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Influence of Handedness Preference on Visuospatial Ability in Lampung Province

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Abstract: The preference for using the right or left hand for different uni-manual tasks is known as handedness. Handedness as functional asymmetry has a correlation with the asymmetric brain. Most types of tools have been developed for right-handed use, leading to different adaptations between left-handed and right-handed individuals. Visuospatial, as one of the cognitive processes, is the ability to visualize two- and or three-dimensional objects. This function allows individuals to remember, plan for the future, navigate, and make decisions, thus visuospatial is one of the primary mental aspects in humans. The aim of this study was to assess whether being left-handed was associated with visuospatial ability. Respondents in this study were 148 adult individuals who lived in Lampung Province. Handedness was assessed based on a questionnaire of self-confessed and hand preference of 10 daily activities. Hand grip performance was measured by using a hand dynamometer. The ability of visuospatial was assessed by using the Right-Left Discrimination method. The results of the visuospatial ability test showed that left-handed individuals had a better average score of visuospatial than right-handed ones (44.00 > 40.86). Males had better visuospatial ability than females (estimate = -0.0768; p-value: 0.0481). The influence of handedness on visuospatial ability was discussed.

Keywords: Brain; Cognitive; Handedness; Lampung; Visuospatial ability

Introduction

The preference to use the right or left hand for different uni-manual tasks on an everyday basis is known as handedness (Marchant & McGrew, 2013). However, minority of left-handed individuals is ubiquitous and it is varied geographically (Flindall et al., 2015). This minority has not changed throughout history as the nature of handedness is an inherited trait (Forrester et al., 2013). Living in a right-handed world makes left-handed individuals challenged by the environment (Stein, 1973) since most types of tools have been developed for right-hand usage, thus it leads to different adaptations between right- and left-handed individuals.

Handedness as functional asymmetries may plausibly have a correlation with asymmetric brains (Amunts et al., 2000; Corballis, 2014) where hormones appear to play a large role (Richards et al., 2021). Hormones play a role particularly in reducing cerebral asymmetries by diminishing cortico-cortical transmission via the corpus callosum (Hausmann et al., 2002). One example is language lateralization that of left-handed individuals have a diversity (about 95 - 99% are left-lateralized) compared to right-handed individuals' (Corballis, 2014). Such findings have led researchers to hypothesize that the brain organization of left-handed individuals is different from those of right-handed ones (Thilers et al., 2007). In addition, previous studies show handedness affects on cerebral asymmetry Kavaklioglu et al. (2017) which is believed it is related to process visuospatial information (Flindall et al., 2015).

Visuospatial, as one of the cognitive processes, is the ability to understand two- and or three-dimensional objects as mental events. This function allows individuals to remember, plan for the future, navigate, and make decisions (Pearson et al., 2015). As for right-handed individuals in general, the visuospatial function is carried out by the right hemisphere, and it is influenced by sex which males have a better function. However, left-handed males show lower visuospatial performance as compared to right-handed males

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(Formisano et al., 2002). On the contrary, left-handed females tend to have higher visuospatial performance than right-handed females (Thilers et al., 2007). Nevertheless, the boundary of brain difference between left- and right-handed individuals remains elusive. Thus the aim of this study is to assess the influence of handedness on visuospatial ability, specifically in Lampung Province, Indonesia.

Method

This research was conducted from January until March 2022 in Lampung Province. The subjects in this research were 58 adult males and 90 adult females living in Lampung Province. Age, birth order, ethnicity, occupation, education, and salary were recorded as confounding variables.

Using a questionnaire is deemed an appropriate method of data collection for this study, thus self-declaration and ten tasks preference were assessed by interview. The subjects were asked about self-declaration for their general handedness (Nurhayu et al., 2018). Next, specific hand preference for ten daily activities based on Rife (1940) were asked. The ten tasks such as ball throwing, racquet holding during badminton, and the use of three distinct large tools (knife, hammer, saw) involve power grip. The other five tasks require precision grip such as playing marble, writing, and the use of three distinct small tools (spoon, scissors, and needle) (Napier, 1956). In addition, each hand grip performance (right: GR and left: GL) was measured using Camry Dynamometer model: EH101 and the relative hand difference were computed as (GR-GL)/(GR+GL).

Right-Left Discrimination Test was conducted to assess visuospatial ability in individuals. The questionnaire consists of stick man figure which has two colors of head, black and white. The black head shows the man from the back, while the white one shows the man from the front. The circle at the end of the arm indicates the hand (Ofte et al., 2002). Participants were asked to mark either right or left hand in accordance with the instructions under the figures in each part with a cross marker (X). The assessment consists of three parts, each session consists of 16 figures and must be completed within 1 minute. In the first part, subjects were given figures of all man from the back view, front view in the second part, and in the third part had a combination of front and back views. Each figure was drawn with different angles and positions of hands against the body.

In this study, ordinal logistic regression was built to assess the effect of handedness and demographic factor on visuospatial ability performance. Handedness and demographic factor were set as predictors, while visuospatial ability as a response. This analysis was performed using R program version 4.1.2.

Result and Discussion

A total of 148 individuals were interviewed and observed: 146 right-handed individuals (90 females and 56 males) and 2 left-handed individuals (all males), resulting in an overall sample frequency of 1.35% left-handed individuals. Age distribution for all the individuals was 17.9 to 31.7 years old with the mean of 21.2 years (median = 20.8 years, SD = 2.2 years). Left-handedness was associated with older age, although it was not significant (P- value = 0.3770).

Handedness had an association with individual's ethnicity, birth order, number of siblings, and sex. Two left-handed individuals were each Chinese and Balinese. Birth order had negative association to handedness with first or second born had higher possibility of being left-handed individuals compared to the latest born (Estimate: -0.023, P-value: 0.6526). Moreover, result shows that males tended to be left-handed individuals compared to females. However, these associations were significant only for two ethnics (Balinese P-value: 0.00105, Chinese P-value: 1.04 x 10−6).

The handedness preference in 10 unimanual activities was mostly right-handed (93.1% - 100.0%). There were females and males, that had a preference to use their left hand when playing marbles (females: 3.3%; males: 6.9%). Some females showed ambidexterity, when one activity can be done by using either hand, in playing marbles, using hammer, sewing, and cutting with scissors (all 1.1%). Males tended to be more flexible in using either hand in more activities such as throwing a ball, holding a racket, cutting with knife and scissors, using hammer, and sewing (1.7 – 3.4%).

Percentages of people based on their power grip are shown in Table 1. Even though there were no left-handed females, there were 12 individuals that had stronger grip in their left hand. The results for males are also the same, with 8 individuals had stronger grip in their left-hand even only 2 left-handed males were recorded. Ambidexterity and ambilaterality perhaps have an effect for the strength of hand grip.

Tabel 1. Percentage People Based on Power Grip

Power Grip	Female	Male
Right hand	86.7% (78)	86.2% (50)
Left hand	13.3% (12)	13.8% (8)
Total	80.0	58.0

Right-Left Discrimination Test was used in this research to assess the visuospatial ability of individuals. Based on back, front, mix, and total score, left-handed individuals had better visuospatial ability than right-handed individuals. However, mix score shows similar

result for both right-handed and left-handed individuals (R = 12.75; L=12.50, Table 4).

Tabel 2. Right-left Discrimination Test of Individuals Based on Handedness

Score	Mean	Mean by Handedness	
		Right	Left
Back view	14.14	14.12	16.00
Front view	14.14	13.99	15.50
Mix view	12.75	12.75	12.50
Total	40.91	40.86	44.00

Back-view score

Left-handedness was found to be associated with higher back-view score (estimate = 0.0294; P-value = 0.823). Although the score was not significant, females was associated with lower score compared to males (estimate = -0.084; P-value = 0.115). The educational background and job had no significant effect. Furthermore, individual with older age had higher result, even though there is no significant result (estimate = 0.3947; P-value = 0.377).

Front-view score

Left-handed individuals had lower score of front-view, although there is no significant value, (estimate = -0.0218; P-value= 0.839). Females had lower score of front-view significantly compared to males (estimate = -0.10032; P- value = 0.0233). The educational background and job had no significant effect. A better visuospatial ability also had association with older age significantly (estimate = 0.8455; P-value = 0.0213).

Mix-view score

Left-handed individuals had higher mix-view score. Females were found to be associated with lower score compared to males (estimate = -0.0477; P-value 0.4317). The educational background and job had no significant effect. Furthermore, individual with older age had higher result, even though there is no significant result (estimate = 0.88530; P-value = 0.0802).

Total Score

Left-handedness was associated to a higher total visuospatial score. Females was associated with lower score compared to males (estimate = -0.0768; P-value = 0.0481). The educational background and job had no significant effect. Furthermore, individual with older age had higher result, even though there is no significant result (estimate = 0.6431; P-value = 0.0462).

The left-handed frequencies in Lampung Province were 1.35% who are all men from the total sample population of 148 individuals. It is more common to have more left-handed males than females in a population. Prenatal testosterone influence could affect the function and structure of the brain by inhibiting the development of the left hemisphere and help the development of the right hemisphere (Geschwind & Galaburda, 1985). Moreover, men can produce testosterone more compared to female, resulting left-handed frequency in men becomes higher compared to female (Vuoksimaa et al., 2010).

Ambidexterity and ambilaterality was found in some individuals. Ambidexterity refers to the ability to do an activity such as writing that can be done with both hands. On the other hand, ambilaterality is an ability when a person can do activities with one hand and the other hand is used to do other activities, such as writing with the right hand and hammering with the left hand (Marchant & McGrew, 2013). Ambidexterity and ambilaterality are influenced by culture and existing equipment, causing individuals to have hand preferences other than the main hand in certain activities. However, ambidexterity and ambilaterality percentages are very small compared to the percentage of left-handed and right-handed individuals (Carlier et al., 2006; Fagard et al., 2015).

In general, left-handed individuals in this study showed better visuospatial compared to right-handed ones. This result is supported by the theory. The right hemisphere brain that performs visuospatial processing also performs processing of motor sensor control in the left hand (Brodie & Dunn, 2005). Furthermore, left-handed individuals seem to have different brain mechanisms compared to right-handed individuals. Most right-handed individuals have language processing in the right hemisphere, and the opposite applies to left-handed individuals in general (Corballis, 2014). Presumed, the same phenomena also occur in visuospatial abilities and the association with handedness.

This study shows that males had better visuospatial abilities compared to females. This is due to the influence of androgens, estrogens, and progesterone that affect brain development. This development makes males to have certain ability to fulfill their needs including the spatial ability to navigate and make various equipment (Collaer et al., 2007; Halpern et al., 2007).

The educational factor in this study had no significant effect because the individuals probably had been trained to use visuospatial skills in each of their education. According to theory, the higher the level of education, the more trained visuospatial abilities are possessed. Each individual will develop the ability, they have to facilitate their work and education. For example, the ability of visual memory to remember learning materials and put objects somewhere (Diezmann & Watters, 2000). The job of an individual did not have effects on visuospatial ability. This is because most jobs require good visuospatial abilities. Our subjects are mostly indoor workers that seems to imply the

visuospatial ability (Castro-Alonso et al., 2019; Cuendet et al., 2014).

Another factor that affects an individual visuospatial score was age. The age factor had a significant influence on the visuospatial ability of each individual. This seems to be influenced by a person's experience. The older an individual is, it is likely that the better visuospatial ability they had, together with the age distribution of our respondents who mostly enter the productive age from 17.9 to 31.7 years old (Barel & Tzischinsky, 2018; Lenroot et al., 2007).

Conclusion

Left-handed individuals tended to have better visuospatial ability compared to right-handed ones. Language processing is typically localized in the right hemisphere for most right-handed individuals, while the opposite is true for left-handed individuals. Thus, it is also assumed that a similar association exists between handedness and visuospatial abilities. Further study needs to involve more subjects from various populations with different backgrounds and age ranges to have more robust results and support the theory.

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Conceptualization, Winati Nurhayu; methodology, Winati Nurhayu; software, Andy Darmawan; validation, Jeane Siswitasari Mulyana and Gres Maretta; formal analysis, Andy Darmawan; investigation, Bobby Permana Putra; resources, Bobby Permana Putra; data curation, Bobby Permana Putra; writing—original draft preparation, Bobby Permana Putra; writing—review and editing, Winati Nurhayu and Andy Darmawan; visualization, Andy Darmawan; supervision, Winati Nurhayu; project administration, Bobby Permana Putra. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

References

Amunts, K., Jäncke, L., Mohlberg, H., Steinmetz, H., & Zilles, K. (2000). Interhemispheric asymmetry of the human motor cortex related to handedness and gender. *Neuropsychologia,* 38(3), 304-312. https://doi.org/10.1016/S0028-3932(99)00075-5

Barel, E., & Tzischinsky, O. (2018). Age and sex differences in verbal and visuospatial abilities. *Advances in Cognitive Psychology*, 2(14), 51. https://doi.org/10.5709/acp-0238-x

Brodie, E.E., & Dunn, E.M. (2005). Visual line bisection in sinistrals and dextrals as a function of hemispace, hand, and scan direction. *Brain and cognition*, 58(2), 149-156. https://doi.org/10.1016/j.bandc.2004.09.01

Carlier, M., Doyen, A.L., & Lamard, C. (2006). Midline crossing: developmental trend from 3 to 10 years of age in a preferential card-reaching task. *Brain and Cognition*, *61*(3), 255-261. https://doi.org/10.1016/j.bandc.2006.01.007

Castro-Alonso, J.C., & Uttal, D.H. (2019). Science Education and Visuospatial Processing. *Visuospatial processing for education in health and natural sciences*, 53-79. https://doi.org/10.1007/978-3-030-20969-8_3

Collaer, M., Reimers, S., & Manning, J. (2007). Visuospatial line judgment performance in relation to sex, sexual orientation and 2D: 4D. *Archives of Sexual Behavior*, *36*(2), 177-192. https://doi.org/10.1007/s10508-006-9152-1

Corballis, M.C. (2014). Left brain. right brain: facts and fantasies. *PLoS biology*, *12*(1). e1001767. https://doi.org/10.1371/journal.pbio.1001767

Cuendet, S., Dehler-Zufferey, J., Arn, C., Bumbacher, E., & Dillenbourg, P. (2014). A study of carpenter apprentices' spatial skills. *Empirical Research in Vocational Education and Training*, *6*(1), 1-16. https://doi.org/10.1186/s40461-014-0003-3

Diezmann, C.M., & Watters, J.J. (2000). Identifying and supporting spatial intelligence in young children. *Contemporary Issues in Early Childhood*, 1(3), 299-313. https://doi.org/10.2304/ciec.2000.1.3.6

Fagard, J., Chapelain, A., & Bonnet, P. (2015). How should "ambidexterity" be estimated? *Laterality: Asymmetries of Body, Brain and Cognition*, *20*(5), 543-570. https://doi.org/10.1080/1357650X.2015.1009089

Flindall, J.W., Stone, K.D., & Gonzalez, C.L. (2015). Evidence for right-hand feeding biases in a left-handed population. *Laterality: Asymmetries of Body, Brain and Cognition*, *20*(3). 287-305. https://doi.org/10.1080/1357650X.2014.961472

Formisano, E., Linden, D.E., Di Salle, F., Trojano, L., Esposito, F., Sack, A.T., … & Goebel. R. (2002). Tracking the mind's image in the brain I: time-resolved fMRI during visuospatial mental imagery. *Neuron*, *35*(1). 185-194. https://doi.org/10.1016/S0896-6273(02)00747-X

Forrester, G.S., Quaresmini, C., Leavens, D.A., Mareschal, D., & Thomas, M.S. (2013). Human handedness: an inherited evolutionary trait. *Behavioural Brain Research*, *237*, 200-206. https://doi.org/10.1016/j.bbr.2012.09.037

Geschwind, N., & Galaburda, A. M. (1985). Cerebral lateralization: Biological mechanisms, associations, and pathology: I. A hypothesis and a program for research. *Archives of neurology*, *42*(5), 428-459. https://doi.org/10.1001/archneur.1985.04060050026008

Halpern, D. F., Benbow, C. P., Geary, D. C., Gur, R. C., Hyde, J. S., & Gernsbacher, M. A. (2007). The science of sex differences in science and mathematics. *Psychological science in the public interest*, *8*(1), 1-51. https://doi.org/10.1111/j.1529-1006.2007.00032.x

Hausmann, M., Becker, C., Gather, U., & Güntürkün, O. (2002). Functional cerebral asymmetries during the menstrual cycle: a cross-sectional and longitudinal analysis. *Neuropsychologia*, 40(7), 808-816. https://doi.org/10.1016/S0028-3932(01)00179-8

Kavaklioglu, T., Guadalupe, T., Zwiers, M. et al. Structural asymmetries of the human cerebellum in relation to cerebral cortical asymmetries and handedness. *Brain Struct Funct, 222*, 1611–1623. https://doi.org/10.1007/s00429-016-1295-9

Lenroot, R.K., Gogtay, N., Greenstein, D.K., Wells, E.M., Wallace, G.L., Clasen, L.S., ... & Giedd, J.N. (2007). Sexual dimorphism of brain developmental trajectories during childhood and adolescence. *Neuroimage*, *36*(4), 1065-1073. https://doi.org/10.1016/j.neuroimage.2007.03.053

Marchant, L.F., & McGrew, W.C. (2013). Handedness is more than laterality: lessons from chimpanzees. *Annals of the New York Academy of Sciences*, *1288*(1), 1-8. https://doi.org/10.1111/nyas.12062

Napier, J. R. (1956). The prehensile movements of the human hand. The Journal of bone and joint surgery. *British volume*, *38*(4), 902-913. https://doi.org/10.1302/0301-620X.38B4.902

Nurhayu, W., Nila, S., Raymond, M., & Suryobroto, B. (2018). Are right-and left- handedness relevant as general categories in a non-industrialized country? *Acta Ethologica*, *21*(1), 21-28. https://doi.org/10.1007/s10211-017-0279-y

Ofte, S.H., & Hugdahl, K. (2002). Right-left discrimination in male and female, young and old subjects. *Journal of Clinical and Experimental Neuropsychology*, *24*(1). 82-92. https://doi.org/10.1076/jcen.24.1.82.966

Pearson, J., Naselaris, T., Holmes, E.A., & Kosslyn. S.M. (2015). Mental imagery: functional mechanisms and clinical applications. *Trends in Cognitive Sciences*, *19*(10). 590-602. https://doi.org/10.1016/j.tics.2015.08.003

Rife, D.C. (1940). Handedness. with special reference to twins. *Genetics*, *25*(2). 178. https://doi.org/10.1093/genetics/25.2.178

Richards, G., Beking, T., Kreukels, B. P., Geuze, R. H., Beaton, A. A., & Groothuis, T. (2021). An examination of the influence of prenatal sex hormones on handedness: Literature review and amniotic fluid data. *Hormones and Behavior*, *129*, 104929. https://doi.org/10.1016/j.yhbeh.2021.104929

Stein, M., 1973. *Personality Correlates of Left-handedness*. University Microfilms, Ann Arbor

Thilers, P.P., MacDonald, S.W., & Herlitz, A. (2007). Sex differences in cognition: The role of handedness. *Physiology & Behavior*, *92*(1-2). 105-109. https://doi.org/10.1016/j.physbeh.2007.05.035

Vuoksimaa, E., Eriksson, C. P., Pulkkinen, L., Rose, R. J., & Kaprio, J. (2010). Decreased prevalence of left-handedness among females with male co- twins: evidence suggesting prenatal testosterone transfer in humans?. *Psychoneuroendocrinology*, *35*(10), 1462-1472. https://doi.org/10.1016/j.psyneuen.2010.04.013