

## Variation of Handedness and Creativity in Bogor Primary and Secondary School Students

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### ABSTRACT

Left-handed individual's minority has been ubiquitous in human population which leads them to be adaptable in right-handed world. As a preference, daily hand used must be consistent across individuals and tasks, known as handedness. Handedness needs to be assessed with specific tasks using tools due to consistency of using either hand. There is a different adaptation that leads to creativity in left-handed individuals. The aim of this study is to assess left-handed individuals and measure their creativity. Handedness was examined by self-declared and 10 specific tasks of 493 both primary and secondary school students in Bogor, Indonesia. The total frequency of left-handed individuals was 7.3%. It seems that there are special adaptations that may signal creative behavior for left-handed individuals. The result showed that the left-handed females had higher creativity score than the males on Adjective Check List. Age and sex influence on creativity are discussed.

### 1. Introduction

Variation of phenotypic traits in human population could change from time to time depending on their adaptation to environmental changes. Each trait has its own advantage and disadvantage in a sense of reproductive success which leads to a phenomenon called natural selection (Darwin 1859). Unfavorable environment would cause selection for these traits and only the adaptive trait that fittest to the environment would persist in the population. Thus, for a very long time, the trait that cannot adapt to the environment would be diminished under this selection. Nevertheless, some disadvantage traits become "Darwinian Puzzle" due to their existence in a population until today even in a minority frequency. If the ratio of minor and the major traits is 1:9, these are included as polymorphism traits (McManus 2009) with the one of the examples is human handedness.

Human, as an individual, prefers using one of their hand especially in uni-manual tasks using tools in everyday basis (Llaurens *et al.* 2009). Without a

skill, it takes longer time and possibly self-injury and bodily harm. When there is a consistency in using one hand for most uni-manual tasks, handedness is recognized as distinct behaviours which leads to a meaningful concept of biological characters (Nurhayu *et al.* 2018). The frequency of handedness varies geographically and left-handed individuals frequency is 10% of a population (Faurie *et al.* 2005; McManus 2009). In addition, ubiquitous but minority of left-handed individuals seems to be persistence throughout the history (e.g., Coren and Porac 1977; Halpern and Coren 1991; McManus 2009, 2019; Papadatou-Pastou *et al.* 2020; Porac *et al.* 1980).

Right-handed world is a challenging environment for left-handed individuals (Stein 1973) since most types of tools have been developed for right-hand usage. Hence, left-handed individuals seems to have certain advantages, one of which is creative behavior (e.g., Annett and Ockwell 1980; Mehrdad and Ahghar 2012; Peterson and Lansky 1977). Even though it is fairly speculative, some clinical studies suggest that more left-handed individuals have better information processing between areas of the brain that leads to bilateral cognitive functions (Coren 1995; Cowell and Gurd 2018). Probably right-handed world produces different adaptations in left-handed individuals

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from behavior, learning to use right-handed tools by non-dominant hand, until physiology, certain brain lateralization that could affect creativity. Creativity is defined as producing multiple new idea and it is developing since adolescence (Kleibeuker *et al.* 2016). This is because the developing of prefrontal cortex which is associated with creativity in this cohort (Huizinga *et al.* 2006) and adolescents have explorative thinking (Johnson and Wilbrecht 2011). Thus, the aim of this study is to assess left-handed individuals frequency and measure their creativity, specifically school students in Bogor, West Java.

## 2. Materials and Methods

### 2.1. Participants

This study was performed between December 2014 and February 2015 in Bogor City, Indonesia. Six senior high schools and six junior high schools which each located in six different districts were determined as sampling location and sampling was performed independently to the proportion of left-handed individuals. As for elementary students, sampling was conducted by door-to-door visits as it needs more time to conduct deep interviews and handedness measures with younger children. Informed consent was provided at the beginning of each interview. The general aim of the study, the type of data collected, and that the data would only be used anonymously for scientific purposes were informed to each participant. Thus, The procedure was followed with a written voluntary agreement. Indonesian language was used during interview. After signing the informed consent, participants were being interviewed with general questions on sex and year of birth.

### 2.2. Handedness Measures

In order to determine generalized-declared handedness, the participants were asked about their self-declared of overall handedness. Next, they were asked about their task-declared handedness (right, left, or both) for ten uni-manual tasks (Rife (1940): playing marble, writing, the use of small tools (spoon, scissors, and needle), throwing a ball, playing badminton with a racquet (a popular game in Indonesia), and the use of large tools (knife, hammer, and saw). Precision grip is applied for the first five tasks when the object is pinched between the fingers and the opposing thumb. On the other

hand, power grip was applied for the last five tasks when the object is held as if in a clamp between the fingers and the palm (Napier 1956). In scoring task-declared handedness, +1 was given each time one of 10 tasks was checked for right while -1 was given for left hand, hence the theoretical range of scores is 0 to +10. Left-handed individuals have often been forced to use their right hand for certain tasks related to culture and possibly they have become ambidextrous (Vuoksima *et al.* 2009). Because of the enforcement background, and the low frequency in this study, ambidextrous was coded as left-handed for the next analysis.

### 2.3. Creativity Assessment

Creativity was assessed by Adjective Check List (ACL) containing 30 adjectives which were chosen by participants if that describe themselves. The 30 adjectives consist of 18 positive items that related to creativity and 12 negative items which describe the opposites. The positive items were: confident, humorous, informal, insightful and inventive etc. The negative items were: affected, cautious, commonplace, sincere, and suspicious etc. In scoring ACL, each time one of 18 positive items was checked +1 would be given, while -1 would be given each time one of 12 negative items was checked. Thus, the theoretical score range is -12 to +18, with less or same as 3 is categorized as not creative, while more than 3 as creative (Gough 1979).

### 2.4. Statistical Analyses

Binomial regression model was built which self-declared of overall handedness as a response variable to assess the influence of sex and age. Independence between general and specific-task preference was assessed using the Fisher exact test on a contingency table. Fleiss' Kappa (via package *irr* in R program) for categorical data was built to assess the concordance of handedness over the 10 tasks (Fleiss 1971), via the R package *irr*. The variability of creativity explained by generalized-declared handedness, sex, and age was evaluated using linear regression. All analyses were conducted using R version 4.1.0.

## 3. Results

### 3.1. Sample Description

A total of 493 individuals (267 females and 226 males) were interviewed. The age of individuals

ranged from 6.2 to 21 years old, the mean was 14.5 years (14.5 years for both females and males), the median was 14.1 years (14.2 years for females and 14.1 years for males), and the standard deviation was 2.4 years (2.3 for females and 2.5 for males).

### 3.2. Declared Hand Preference

Based on self-confessed of overall handedness, there were 36 left-handed (15 females and 21 males) and 457 right-handed (252 females and 205 males), resulting 7.3% of left-handed individuals (Table 1). Generalized-declared handedness did not differ significantly by both sex ( $P = 0.12$ ) and age ( $P = 0.89$ ).

All individuals declared their handedness for 10 uni-manual tasks, resulting in a total of 4,860 reports. This study found that 151 (3.1%) were declared as ambidextrous which defined as an ability to use both hands with equal ease for a uni-manual task. The frequency of ambidextrous reports was between 0 (for 4 tasks) and 3 (for 5 tasks) for any given task. This ambidextrous individuals was coded as left-handed. Overall, the percentage of tasks done by left hand ranged from 5.5% to 18.4% (Table 1). Concordance in individuals for the 10 tasks was significant (Fleiss's Kappa = 0.582,  $z = 86.6$ ,  $P < 10^{-4}$ ). The result even more robust when using spoon handedness, which is prone to cultural influences, was excluded (Fleiss's Kappa = 0.627,  $z = 83.5$ ,  $P < 10^{-4}$ ). Furthermore, overall handedness was correlated with handedness in each of the uni-manual tasks significantly ( $r = 0.92$ ,  $P < 10^{-10}$ ).

The numbers of left-handed individuals with left hand usage preference based on ten tasks' total scores are shown in Table 2. Due to the lowest number of left-handedness (5.5%; Table 1), using the spoon task was omitted. In this study, females tended to confess as left-handed individuals if they

Table 1. The number of individuals reporting self-confessed of overall handedness and ten uni-manual tasks

Reported handedness	Right	Left	Percentage of left-handed individuals (%)
Overall	457	36	7.3
Uni-manual tasks:			
Throwing	402	91	18.4
Racquet holding	447	46	9.3
Marbles	453	40	8.1
Knife/machete	456	37	7.5
Spoon	466	27	5.5
Hammer	450	43	8.7
Saw	455	38	7.7
Sewing	453	40	8.1
Writing	456	37	7.5
Scissors	442	51	10.3

Table 2. The number of left-handed individuals reporting a left hand usage preference for specific tasks (spoon handedness is excluded)

Number of specific tasks with a left hand usage preference	Sex	
	Female	Male
0	0	0
1	0	0
2	0	1
3	0	0
4	1	0
5	0	2
6	1	0
7	0	2
8	6	5
9	7	11

use their left hand for 4 activities or more, while that males for 2 activities or more. Furthermore, females tended to use different hands for different tasks (53%; 8/15 individuals) compare to males (47.6%; 10/21 individuals).

### 3.3. Creativity

All individuals in this study filled the Adjective Check List, resulting in 203 individuals being considered as creative while 290 individuals were described as not creative. Males of females had similar creativity ( $P = 0.09$ ). Yet, it was associated with younger age ( $P = 0.03$ ) with a 0.123 decrease of linear unit (i.e., log of odd ratio) for each additional year. Left-handed individuals had ACL scores ranging from -4 to +10 and most of them got +2 (6 individuals) and +3 (6 individuals). The percentage of left-handed individuals that were considered creative (ACL >3) was 25% (9/36). Creativity was influenced by self-confessed of overall handedness ( $P < 10^{-2}$ ), with left-handed individuals tending to be not creative. However, the interaction between self-confessed of overall handedness and sex had a significant effect on higher creativity scores ( $P = 0.03$ ), although this was applied only to left-handed females.

## 4. Discussion

The study in primary and secondary school students indicates that the variation of creativity was influenced by self-confessed of overall. Regardless of the handedness, creativity did not differ significantly by sex. In spite of this, left-handed females show higher creativity score than left-handed males. The younger age had a

significant influence on the higher creativity for both handednesses.

The number of left-handed individuals always far below 50% in human populations, but it varies geographically (Dellatolas *et al.* 1991; De Agostini *et al.* 1997; Llaurens *et al.* 2009; McManus 2019; Papadatou-Pastou *et al.* 2020; Raymond and Pontier 2004). As a heritable trait (Armour *et al.* 2014; Carter-Saltzman 1980; Hicks and Kinsbourne 1976; Llaurens *et al.* 2009; Longstreth 1980; McKeever, 2000; Medland *et al.* 2009; Nurhayu *et al.* 2018; Saudino and McManus 1998; Sicotte *et al.* 1999), left-handedness would become extinct in the population if the costs of being left-handed is higher than its benefits (Ghirlanda *et al.* 2009) and it leads to a loss in genetic drift (Raymond *et al.* 1996; Raymond and Pontier, 2004). Thus, the result of this study is implying that being left-handed individuals is not a disadvantage, and it seems to be associated with counterbalancing advantages, specifically creativity.

Handedness, specifically in non-industrial societies, is a biological characteristic (Nurhayu *et al.* 2018), describing a preference to use either hand for uni-manual tasks, and it shows efficiency in performing such tasks with one hand (Papadatou-Pastou and Tomprou 2015; Willems *et al.* 2014). The consistency between questionnaire and performance measurement allows interview-based assessments were conducted instead of behavioural (e.g. Raczkowski and Kalat 1974; Coren and Porac 1978). In addition, all individuals were capable to describe their generalized handedness, which indicates that handedness is wired on daily basis. The individuals sampled were all familiar with the 10 tasks used in the questionnaire.

Task-specific handedness assessment shows that the adaptability to use right hand was more shows in left-handed females compared to left-handed males. Left-handed individuals live in a right-handed world which require special adaptations for them in dealing with the environment, thus left-handed individuals may develop better creative behavior (Mehrdad and Ahghar 2012; Newland 1981). Ambilaterality is referred as a capability of using one hand for a task and the other hand for another task (Marchant and McGrew 2013). The result shows that left-handed females' who were ambilateral probably shows adaptability to right-handed world and might lead these individuals to have higher

creativity. Ambilaterality was reported to have an association to higher creativity even though the sex effect is still elusive (Badzakova-Trajkov *et al.* 2011).

The overall result showed the right-handed individuals had higher creativity than left-handed ones, in contrast to expectation. Same result was shown in large Dutch population sample for creativity in convergent and divergent thinking, and also artistic creativity (Zickert *et al.* 2018). However, other studies reported that left-handed individuals show greater creativity especially in elaboration (Stewart and Clayson 1980), particularly in school that involved creativity such as art, music, and architecture (Götestam 1990). In this research, as school students, their creativity was influenced by school activity. right-handed students may explore more of their hobbies such as playing music instrument, drawing, singing, and dancing which develop creativity (Fleith 2000).

Moreover, creativity could be a result of the interaction between the student and his/her class environment, including learning methods. Classroom characteristics could inhibit creativity in certain ways. The use of one right answer, no mistakes are allowed, ignored difference ideas, drill work, emphasis on curriculum, and lack of time (Fleith 2000; Tan *et al.* 2016). Hence the classroom environment in general probably made creativity of students, regardless of their handedness, did not develop and it is also supported by age data which explains that older students tend not to be creative.

In conclusion, the variation of creativity was influenced by generalized-declared handedness in primary and secondary school students with right-handed students showed higher creativity. It may well be possible, with larger sample sizes, to see the variation of creativity and handedness more clearly. The present shows that left-handed females were more creative than the males due to their adaptability in using right hand; however, further research is needed before any firm conclusions can be established.

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