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Lateral Preferences and Hemispheric Language Dominance in Students in Ahmadu Bello University Zaria, Nigeria

Musa Mustapha[1], John Ijasini[1], Ahmed U. Shehu[2], Aliyu I. Aliyu[1], Tasiu Ibrahim[1], Ismail Ahmed[1], Musa O. Iliyasu[1], Ibrahim M. Ahmed[3], Abubakar S. Adamu[1]

[1]Department of Human Anatomy, Faculty of Medicine, Ahmadu Bello University. Zaria. Nigeria
[2]Department of Anatomy, College of Medicine, Kaduna State University, Nigeria
[4]Department of Human Anatomy, Faculty of Basic Medical Sciences, Usman Danfodio University, Sokoto, Nigeria

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ABSTRACT

Lateral preference, also known as laterality is defined as the predilection for the use of one side of the body over the other in humans. This study was aimed at investigating the relationship between hand and foot preferences and language dominance, as well as their sex-related differences in both sexes in a Nigerian population. A total number of 1000 apparently healthy adult subjects (548 males and 452 females), and students of Ahmadu Bello University, Zaria were randomly selected and recruited for the study. Hand preference was assessed using the Edinburgh Handedness Inventory questionnaire (EHI) and foot preference with the Waterloo Footedness Questionnaire-Revised (WFQ-R). Language dominance was extrapolated from the established fact of left cerebral hemisphere dominance for several aspects of speech and perception in the majority of the population. The sex-related differences in hand and foot preferences, and the association between foot preferences based on the hand preference were determined using the Chi-square analysis. All statistical analyses were performed with Statistical Product and Service Solutions (SPSS) version 23.0, and the significance level was set at $p<0.001$. No significant sex-related difference was observed in the hand and foot preferences ($p>0.001$). There was a statistically significant association between hand and foot preferences in both sexes ($X2=94.81$, $p<0.001$). Language dominance was also associated with lateral preferences. From this study, it could be concluded that gender may not necessarily affect lateralization, and the extent to which culture and ethnicity affect hand preference may vary from one community to the other, and hence the different incidences of hand and foot preferences that are seen.

Key words: *Foot preference, Hand preference, Laterality*

INTRODUCTION

Lateral preference, also known as laterality is defined as the predilection for the use of one side of the body over the other in humans. It is a terminology used to allude to the primary use of the right or left cerebral hemisphere in the brain. Studies have shown that several theoretical models have been used by various researchers to explain lateral preference in the population, for exampe, the genetic theory (McCartney and Hepper 1999; Francks et al. 2007; McManus et al. 2009), culture and environment (Liederman and Coryell 1981; Lenroot and Giedd 2008; Yoon et al. 2010), ultrasonography (McManus 1993; Salvesen et al. 1993; Kieler et al. 1998), evolutionary (Corballis 1983) and developmental theory (Moffat et al. 1998; Frederikse et al. 1999). Geschwind and Galaburda (1985) claimed that exposure to the higher rate of testosterone before

Correspondence: Musa Mustapha, MSc, Department of Human Anatomy, Faculty of Medicine, Ahmadu Bello University. PMB 1044, Zaria. Nigeria. mmustapha@abu.edu.ng; +2348039297156

birth can lead to a suppressed right handedness such that a left-handed child is born. This theory is known as the Geschwind theory, and it states that variation in the level of testosterone during pregnancy will shape the development of the foetal brain, such that neurons in the left cerebral hemisphere are suppressed in growth and those in the right cerebral hemisphere being well developed, take over the predominant cerebral functions. thus making the individual become left handed.

The most universally studied lateral preferences in humans are handedness; nevertheless, similar studies have also been documented for other paired organs like the ears, eyes and feet (Mohr et al. 2003). According to Dragovic (2004), hand preference has now become a standard measuring tool in most of the neuropsychological and behavioural asymmetrical investigations. Several authors have documented studies on the correlations between cerebral laterality and handedness (Watson et al. 1998; Reiss et al. 1999; Kang and Harris 2000; Singh et al. 2001; Mohr et al. 2003). Research has also shown that in the right-handers, right brain efficiency is negatively related to the degree of the right-hand preference (Tan and Akgun 1992), and the converse is true for the left-handers (Tan 1990). Footedness in recent studies have been shown to be less influenced by culture or the environment and this makes it a better predictor of language dominance than the handedness (Elias and Bryden 1998; Bell and Gabbard 2000; Kang and Harris 2000; Singh et al. 2001).

Even though hand preference has been considered as the most valid predictor for language dominance, recent studies have documented a close correlation between footedness and language dominance (Elias and Bryden 1998), or lateral preferences in postural whole body actions and language dominance (Mohr et al. 2003). In a bid to widen the viewpoints of the aforementioned research works, this study sets out to determine the relationship between hand and foot preferences and language dominance as well as their sex-related differences in both sexes in a Nigerian population.

MATERIALS AND METHODS

A total number of 1000 adult subjects (548 males and 452 females), and students of Ahmadu Bello University, Zaria with no obvious evidence of hand or foot deformity/injury were randomly selected and recruited for the study. This population was chosen for the ease of sample collection irrespective of age, marital status, religion, ethnic background, and the length of stay of the respondents in the university or locality. The Ethics Committee on Human Research, Ahmadu Bello University, Zaria endorsed the study protocol.

Hand Preference Determination

The Edinburgh Handedness Inventory questionnaire (EHI) (Oldfield 1971) was used to determine hand preference. The respondents were asked 10 different questions which include; hand preferences for drawing, writing, throwing, using different implements such as jar opening, knife without a fork, scissors, spoon, striking matches, and toothbrush. In the column related to the hand they used to carry out the task, that is, right-hand column (RH) and left-hand column (LH), they were instructed to put “1” in the related columns and where the preference was so powerful, that they would never use the unconventional hand, except when compelled to, they were instructed to put “2” in the related column and if indifferent to put a 1 in each column (1 | 1). The total of these points from each column was used to calculate the cumulative total (CT), (CT=RH+LH) and the difference (D), (D=RH-LH). The result (R) was calculated using the formula R=D/CTx100 and interpreted as follows: Left Handed: $R < -40$; Ambidextrous: $-40 \leq R \leq +40$); and Right Handed: $R > +40$).

Foot Preference Determination

Footedness was appraised with the Waterloo Footedness Questionnaire-Revised (WFQ-R) (Elias et al, 1998). Two types of tasks were asked in the questionnaire for the foot preference; the first half examined the foot preference for mobilizing tasks in manoeuvring an object such as; kicking and picking up a ball and marble, respectively. The last half of the questionnaire examined foot preference for stabilizing tasks such as balancing on a railway track, standing on one foot among others. The data in the questionnaire were graded as; (1) left-always, (2) left-usually, (3) equal, (4) right-usually, and (5) right-always, and were graded on a scale of -2 to +2. This provided a wide range of values from +20 for the most right-footed to -20 for the most left-footed. Then, following Elias et al. (1998), the subjects were grouped into three; right-footed (+7 to +20), left-footed (-7 to -20), and mixed-footed (-6 to +6).

Language Dominance Determination

Language dominance was extrapolated from the established fact of left cerebral hemisphere dominance for several aspects of speech and perception in the majority of the population (Hugdahl 2000; Friederici and Alter 2004; Corballis 2009; Friederici 2011; Hugdahl 2011; Corballis 2012; Ocklenburg et al. 2014).

Statistical Analysis

The sex-related differences in hand and foot preferences and the association between foot preferences based on the hand preference were determined using the Chi-square analysis. All analyses were carried out with Statistical Product and Service Solutions (SPSS) version 23.0 and the significance level was set at $p<0.001$.

RESULTS

Hand Preference

Figure 1 is a chart showing sex-related differences in the hand preferences. In the male subjects, 76.6% were right-handed, 18.2% left-handed and 5.1% ambidextrous, while in females; 79.4% were right-handed, 15.3% left-handed and 5.3% ambidextrous. However, no significant sexual dimorphism was observed in the hand preferences (X2=1.56, p=0.46).

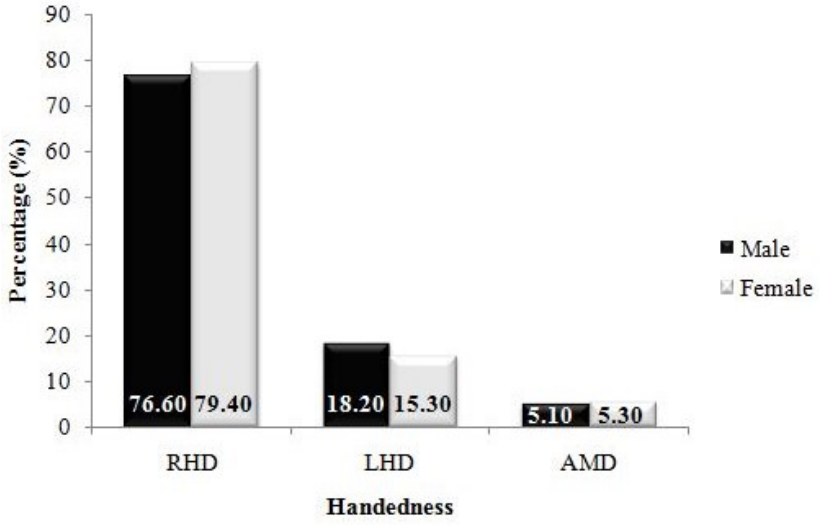

Figure 1: Distribution of Hand preference according to sex (X2 = 1.569; p = 0.456) (RHD: Right Handedness; LHD: Left Handedness; AMD: Ambidextrous)

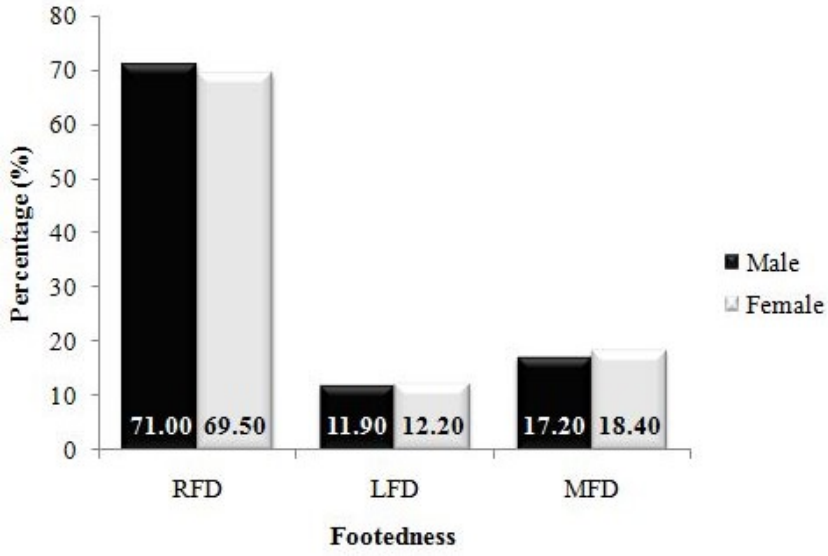

Figure 2: Distribution of foot preference according to sex (X2 = 0.305; p = 0.858)(RFD: Right Footedness; LFD: Left Footedness; MFD: Mixed footedness

Foot Preference

For the foot preferences in figure 2, no significant sexual dimorphism was also observed (X2=0.305, p=0.86) such that; in males, 71% were right-footed, 11.9% left-footed and 17.2% mixed-footed; while in females; 69.5% were right-footed, 12.2% left-footed and 18.4% mixed-footed.

The result in Table 1 revealed that 79.3% were right-footed, 6.4% left-footed, and 14.3% mixed footed in the male right-handers, whereas in the left-handed men, 51% were right-footed, 34% left foot, and 15% mixed footed. In the ambidextrous men, 17.9% were right-footed, 14.3% left-footed, and 67.9% mixed footed. There was a statistically significant difference between these percentages (X2=94.81, p<0.001).

Of the female right-handers, 78.3% were right-footed, 5.8% left-footed, and 15.9% mixed footed, whereas in the female left-handers 36.2% were right-footed, 42% left-footed, and 21.7% mixed footed. In the ambidextrous women, 33.3% were right-footed, 20.8% left-footed, and 45.8% mixed footed (Table 1). There was a statistically significant difference between these percentages (X2=94.81, p<0.001).

DISCUSSION

Generally, from the present study irrespective of the sexes, the preponderant use of the right limbs among respondents was noted. This is important and with underlying anatomic basis defined within the concept of human laterality (Melsbach et al. 1996). There is no doubt that the human brain is unique both in its components and size (Heinz et al. 1988), compared to primates. Deacon (1997) already noted that such marked difference in the human brain is mostly due to superficial gross anatomical features. Furthermore, the recognition drew from knowledge of the functional diversity of the brain as understood from the fields of neuroanatomy, developmental biology and genetics correlate with the morphology of the brain, and the topographical anatomy (McManus and Bryden 1993; McManus et al. 2009). Pyramidal decussation of corticospinal tract transmission is known to account for contralateral manifestations of the brain's activities in the limbs (Nielsen et al. 2002).

In the study of foot preferences in relation to hand preferences by Barut et al. (2007), 75.5% were right-footed, 7.1% left-footed, and 17.4% mixed footed in

the right male handers, whereas in the ambidextrous male subjects, 44.0% were right-footed, 28.0% left-footed, and 28.0% mixed footed. In the male left-handers, 32.3% were right footed, left-footed (56.9%), and mixed footed (10.8%). In the female right-handers, 89.9% were right-footed, 1.2% left-footed, 8.9% mixed footed, whereas in the ambidextrous women, 50.0% were right-footed, left-footed (12.5%), and mixed footed (37.5%). In the female left-handers, right footed was 8.8%, left-footed (79.4%), and mixed footed (11.8%). There was a significant relationship between these percentages in both sexes.

This present study have revealed the percentages of right footedness of the male and female right-handers, left-footedness of male and female right-handers, mixed footedness for the male and female right-handers, mixed footedness of both male and female left-handers and ambidextrous to be more than the values reported by Barut et al. (2007) (Table 1). On the other hand, right footedness of the male and female left-handers, left-footedness of the male and female left-handers, right footedness of male and female ambidextrous and left-footedness of male and female ambidextrous in the present study were found to be lower than those reported by Barut et al. (2007) (Table 1). The disparity between the two studies may stem from ethnic and individual differences, sample size and the type of questionnaires. However, it is not out of place to suggest that right-handed individuals were more likely to show right foot preference and the converse is true for the left-handed individuals.

When compared with the present study, Kang and Harris (2000) found that out of the 88.8% of the right-handed individuals 8.4% were right-footed, 2.7% mixed footed and 8.4% left-footed, whereas in the left-handed individuals 37.1% were right-footed, 62.9% left footed and that 100% of the ambidextrous were left footed. There were no reports documented concerning sex difference. In a similar study by Hatta et al. (2005), out of the 329 right-handed individuals, 0.3% were left-footed, 79.3% right-footed, and 20.4% mixed footed, while the out of the 8 left-handed individuals, 12.5% were right-footed, 50% left-footed, and 37.5% mixed-footed. The findings are inconsistent and the discrepancies seen could be attributed to the composition of the groups, cultural differences between the populations, and the sample size employed.

The hand and foot preferences in children aged 3 to 5 years were studied by Gabbard (1992) and that 67% of the right-handed children were right-footed, 4% left footed and 29% mixed footed, whereas 19% of the left-handed children were right and left-footed and 67% mixed footed and of the ambidextrous subject 32% were right-footed, 0.8% left footed and 60% mixed footed. The present study differs with that of Gabbard (1992) in terms of the age of subjects, in addition to the cultural and environmental influences.

Worth remarking, however, is that culture and other environmental factors do not alone suffice for the explanation of the observations from this study. What must not be ignored are the other variables that influence the anatomic arrangement in the brain even early in life (Hepper et al. 1998), as possible explanations for human laterality. An example is the concept of hormonal influence. Previous researchers (Geschwind and Galaburda 1985) claimed that exposure to a higher rate of testosterone before birth can lead to a suppressed right handedness such that a left-handed child is born. This theory is known as the Geschwind theory which states that variation in the level of testosterone during pregnancy will shape the development of the foetal brain such that neurons in the left cerebral hemisphere are suppressed in

Table 1: Foot Preference Distributions Based on the Hand Preference

SEX	R. Footedness	L. Footedness	M. Footedness	Total	X^2-value	P-value
MALE	n (%)	n (%)	n (%)	n (%)		
Right Handedness	333(79.30)*	27(6.40)*	60(14.30)	420(100)	94.811	0.001
Left Handedness	51(51.00)*	34(34.00)*	15(15.00)*	100(100)		
Ambidextrous	5(17.90)*	4(14.30)*	19(67.90)*	28(100)*		
FEMALE						
Right Handedness	281(78.30)*	21(5.80)*	57(15.90)	359(100)	94.811	0.001
Left Handedness	25(36.20)*	29(42.00)*	15(21.70)*	69(100)		
Ambidextrous	8(33.30)	5(20.80)	11(45.80)	24(100)		

R: Right; L: Left; M: Mixed; and *: $p < 0.001$

growth and those in the right cerebral hemisphere is well developed, take over the predominant cerebral functions; thus making the individual become left-handed (Geschwind and Galaburda 1985). This implies that prenatal testosterone contributes to brain organization (Elkadi et al. 1999).

Remarkably, previous studies have found a relationship between language dominance, handedness and footedness. About 95% of right-handers, but only between 70% and 85% of left-handers show typical left-hemispheric language dominance (Elias and Bryden 1998; Knecht et al. 2000; Perlaki et al. 2013). Similar to the previous findings, the present study also found majority of the study cohort to be right handed and footed, and this implies left hemispheric cerebral language dominance.

Conclusion

From this study it could be concluded that gender may not necessarily affect lateralization, as such prediction of the dominant cerebral hemisphere will be more precise taking cognizance of other variables such as; culture, environmental influence, anatomic arrangement, structuring of the brain and hormonal factors. The extent to which culture and ethnicity affect hand preference may vary from one community to the other, and hence the different incidences of hand and foot preferences that are seen.

Conflict of Interest

None declared.

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