand may be more closely involved in the prediction mechanism and promote motor learning. Conceptually, the idea of representing quality motion states could challenge motor learning affects through mental workout.

The idea of this article is that physical and mental exercises are involved in common plastic neural mechanisms that are motor learning and performance base via upper and-non upper hand. In comparison with non-dominant hand, mental exercises with upper hand lead to further progress performance. These differences can be basis of Relative specialization (superiority hypothesis laterality- dynamics) and motion experience (workout upper hand depends on experience) in cerebral hemispheres. These mechanisms are still somewhat hypothetical; therefore, further investigation is needed. Future research could investigate that weather the neural processes which discussed here for other tasks or actions that have not sequential nature can be applied? In general, since both benefit from mental workout, this research could compromise motion mental workout to upper and non-upper hand rehabilitation.

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