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Correlation of Hand Function Differences and Brain Preference: Focusing on Young Adults

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Abstract

The purpose of this study was to investigate the correlation between differences in hand functions and brain preference in young adults. The participants were 52 right-handed, healthy adults in their 20s. Brain preference was classified as having a left-brain preference, right-brain preference, or whole-brain preference by the Brain Preference Indicator. Hand dexterity was measured by the Purdue Pegboard Test. The difference between right- and left-hand functions was statistically significant for subjects in all brain preference types. Right-hand dexterity in those with left- and right-brain preference was significantly faster than in those with whole-brain preference, while left-hand dexterity among the three groups was not significantly different. The difference in hand dexterity between the right and left hand was not significant in all groups. This study examined the correlation between hand dexterity and brain preference type. Those in the unilateral brain preference groups showed better dexterity than those in the both brain preference group.

Keywords: Brain Preference; Dexterity; Hand Function; Right-Handed

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Introduction

Hands are commonly used as non-verbal means of communication and can express a variety of emotions. Hand functions include various grasping, gripping, and releasing. Humans use hands to grasp, manipulate, or interact with various objects in the environment (Han JJ*et al.*, 2015)

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The left and right hemispheres of the human brain are dimorphic. In general, the left brain is responsible more for functions such as linguistic, logical, analytical, and mathematical calculations, while the right-brain is more associated with non-verbal, visual, tactile, spatial, and creative functions (OakleyD A, 2018). Additionally, neural pathways decussate in the brain and spinal cord, causing each hemisphere to control the contralateral side of the body (Toga AW*et al.*, 2003). Therefore, hand control depends on the degree of functioning of the contralateral hemisphere (Serrien DJ*et al.*, 2006). The differentiated functionality of the hemispheres is called brain preference, and a motor or behavioral function can be referred to as having a left-brain preference, right-brain preference, and whole-brain preferences(Min C R*et al.*,2012).

Most people predominantly use one hand, which is termed right- or left-handed (Michel GF*et al.*,2018). Generally, when analyzing hand function, this is more commonly defined as dominant or non-dominant hand. Importantly, brain activity can differ depending on which hand is dominant. There may be functional differences according to brain preference (Rogers L.J., 2009).

Here, we investigated the correlation between bilateral hand functions and brain preferencein young adults (aged 20-29 years)using the Purdue Pegboard test. While there have been studies correlating brain preference with academic ability, personality, idea development, and information utilization ability (Hazrati M K*et al.*,2010; Roebroeck A*et al.*,2011), there havebeen fewinvestigations associating hand functions with brain preference.

Multiple studies have focused on the relationship between hand functions and brain structural correlates using the brain imaging technique (Brozzoli C*et al.*,2011). Therefore, sincehemispheric differentiation can regulate hand function (Jansen van Vuuren A*et al.*,2017),an examination of the relationship between brain preference and hand function can aid in our understanding of hemispheric differences.

We sought to understand this association with two outcomes. First, we examined the differences between the right- and left-hand functions in the three brain preference groups. Second, we compared the either left- or right-hand functions among the three groups.Our hypothesis, which is based on a previous study showing that the left hemisphere is activated mainly when the right hand is used, and vice versa (Gut M*et al.*,2007), is that brain preference is related to hand dexterity

Materials and Methods

Participants

The subjects in this study were 52 college students 12 (23.1%) males and 40 (76.9%) females. The study was conducted from August to December 2017.

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Procedures

The Brain Preference Indicator (BPI) test was performed to determine the brain preference of the subjects. The Purdue Pegboard test was used to investigate the dexterity of the hands. To rule out the influence of the order of which a hand was tested, the testing order was determined by drawing lots. The dominant hand of the subject was determined based on self-reporting.

Assessments

Brain Preference Indicator

The BPI was used to identify the brain preference of the participants. This evaluation tool was developed by Torrance et al. (1997). It was translated into Korean in consideration of the Korean culture. The translated version was used in this study. Test-retest reliability was r = 0.76. The assessment is a self-administered test consisting of 40 items. Each item contains three statements related to left-brain use, whole-brain use, and right brain use. Participants choose the statement that best describes themselves. The total score is determined as the sum of the answers selected by the participants for each item. The BPI value is the average of the total points divided by the number of questions. The BPI value is rounded to the nearest two decimal places. A score between 1 and 4.4 is regarded as having a left-brain preference; a score between 4.4 and 5.5 is regarded as having a whole-brain preference; a score between 5.5 and 9 is regarded as having a right-brain preference (Min CR*et al.*,2012).

The Purdue Pegboard Test

The Purdue Pegboard Test is an assessment used to evaluate hand dexterity (Langer D*et al.*,2012).It consists of pins, colors, washers, and a wooden board. The test contains two main methods of measurement. First, the number of pins inserted into a hole is counted with the right hand only, the left-hand only, or both hands for 30 seconds each. The second method includes counting the number of assemblies in one hole in the order of a pin with the dominant hand, a washer with the non-dominant hand, a color with a dominant hand, and a washer with a non-dominant hand for 60 seconds. The test-retest reliability of the instrument is ICC = 0.88 (Lim SG*et al.*,2012). In this study, participants used a method of counting the number of pins inserted into the hole by both the right and left-hand for 30 seconds.

Data analysis

The data were analyzed using SPSS 20.0. Kolmogorov-Smirnov and chi-squared tests were conducted to test the normality. Paired t-tests were used to compare the functions between the right- and left-hands in each brain-preference group. ANOVA was utilized to compare right- and left-hand function among the three brain preference groups. Least significant difference (LSD) was performed for post-analysis.

Results and Discussion

BPI analysis showed that 16 subjects had a left-brain preference (30.8%), 24 had a whole-brain preference (46.2%), and 12 had a right-brain preference (23%). Among males, 4 subjects had a left-brain preference (33.3%), 6 had a whole-brain preference (50%), and 2 had a right-brain preference (16.7%). Among females, 12 had a left-brain preference (30%), 18 had a whole-brain preference (45%), and 10 had a right-brain preference (25%) as shown in table 1.

Among all brain preference types, the right hand was statistically faster at accomplishing the task than the left-hand in Fig. 1. As such, the difference between right and left-hand dexterity was the largest for those with left-brain preference, followed by those with right-brain and whole-brain preference. Among the three groups, the difference values between the two hands were not statistically significant in Fig. 2.

Those with left- and right-brain preference had significantly better right-hand dexterity than those with whole-brain preference. As shown in table 2, those with right-brain preference showed the highest left-hand dexterity among all three groups, followed by those with left-brain preference and whole-brain preference; however, the differences were not statistically significant in Fig. 3.

Table 1. General subject characteristics according to BPI

Group	Left-brain preference	Whole-brain preference	Right-brain preference	Total
Male	4 (33.3%)	6 (50.0%)	2 (16.7%)	12 (100%)
Female	12 (30.0%)	18 (45.0%)	10 (25.0%)	40 (100%)
Total	16 (30.8%)	24 (46.2%)	12 (23.0%)	52 (100%)

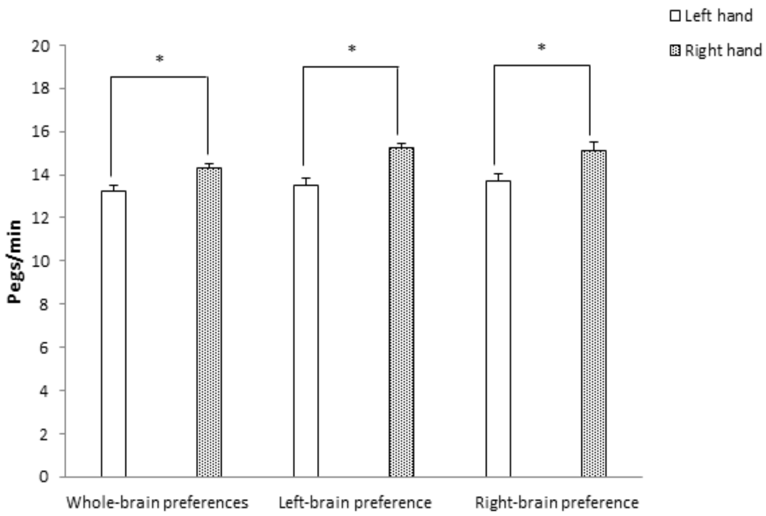

Figure 1: Comparison of Right- and Left-hand Functions in relation to Brain preference.

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There was a significant difference between right- and left-hand dexterity for those with whole-brain, left-brain, and right-brain preferences. The result of the Purdue Pegboard Test showed the right hand was faster than the left hand in all groups.

*p<.05

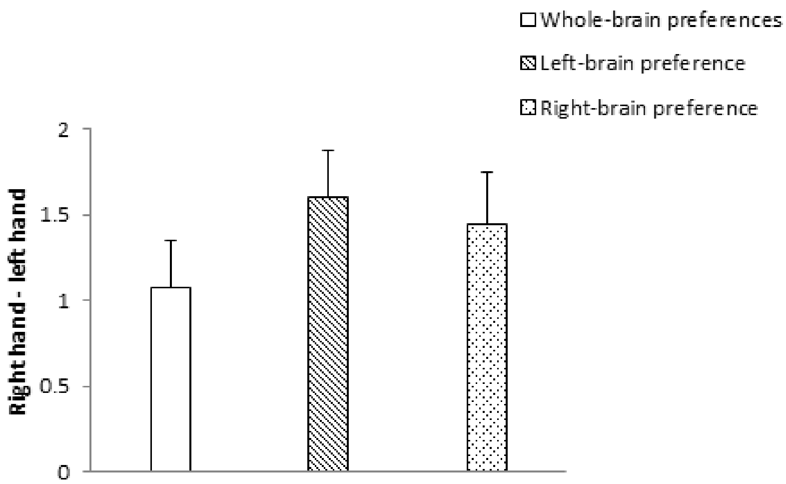

Figure 2:Comparison of theDifference between theRight- and Left-hand in relation to Brain Preference.

The difference in hand dexterity between the right- and left-hand was the largest in the left-brain preference group, followed by those with right-brain preference, and, finally, those with whole-brain preference. The difference inthe dexterity of the right-and left-hand among the three groups was not significant.

Table 2. The Difference in right- and left-hands between groups

	Group	M±SD	*F*
Right-hand	Left-brain preference	15.23±0.88[a]	4.265*
	Whole-brain preference	14.29±1.17[b]	
	Right-brain preference	15.14±1.24[a]	
Left-hand	Left-brain preference	13.50±1.43[a]	0.556
	Whole-brain preference	13.21±1.37[a]	
	Right-brain preference	13.69±1.23[a]	

*p<0.05

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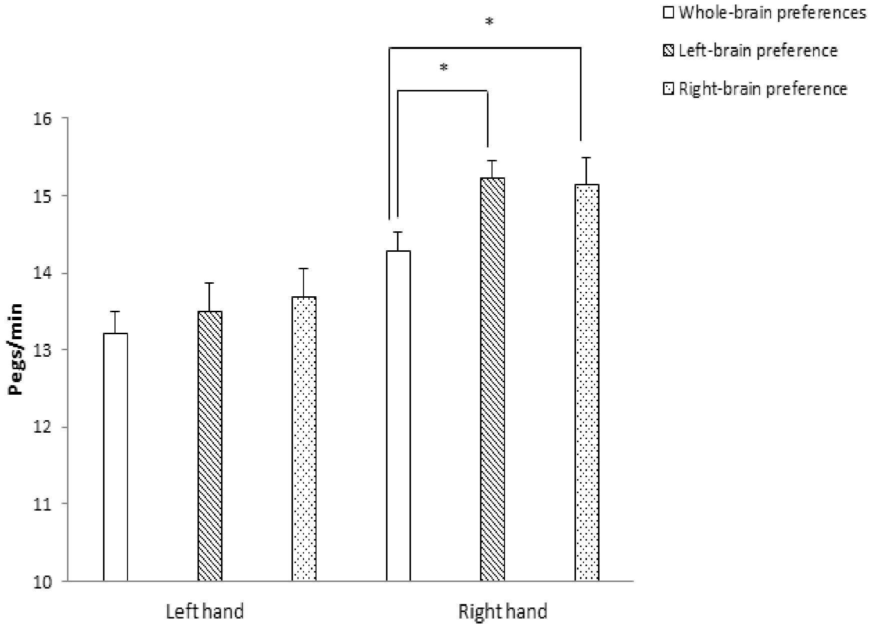

Figure 3: Brain Preference Group Differences between Right- and Left-hand.

Results from the Purdue Pegboard Test showed that right-had dexterity was best among those with left-brain preference, followed by those with right-brain preference, and, finally, those with whole-brain preference. Right-hand dexterity in the right- and left-brain preference groups was significantly higher than the whole-brain preference group.

$^{*}p<.05$

Generally, a BPI score less than 5, which is the median value of 1 and 9, tends to indicate a person with a more dominant left-brain, whereas a score greater than 5 is commonly associated with right-brain dominance. The BPI score is simply a means of understanding thought processing and does not indicate a positive or negative outcome. The mean BPI value of the subjects in this study was 4.88, which is in agreement with a previous study that showed that BPI values among the general population are around 5 (Min CR*et al.*,2012). Therefore, in this study, BPI scores less than 4.4 were classified as having a left-brain preference; scores between 4.4 to 5.5 were classified as having a whole-brain preference; scores 5.5 and above were classified as having a right-brain preference.

The human brain consists of two hemispheres and develops asymmetrically. Moreover, hemispheric dimorphism has been shown to be regulated by individual experiences (GunturkunO*et al.*,2020). Hand functionality may vary according to hemispherical differences that occur during brain development (Annett M., 2002). In this study, those with a left-brain preference and those with a right-brain preference showed more dexterous in hand functions than those with whole-brain preference.

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We found that males were more likely to be in the whole-brain group than females. The reason for this may be related to the observation that males tend to have better spatial and athletic abilities than females. Conversely, we observed a higher proportion of right-brain preference among females than males. This may be because memory and social cognitive abilities, which are associated with the right-brain, tend to be better in females (Ingalhalikar M. *et al*., 2014; Zaidi ZF, 2010).

This study examined the correlation of differences in right- and left-hand dexterity with brain preference type. When dexterity in each hand was tested among the three groups, no significant difference was observed for the left-hand; however, significant differences were observed for the right hand among the three brain-preference groups. Specifically, we found that right-hand dexterity was significantly greater among those with left- or right-brain preference than those with whole-brain preference, suggesting that lateralization of the cerebral hemisphere affects hand dexterity.

The lateralization of the cerebral hemisphere is closely related to dexterity and may have a significant influence on hand motor control (Bryden MP, 2012; Young A., 2012). Since the right hand was found to have higher dexterity than the left-hand in all brain-preference groups, the influence of cerebral lateralization on dexterity may be more prominent in the dominant hand. Motor movement and planning of upper extremitiesare typically governed more unilaterally, as movement selection by the premotor cortex has been shown to be lateralized to the left hemisphere (Rushworth MFS*et al.*,2003). Moreover,Serrien et al (2006)emphasized that hand movements can be altered via activation of certain lateralized regions of the brain. These results suggest that hand functions may be dependent on lateralized brain regions, such as the premotor cortex.

We observed a statistically significant difference in dexterity between the right- and left-hands in the three brain-preference types. This result is in line with a previous study, which reported that when a right-handed person performs a simple movement that requires both hands, the left-hand has a fast reaction speed and the right hand has a fast execution speed (Helsen WF*et al.*,1998; Mieschke PE*et al.*,2001). Another study on right and left arm reaching showed that the right hand had a smooth, constant speed of motion that used an efficient torque strategy, whereas the left-hand had a low accuracy of motion with a drastically uneven motion path (Przybyla A*et al.*,2012). As humans grow, lateralized regions develop differently, which some suggest has an influence on an individual’s preferences, personality, career choices, and functional movements of the body (Dulger O., 2012).Multiple studies have reported that the left cerebral hemisphere plays a greater role in planned motor movement than the right hemisphere (Kobayashi M*et al.*,2003; Nirkko AC*et al.*,2001; Solodkin A., 2001; Van Impe A*et al.*,2009).That is, right-hand movement is

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mainly controlled by the left hemisphere, whereasleft-hand movement is controlled by both hemispheres (Gut M et al., 2007).When performing simple movements, the brain activation pattern is similar regardless of which hand is used. However, brain activity is different when performing complex movements with either the right or left hand. Specifically, the left hemisphere is unilaterally activated when performing complex movements with the right hand. However, when performing complex movements with the left-hand, the contralateral right hemisphere and the ipsilateralleft hemisphere is activated, thereby eliciting a greater area of activation (Gut M et al., 2007). In terms of dexterity, hemispheric asymmetry is thought to play an important role. Bilateral (symmetric) circuits rely more on the exchange of information between hemispheres, where unilateral (asymmetric) circuits rely heavily on processes within the hemisphere (Ringo J L*et al.*,1994). In general, the dominant hand is mainly controlled by the contralateral hemisphere, but the non-dominant hand is controlled by both the left and right hemispheres(Gut M et al., 2007). Moreover, the motor circuitry of the left hemisphere is related to motor performance(Barber AD*et al.*,2012).Taken together, these data indicate that the right hand, which is dominated by the left hemisphere, performs better than the left-hand, suggesting that bilateral hemispheric motor control is ineffective in governing hand dexterity.

Since hand movement speed, preferred movement method, and perception and attitude of the movement may be differently regulated by brain-preference type (Verstynen T*et al.,* 2005), future studies should analyze upper limb function in relation to brain-preference type.

This study provided strong evidence of the differences in hand function in relation to brain preference type by using a hand function evaluation and the brain preference tool. These tools are to use and do not require brain imaging techniques that may be difficult to access and expensive.

Conclusion

This study evaluated the correlation between hand dexterity and brain preference type. We found that those with unilateral brain-preference types (i.e., right-brain or left-brain) had better dexterity than those with the whole-brain preference type. In the future, this study can be used as basic data on the correlation between hand function and brain preference type. Additionally, future studies should focus on other upper extremity measurement methods and more specifically focus left-handed people. Research on the effect of brain preference type on hand functions after brain damage will also be needed.

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