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Brain Lateralization and Its Influence on Motor Learning: Time Taken in the Acquisition of a Novel Motor Task in the Right and Left Hand Dominant Healthy Subjects

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To identify the difference in motor learning duration between right and left dominant subjects for a novel task.
Study Design: Quasi-experimental study design with two groups, pre and post-intervention assessment
Place and Duration of Study: The study was conducted at KMCH College of Physiotherapy, Coimbatore, between January to July 2018.
Methodology: 30 healthy subjects, 15 right dominant in group A and 15 left dominant in group B, within the age group of 18 to 25 years, were selected for the study. A well-designed practice protocol was made for a novel motor task of transferring wooden cubes of $1cm^3$ from one tray to another using chopsticks. Pre and post-test scores were recorded as the total time taken to transfer 50 cubes.
Results: 9 males and 6 females were recruited in each group. It was identified that both groups had a significant reduction in the time taken to complete the task. (Mean Difference Group A=109.2±5.5; B=111.1±5.7).

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Conclusion: We conclude that there is no difference in the duration of motor learning between right and left dominant subjects. Both groups demonstrated a significant reduction in the time taken to complete the novel task with 7 sessions of practice. Hand dominance will not influence the time taken in acquiring skill in performing a motor activity through practice/training.

Keywords: Motor learning; hand dominance; brain lateralization; duration of motor learning; novel motor task.

1. INTRODUCTION

Motor learning is considered as the acquisition or improvisation of a motor skill through practice [1]. It is also experience-driven leading to changes in neural representations, which helps in the performance of a task [2]. Various theories have been postulated in view of understanding this concept. The three-stage models proposed by Fitt and Posner in 1967 explain the acquisition of skill through different stages of varying demand for attention [1]. They are the 'cognitive stage', where increased attention is demanded to understand the task, 'associative stage' where the skill is refined, and 'autonomous stage' where the performance is automatic with low attention demanded.

An infant's motor development is a step-by-step process that progresses in a sequential pattern. The introduction of a new task and the amount of practice determines the speed of skill acquisition. The same is true with any of the motor learning occurring in childhood and adulthood, such as learning to use and tools or riding a bicycle. But the amount of practice required or the specific changes that occur within the brain with practice is still a contemporary topic in scientific research.

Two processes which complete motor learning are implicit and explicit knowledge [3]. Implicit knowledge provides information on how to do the task, whereas explicit knowledge makes it understand what is to be done. Experience, type of task, and the duration of learning account for the completeness of learning [2,3]. It has been postulated that the contralateral hemisphere mainly controls the distal hand movements [4]. The dominant hand executes movements with less variability when compared to that of the non-dominant hand. This includes amplitude, peak velocity, torque generation, and coordination between distal and proximal joint structures [5]. This leads to a hypothesis of asymmetrical neural control in brain lateralization. It has been observed that the lesion over the dominant hemisphere causes greater variability in performing a novel task and the acquisition of a new bimanual task [6].

Although many literatures are available that explored the motor learning between dominant and non-dominant side within an individual and inter-limb transfer of motor skills, no literatures have been identified by us which have explored motor learning in the right and left dominant individuals. We designed this study to identify the difference in motor learning skills by right and left dominant subjects for a novel motor task.

2. MATERIALS AND METHODS

This study adopted a quasi-experimental design and included healthy adults of both genders between 18-25 years of age. Both right-handed and left-handed individuals of the preferred age group, and those who were not familiar with the study task were the study's inclusion criteria. Subjects who undergo any physical or mental training and practice sessions during the study period, those with any neurological illness, pain or weakness of limbs, old fracture of upper limbs, and those with deformities that hinder the performance of the designed task were excluded from the study. Subjects who fulfill the study criteria and showing their willingness to participate by signing the informed consent form were recruited for the study and were divided into two groups of right (Group A) and left (Group B) hand dominance which as identified using Edinburgh Handedness Inventory - Short Form.

Participants were given a novel task of picking up 1x1cm wooden cubes of equal size from one tray to another using chopsticks held in their dominant hand. The trays were kept at 1m apart on a table kept at the elbow height of participants who were seated on a standard stool. This setting was maintained for all the participants.

Participants were made familiar with the task environment, and the chopsticks were given to them prior to the explanation of the task. The investigator explained the method of holding the chopsticks and its manipulation on the first day, and three practical demonstration trials were provided to all. The demonstration included hands-on training along with real-time error

correction using verbal commands. Each demo trial lasted for 3 minutes with the same task setting as for the study. 1 minute rest period was provided between the demo trials. Pre-test scores were measured after 10 minutes of rest period post demo trials, during which subjects were asked not to recollect the task practiced or to prepare for the task mentally. The participants were directed to other things such as casual talks with friends or using their mobile phones for social networking. Pre and post-test scores were collected using a stopwatch for the time required to transfer 50 wooden cubes from the tray kept on the dominant side to the other side on the table, kept 1m apart.

Practice sessions began on the same day of the recruitment, 10 minutes after the pre-test measurements. Each session lasted for 30 minutes, one session per day. Distributed blocked practice was done for all the participants, where they were asked to transfer all the 50 wooden cubes at a time at their own pace. A rest period was given after completing the transfer of all cubes, which was 2 minutes extra from the time taken for completing the previous task. Subjects were asked to practice mentally during the rest periods. Participants have stopped practice sessions exactly when 30 minutes were over. The daily activities of participants were not interfered with by the researcher. The practice sessions were conducted for continuous 7 days at the same time of the day.

Post-test measures were taken on the 7^{th} day, 10 minutes after the 30 minutes practice session. The data collected were analysed with t-test using IBM SPSS statistics version 20.0 (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY).

3. RESULTS AND DISCUSSION

A total of 30 individuals participated in the study, with 15 right had dominant subjects in group A and 15 left-hand dominant subjects in group B. The mean age of group A was 21.6±1.9, and group B was 21.7±2.3 years. Both groups consisted of 9 males and 6 females. Table 1 provides statistical analysis of pre and post-test data of two groups.

It has been observed that both the groups significantly reduced the time taken for completing with task with 7 practice sessions. The mean difference between two groups demonstrated a slightly increased change in group B than that of the other.

This is a first-of-its-kind study which identified the difference in motor learning capacity between right and left dominant subjects for a novel motor task. We identified no difference in the acquisition skills between the two groups.

A motor skill is acquired through an initial fast learning stage followed by slow learning, which reflects the mechanism of neuroplasticity [2]. It has been identified that training recruits additional primary motor cortex units towards the new motor sequence. These changes are mostly illustrated in the early stages of learning [7]. The initial learning stages also show activation of prefrontal areas, rostral cingulate zone, pre-supplementary motor area, secondary motor areas and sensory associated areas, lateral premotor cortex, etc. [8].

Basal ganglia are the storehouse of motor programs and sequences. It is thereby required that practice-related changes must occur within basal ganglia structures for storage of information. Anterior caudate nucleus activation is reported in the early acquisition of skill, which progresses in the later stage to storing motor sequences [8]. Cerebellum also works hand to hand with basal ganglia, assisting the cortex-basal ganglia-cortex circuit in the execution of movements. Hikosaka et al. reported that basal ganglia and cerebellum are guided by error signals or feedbacks [9]. The dopamine neurons of basal ganglia encode expectation error and/or novelty of task, whereas the climbing fibers of cerebellum encodes sensorimotor errors. We postulate that the practice-specific neuronal changes in subjects of both right and left dominancy must be equal to attain our results.

Table 1. Pre and post-test analysis between two groups

Group	Pre Test	Post Test	Mean Difference ± SD	P-value
	Mean ± SD			
A	210±17	100.8±13.1	109.2±13.6	< .001*
B	213.4±19.4	102.3±10.5	111.1±17.7	< .001*

**statistically significant*

Offline skill development between the practice sessions is proven during consolidation, which mainly provides goal-based improvements [10,11]. This will be enhanced by sleep and wake cycles. Movement-based improvements that occur with practice during daytime engage the primary motor cortex, whereas goal-based improvements during intervals engage parietal and prefrontal cortices [6,9]. We had designed the task so that the interval and practice durations kept similar to all subjects so as to nullify the changes thereby.

The functional hemispheric asymmetry is related to asymmetry in brain growth in the early stages. The study by Chiron et al. identified strong regional asymmetry in cerebra blood flow in 39 subjects in the sensorimotor cortex, Broca's area, and associative areas, which leads to lateralization, handedness, and language [12]. They observed an increased left cerebral blood flow at around 2.5 years of age, which correlates with right-handedness and improvements in fine motor skills at this age. We postulate that the changes occur in infancy leading to lateralization is dominant side specific, with no changes between right and left dominant subjects. Thus the capability of acquisition of skills does not vary between them. The findings may also be replicated in patients with neurological insult, assuming that the therapy sessions provided to achieve independence in the motor activities of daily living post-injury may not be influenced by the hand dominance of the individuals.

Our study pose several limitations. We had limited resources to perform an fMRI study which would have explained our findings better. We had not identified the retention of novel tasks, which can be considered future research in this topic.

4. CONCLUSION

We conclude that the duration of motor learning for a novel motor task is the same for both right and left dominant subjects. It was observed that seven sessions of 30 minutes of practice were enough to demonstrate a significant difference in completing the novel task in both groups. Hand dominance will not influence the time taken in acquiring skills in performing a motor activity through practice/training.

CONSENT

All authors declare that written informed consent was obtained from the participants for recruitment to the study and publication of the collected data.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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