



EFFECTS OF LATERALIZATION ON BRAIN ACTIVITY IN HUMAN

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ABSTRACT

Lateralization refers to the acquisition of laterality specifically, the functional dominance of one side of the central nervous system over the other. The concept of lateralization has been extended to numerous other cognitive functions and to sensory information processing, such as somatosensory perception, hearing, and vision. However, the influence of lateralization on certain higher mental functions particularly selective attention has received little investigation. The aim of this study is to evaluate the effect of laterality on selective attention. Regarding the Stroop test, after the picture cards were distributed, the experimenter read the instructions for the current stage and started the stopwatch as soon as the subject began reading the picture cards. Our results showed that left-handers were faster than right-handers across all test conditions. Furthermore, during the naming task, left-handers took an average of 1.17 seconds compared to 1.80 seconds for right-handers ($p=0.001$), indicating greater efficiency. Regarding uncorrected interference errors, there is a significant difference ($p=0.001$): left-handers performed well, with an average of 1.42 compared to 1.90 for right-handers. Ultimately, we can conclude that individuals with left-sided lateralization perform better on the cognitive tasks presented to them than those with right-sided lateralization.

Keywords: CVLT, STOOPT Test, Lateralisation, Left-Handers, Right-Handers,

1 INTRODUCTION

Structural asymmetry in organisms is a well-known biological fact observed at all stages of evolution, even in the most primitive animal forms (Monod, 1969). However, the developmental, genetic, and molecular origins as well as the functions of these asymmetries remain poorly understood, and studies involving humans are often controversial. The meaning of asymmetry, the issue of its genetic transmission, and the apparent contradiction between structural

asymmetry and behavioral symmetry all present enigmas for biologists and for psychologists investigating human laterality. For instance, both hemispheres contribute to understanding the causality of events, with each processing a different dimension of causality: while the left hemisphere can draw simple causal conclusions, it cannot determine the nature of that causality; the reverse is true for the right hemisphere, which can understand the cause of events but cannot draw conclusions from them (Roser et al., 2005). These studies have also confirmed the left hemisphere's role in language and revealed the right hemisphere's visuospatial capabilities. Since then, brain imaging techniques such as magnetic resonance imaging (MRI) and electroencephalography (EEG) have provided a better understanding of the concept of cerebral lateralization (Charles et al., 1994; Powell et al., 2006; Steinmann et al., 2018). These techniques have made it possible to identify the cognitive functions associated with the lateralized processing of information. Indeed, while behavioral tasks involving emotions (Davidson, 1992; Suberi & McKeever, 1977) or spatial navigation (Gramann et al., 2006; Van Asselen et al., 2006) are associated with right-hemisphere activation, those involving speech (Corina et al., 1992; Vigneau et al., 2006) or certain calculation-related aspects (Jung et al., 1984; Shepherd & Gale, 1982) lead to left-hemisphere activation. There is a correlation between hand dominance, the maturation of the central nervous system, and child development (Gendrier, 2004). This manual preference is also inextricably linked to the division of functions between the two hemispheres, in that it also stems from a central asymmetry (Azemar, 2003).

The links between asymmetries and brain functions are not clearly identified, and the question of the existence of evolutionarily conserved mechanisms remains open.

Several studies on the subject of cerebral lateralisation show that this is a matter of great importance (Josse et al., 2004).

Numerous studies have been conducted on the phenomenon of lateralization regarding language, pain, motor function, and olfaction. However, few studies have investigated lateralization in relation to certain higher mental functions, particularly selective attention.

Thus, this study aims to provide answers regarding the impact of lateralization on attention using the Stroop test.

2 MATERIALS

2.1 Subjects

For this study, 40 participants were recruited and divided into four groups: two groups consisting of right-handed (10) and left-handed (10) women, and two groups of right-handed (10) and left-handed (10) men.

Preliminary tests including the Edinburgh Handedness Inventory, questionnaires on daily activities, and assessments of psychological state and alertness were conducted on these students to determine their handedness and to rule out potential pathological conditions or vigilance disorders.

All tests were conducted at the Neuroscience Laboratory of Félix Houphouët-Boigny University between March 15 and May 15, 2025.

2.2 Technical equipment

The technical equipment consists of: stopwatch, Stroop test sheets, Stroop test score sheets, an Edinburgh questionnaire form, and a laptop.

3 METHODS

3.1 Determination of subject laterality

Before the testing procedure, the subject is asked to complete a request form incorporating the Edinburgh questionnaire and indicating their hand preference for ten daily tasks: writing, drawing, throwing an object, using scissors, holding a toothbrush, using a spoon, pressing a handkerchief against the nose to blow it, opening a window, striking a match, and unscrewing a knob.

According to Claude-Henri Chouard, this questionnaire is "sufficiently detailed to serve as a reference for most of the publications it thereby renders comparable." In his view, the evaluation of responses to the questionnaire is based on a five-point Likert scale, designed to determine an individual's degree of handedness:

Five possible responses in each case: always to the left equals minus ten; usually to the left equals minus five; no preference equals zero; usually to the right equals plus five; always to the right equals plus ten.

By summing the scores obtained, one can quantitatively assess hand dominance on a scale ranging from minus one hundred (perfect left-handers) to plus one hundred (perfect right-handers). A negative score corresponds to true left-handers, a score between 0 and 70 to intermediate subjects, and a score above 70 to true right-handers (Chouard Claude-Henri, 2001).

3.2 Cognitive assessment tests

Regarding the cognitive activities to be tested, we selected attention, which will be assessed using the Stroop test.

3.2.1 Stroop Test

The Stroop test (Stroop, 1935; Godefroy & Grefex, 2008) is used in the context of experimental psychology. It focuses on phenomena of association and inhibition or interference in subjects in order to assess selective attention and inhibitory or interference-related capabilities. There are several versions of the Stroop test, and the differences between them can be summarized in six specific points. Across these existing variants, there are three stimulus cards corresponding to three levels of administration:

- a sheet of rectangles of different colors (naming),
- a list of words identifying colors, but printed in black (reading);
- a list of color names printed in colors different from the ones they designate (interference or inhibition);

During administration, the test involves going through the sheets in order (naming-reading-inhibition or naming-interference) either reading the written words or naming the colors as quickly as possible. The evaluator records the number of words read or colors named by the subject and subsequently calculates the score obtained for each level of the test.

During the Stroop test, after the stimulus cards have been handed out, the examiner reads the instructions for the current stage and starts the stopwatch when the subject begins reading the card. Reading proceeds from left to right, line by line, until the end.

- Step 1 - Plate 1: Identification of rectangle colors. The participants must name the color of the rectangles (green, blue, or red).
- Step 2 - Plate 2: Word reading. The participants must read the words printed in black (green, blue, or red).
- Step 3 - Plate 3: Identifying word color. The participants must name the color of the ink used to print the words (green, blue, or red).

3.3 Statistical processing

The collected data were first analyzed using STATISTICA software (version 7.1). A single test was performed: an analysis of proportions (a non-parametric test) was used to examine parameters related to attentional dysfunction (specifically, corrected and uncorrected errors) as well as performance parameters. Where significant differences between proportions were found, the Fisher test used to compare two independent samples (groups) yielded a p-value of less than 0.05.

4 RESULTS

The sample comprises 10 left-handed women, 10 left-handed men, 10 right-handed women, and 10 right-handed men. We prioritized including equal numbers of left-lateralized and right-lateralized individuals within the given population.

4.1 The Stroop attention test

4.1.1 total time in passing (TTP)

Figure 1 shows the participants' performance across the different trials of the Stroop test. It therefore shows the total time taken by the participants to name the colours and to read the words indicating the colour of the words. A significant effect was observed ($p=0.001$). Left-handed participants achieved a better score than right-handed participants. Indeed, left-handed participants took an average total time of $271 \pm 0,89$ seconds, whereas right-handed participants took an average of $302.30 \pm 0,83$ seconds. Left-handed participants were therefore faster than right-handed participants across all trials.

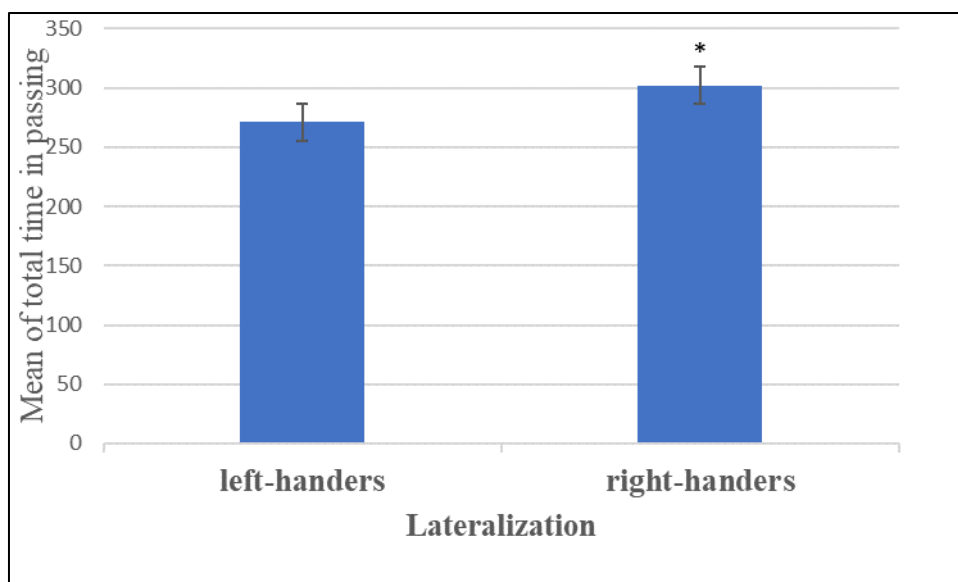


Figure 1: Total time taken for the tasks (naming, Reading, interference)

*indicates a significant difference between left-handers and right-handers

4.2 Total errors in naming (TEN)

During the naming activity, left-handers took an average of $1.17 \pm 0,02$, compared with $1.80 \pm 0,02$ for right-handers. The results for corrected naming errors (CNE) show a significant difference ($p=0.001$) (Figure 2). Furthermore, among left-handed participants, there were $0.98 \pm 0,32$ uncorrected errors during the naming. Right-handed participants, had an average of $1.10 \pm 0,24$ uncorrected errors. With regard to naming uncorrected errors (NUE), there was no a significant difference ($p=0.20$) (Figure 3).

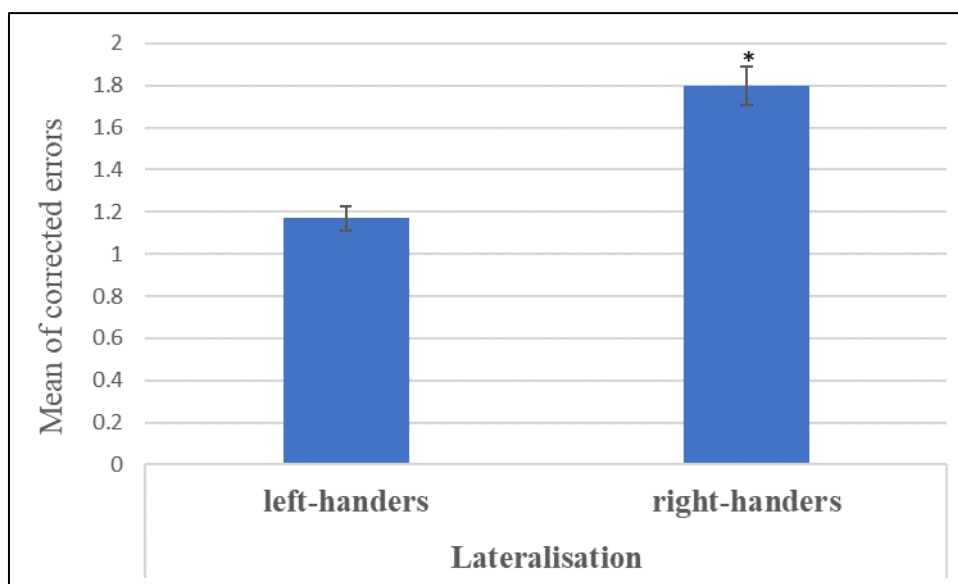


Figure 2: Corrected errors during naming

*indicates a significant difference between left-handers and right-handers.

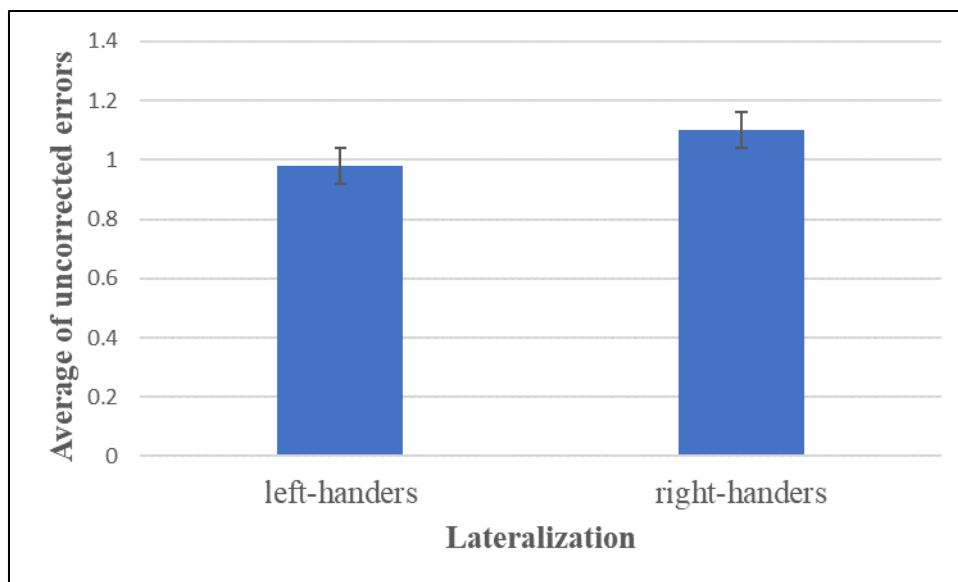


Figure 3: Uncorrected errors during naming

4.3 Total errors during interference (TEI)

No significant difference was observed in terms of interference. The two groups of participants left-handers and right-handers had statistically identical scores in terms of total errors. The mean was 4.57 ± 0.54 for right-handers and 4.67 ± 0.53 for left-handers, with a p-value of 0.55 (Figure 4). Nor was there a significant difference between the two groups in terms of corrected errors.

However, in terms of uncorrected errors under conditions of interference, there was a significant difference ($p=0.001$) : left-handers performed well, with an average of 1.42 ± 0.13 , compared with 1.90 ± 0.09 for right-handers (Figure 5).

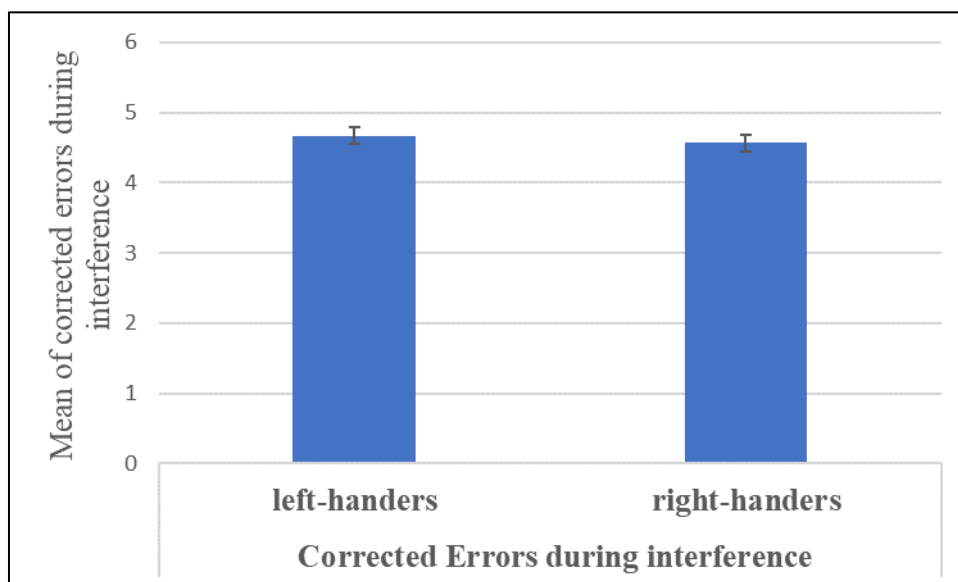


Figure 4: Corrected errors during interference

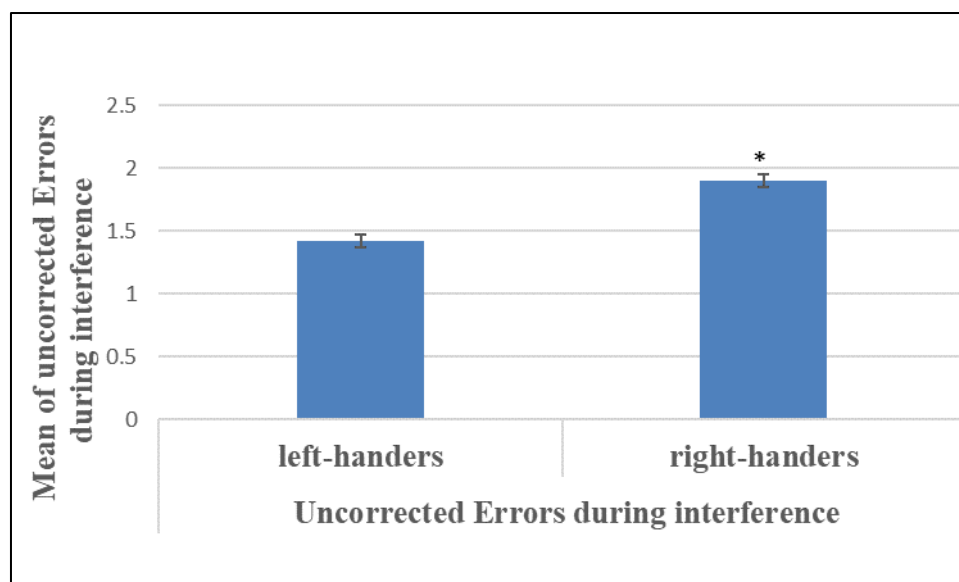


Figure 5: Uncorrected errors during interference

*indicates a significant difference between left-handers and right-handers.

5 DISCUSSION

The results of this study support the hypothesis that left-handed people perform better than right-handed people in several fields of activity.

Regarding the Stroop test, the results reveal that the average scores obtained by left-handers are generally higher than those obtained by right-handers. Indeed, the p-value is 0.03, indicating a significant effect.

This performance disparity in chromography activities, reflects the relative cognitive difficulty right-handers face in providing rapid responses. The greater speed of left-handers compared to right-handers in task execution is thought to be linked to specific characteristics of their brain structure. The corpus callosum, a bundle of neurons connecting the two hemispheres is larger in left-handers than in right-handers; consequently, interhemispheric communication is more extensive and faster (Gil, 2010). According to Fagard and Dahmen (2004), The temporal planum, which plays a role in language processing, is thought to be developed in both hemispheres, is developed in both hemispheres in left-handers, whereas in right-handers it is developed only in the right hemisphere.

The results also show that scores for the first two activities (activity1 and activity 2) are higher than those for the final activity (interference), for both left-handed and right-handed individuals. This is due to the nature of the card used in activity 3 (words in color). This sheet is described as "incongruent," meaning that processing it requires a more complex cognitive process (involving the inhibition of certain tasks) (Lemarcier, 2002). A conflict arises from the two-dimensional stimulus: there is interference between the process of reading the word and the process of naming its color. Peterson et al. (1999) indicated that this interference effect is mediated by the functioning of the anterior cingulate cortex. This region coordinates and manages information from mediated attentional subunits involved in the different stages of stimulus processing, with which it maintains functional connections. These results are similar to those Golden (1978), who obtained mean scores of 80 for the color-naming sheet (sheet C), 108 for the word-reading sheet (sheet M), and 45 for the color-of-words sheet (CM).

6 CONCLUSION

This study examines the causal relationship between lateralization and attention in humans. To conduct this research, we used the Stroop test to gather specific data on left-handed and right-handed individuals. The results revealed that hand preference whether left or right is influenced by several factors, with genetic factors being the most extensively studied.

The results show that individuals with left-sided lateralization perform better on the cognitive activities presented to them than those with right-sided lateralization. Thus, our findings confirm the hypothesis that left-handers are more gifted than right-handers.

The tests used in this study have proven validity and reliability; However, it is essential to be thoroughly familiar with how to administer these tests. Furthermore, to enhance the study, we suggest including a larger number of participants and incorporating additional tests to assess cognitive activities.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors have explicitly declared that there is no conflict of interest in relation to this article.

Statement of informed consent

This study was carried out at our university. All the students agreed to take part in this study of their own free will.

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