

## Handedness and Asymmetry of Motor Skill Learning in Right-handers

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**Background and Purpose:** The most remarkable behavioral asymmetry is handedness. The preferred hand often has better performance, motor strength, nonpreferred hand. However, whether these components are associated with skill learning is not clear.

**Methods:** We evaluated healthy right-handers by setting a series of motor-performance tasks including skill learning, grip strength, and speed.

**Results:** The preferred hand showed better skill performance and learning rate. However, the degree of the right-left difference in grip strength or speed difference did not correlate with the asymmetry in skill-learning rate. Therefore, although the preferred hand exhibits a better skill-learning capacity than the nonpreferred hand, asymmetry in skill learning cannot be explained by motor strength or speed.

**Conclusions:** Our findings suggest that better skill performance of the right hand in right-handers cannot be attributed to the degree of hand preference score, strength, or motor speed.

*J Clin Neurol 2(2):113-117, 2006*

**Key Words :** Handedness, Preference, Skill learning, Speed, Strength

### INTRODUCTION

The most obvious behavioral asymmetry observed in people is handedness. Approximately 90% of people prefer using the right hand, with the remaining 10% either preferring to use the left or exhibiting no hand preference. Once a person develops a handedness, it is rare for this to change.

Several theories have been proposed for the factors that determine handedness.<sup>1</sup> Broca's original observation, which stated that right-handedness appears to be closely associated with left-hemisphere dominance for language, linked handedness with language lateralization.<sup>2</sup> The

influence of asymmetries in attention and in the intentional system has also been proposed to account for handedness. For example, whereas the left hemisphere primarily prepares the right-side limbs for movement, the right hemisphere prepares both sides for movement.<sup>3</sup> Elementary motor asymmetry has also been proposed to account for handedness. The preferred hand is often the hand that is stronger, more accurate, or can move more rapidly than the nonpreferred hand.<sup>4</sup> Unfortunately, the neuronal asymmetry that accounts for these elementary motor asymmetries remains unknown. In 1919, Watson proposed a learning theory that culture and social pressures influence handedness. Although culture and social pressures alone cannot fully account for hand preference,

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\*This research was supported by the Basic Research program of the Korea Science and Engineering Foundation (Grant No. R01-2006-000-10223-0).

Eacott and Gaffan showed in 1989 that information about the reward history of the stimulus is integrated between the hemispheres before it influences the motor control of the hand. A study on the effects of hand asymmetry by hemispheric brain injury in hemiplegic children suggests the possibility of handedness being able to shift.<sup>5</sup>

The preferred hand has a better skill performance and is easier to use than the nonpreferred hand.<sup>6</sup> However, it is unknown whether the better performance results from frequent use (and thus is a training effect due to cultural or environmental factors),<sup>7-13</sup> or from a genetically determined trait lateralized to one hand.<sup>14-16</sup> If in right-handers the rate of skill learning is identical in each hand, one might conclude that environmental or cultural factors mainly affect the development of handedness. However, if the handedness is genetically determined, the rate of skill learning will be asymmetric (lateralized to one hand). The purpose of our study was to test this postulate and determine whether motor learning is associated with elementary motor asymmetry.<sup>17</sup>

## MATERIALS AND METHODS

### 1. Subjects and hand preference

We recruited 24 healthy volunteers to serve as subjects. There were 12 men and 12 women, and all were right-handed with an age of  $32.3 \pm 10.1$  years (mean  $\pm$  SD). Hand-preference was evaluated by 74 questions in a preference questionnaire. 1818 Subjects were asked to answer each question on the following 5-point Likert-type scale: +2, always preferring to use the right hand; +1, usually preferring to use the right hand; 0, no preference; -1, usually preferring to use the left hand; and -2, always preferring to use the left hand. The preference score therefore ranged from -148 to +148.

None of the subjects had a history of neurological or psychiatric disease, head trauma, or learning disability, nor did they take any medication that might influence motor performance.

### 2. Tests for motor-skill learning and elementary motor performance (grip strength and tapping speed)

Motor-skill learning was evaluated with the Pursuit Rotor test (Vienna system). In brief, this test uses a rotating photo point (300 mm in diameter) that the subject pursues with a photo-detecting stylus. The rotational speed was 30 rpm. Performance was measured by the total contact time between the photo point and the photo-detecting stylus over the course of a 20-sec trial. Ten successive trials were made for each 14 hand (in random order), with a 10-sec rest interval between trials. The motor-learning rate was evaluated by the improved performance per trial.

The grip strength of each hand was measured using a hand dynamometer. As an indicator of speed, we used a finger-tapping test in which the total number of taps achieved in 10 sec was recorded. The mean score from three independent trials was used for data analysis.

### 3. Data analysis

Right-left asymmetry in motor-skill performance, learning rate, grip strength, and speed were analyzed by a paired t-test. Spearman correlation analysis was used to determine whether the elementary motor performance (power and speed) was associated with skill-learning rate. We also evaluated the right-left difference to determine whether the asymmetry in learning motor skills was related to the degree of right-left difference in elementary motor performance. Statistical analyses were performed using SPSS (ver. 10.0).

## RESULTS

### 1. Grip strength, tapping speed, and learning rate in motor-skill performance

The grip strength was  $32.8 \pm 13.4$  kg for the right hand and  $31.3 \pm 12.2$  kg for the left hand (Fig. 1-A;  $p > 0.05$ ). The number of taps in 10 sec (tapping frequency) was higher for the right hand ( $133.8 \pm 13.8$ ) than for the

left hand (119.9±16.6), showing that the motor speed is faster for the former (Fig. 1-B;  $p<0.05$ ).

Motor-skill performance at baseline, as assessed by the Pursuit Rotor test, was 1.72±0.21 sec for the right hand and 1.07±0.19 for the left hand, which increased to 4.82±0.41 and 3.08±0.25, respectively, after 10 successive trials. The performance scores were better for the right hand both at baseline and the last trial (Fig. 1-C;  $p<0.05$ ). The learning rate, as measured by the increase in motor skill across the 10 trials, was 0.29±0.24 sec/trial for the right hand and 0.19±0.18 sec/trial for the left hand ( $p<0.05$ ).

## 2. Association of motor power and speed with motor learning rate

Elementary motor components - grip strength and tapping speed - were analyzed against motor learning. The subjects who had a stronger grip strength showed better motor learning performance ( $r=0.40$  by Spearman correlation analysis,  $p<0.05$ ). Subjects who had a higher tapping speed also showed a better performance in motor learning ( $r=0.52$ ;  $p<0.05$ ). However, the right-left difference of grip strength did not correlate with the right-left difference in the motor learning rate ( $r=0.28$  by Spearman correlation analysis;  $p>0.1$ ). The right-left difference in tapping speed also did not correlate with

the right-left asymmetry in the motor learning rate ( $r=0.21$ ,  $p>0.1$ ).

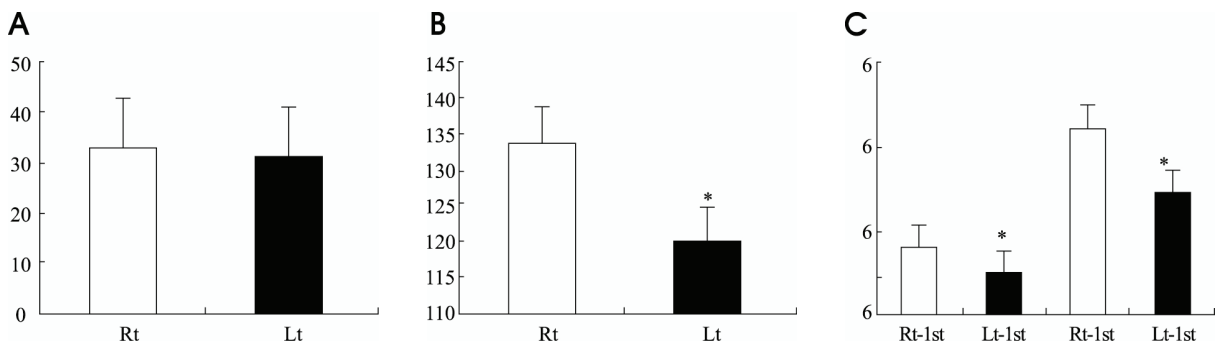
## 3. Effect of preference, education, or age on motor learning

The preference score in our right-handed subjects was 104.4±13.8, and ranged from 86 to 127. The preference score did not correlate with the right-left difference in motor learning ( $r=0.24$ ;  $p>0.1$ ). Neither education level (mean 13.0±2.1 years) nor age contributed to the right-left difference in motor learning rate ( $r=0.47$ ,  $-0.26$  respectively;  $p>0.1$ ). A gender difference was not observed.

# DISCUSSION

In this study we tested whether handedness is related to skill learning and whether motor learning is associated with elementary motor asymmetry, degree of hand preference, strength, or motor speed. Our data showed that, in right-handers, the rate of skill learning was better with the right hand than with the left, a finding that cannot be due to elementary motor asymmetry.

That people prefer to use one hand rather than the other is a remarkable behavioral asymmetry, and means that the preferred hand often performs skills better than



**Figure 1.** Grip strength, speed, and motor-skill performance. (A) Mean grip strength (kg). Scores for the right and left hands are not significantly different. (B) Tapping frequency (taps per 10 sec). The mean tapping frequency was faster for the right hand than for the left hand. (C) Motor-skill performance (seconds of correct tracking). The performance scores were better for the right hand than for the left hand at both baseline and after 10 trials. The improvement in performance across the 10 trials was 3.1±0.21 sec for the right hand and 2.08±0.15 sec for the left hand.

Rt; right hand, Lt; left hand, Rt-1st; first trial with right hand, Lt-1st; first trial with left hand, Rt-last; last trial with right hand, Lt-last; last trial with left hand. \* $p<0.05$ .

the nonpreferred hand.<sup>19</sup> Genetic and familial influences, as well as social and cultural factors,<sup>20</sup> have been considered to underlie handedness. Better skill performance in one hand can be seen as a training effect from more frequent use of one hand. Social or cultural factors may contribute to this.<sup>7-13,20</sup> Alternatively, better skill performance might originate from a genetically determined capacity for lateralized skill-learning, which may also improve skill performance and develop handedness.<sup>14-16</sup> Our data showed that, in right-handers, the rate of skill learning was better with the right hand than with the left. Education level, age, or preference score cannot explain this asymmetry. This finding supports the postulate that handedness is mainly determined by genetic or familial factors. However, this result does not preclude the presence of a practice effect.

Taylor and Heilman (1988) proposed that praxis is related to handedness. Loss of the ability to perform learned skilled movements is often caused by left-hemisphere lesions. If one has lateralized representations and is learning a new skill, the hand opposite to these representations should not only acquire skill more rapidly but also benefit the preferred hand when the acquired skill is learned with the nonpreferred hand. Visuomotor information is transferred via the corpus callosum and this callosal transfer shows left-right asymmetry.<sup>21-28</sup> Further study of this pretraining effect remains to be tested, but in our investigation motor-learning trials were made randomly for both hands and did not show a difference.

Motor-skill learning is a complex phenomenon that requires harmony of several elementary motor components, such as adequate power, appropriate speed and accuracy, as well as visuomotor integration between the hemispheres.<sup>29</sup> Our data showed that the rate of skill learning was not correlated with a greater difference in right-left motor power or tapping rate. An efficient elementary motor system may help in skill learning. However, the development of elementary motor asymmetry<sup>30</sup> cannot explain the development of skill-learning laterality. Therefore, although elementary motor components are associated with skill performance, skill learning may independently affect the development of handedness,<sup>31</sup> and suggests that improving the motor

power or speed may not necessarily affect the motor-skill learning.

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