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Original Research Article

Difference in Visual Reaction Time between Dominant and Non-Dominant Hands Among Undergraduate Students

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ABSTRACT

Background: Reaction time (RT) is the time taken by an individual to response to a stimulus. It is a fundamental indicator of sensory–motor integration and central nervous system efficiency. Hand dominance is associated with cerebral lateralization and may influence motor performance. However, existing literature shows variability in dominance-related reaction time differences.

Aim: To compare visual reaction time (VRT) between dominant and non-dominant hands among undergraduate students and to analyze gender-based differences.

Materials and Methods: This cross-sectional study was conducted over a period of 6 months among 210 undergraduate students aged 18–25 years. Hand dominance was identified through self-report. Visual reaction time (VRT) was assessed using a standard reaction time instrument. Mean reaction times were compared using paired t-test, and gender-based comparisons were analyzed using independent t-test.

Results: The dominant hand demonstrated significantly faster VRT than the non-dominant hand (238.6 ± 24.1 ms vs 262.4 ± 27.9 ms; $p < 0.001$). The mean difference was 23.8 ms (95% CI: 20.1–27.5 ms) with a large effect size (Cohen's d = 0.92). Both male and female participants showed similar dominance-related trends, with males exhibiting marginally faster reaction times overall of 232.1 ms, compared to 244.8 ms in females.

Conclusion: Dominant hand VRT was significantly faster, reflecting superior sensory–motor coordination and neural efficiency. Reaction time measurement can be used as a simple clinical tool to assess neuromuscular coordinationand psychomotor performance.

Keywords: Reaction time, handedness, lateralization, university students, motor performancewrite relevant keywords

INTRODUCTION

Reaction time is defined as the interval between the presentation of a stimulus and the initiation of a voluntary motor response and is widely used as an indicator of central nervous system processing efficiency.[1,2,3] It reflects the integrated functioning of sensory reception, neural transmission, cognitive processing, and motor execution.[3,4,5] Due to its sensitivity to neural performance, reaction time assessment is commonly utilized in clinical physiology, neurology, sports science, and rehabilitation to evaluate sensory–motor coordination and functional integrity.[5,6]

Hand dominance refers to the consistent preference for one hand during skilled and routine activities and is closely associated with cerebral lateralization. [7,8] The dominant hand is generally believed to exhibit superior motor precision and faster response execution due to greater cortical representation and frequent use.[9]

Visual reaction time tasks are particularly effective in assessing dominance-related differences because they require rapid processing of visual input followed by immediate motor output. [4, 10] Several studies have reported variability in findings, necessitating further investigation. [3,4,11,12]

MATERIALS & METHODS

Study Design, Duration, and Setting

This cross-sectional observational study was conducted over a period of 6 months at a tertiary educational institution. The study was carried out in a controlled laboratory environment within the Department of Physiology to ensure uniform testing conditions.

Study Population and Sampling Technique

A total of 210 undergraduate students aged 18–25 years were recruited using convenience sampling. Participants included both male and female students from various academic disciplines. Prior to participation, all subjects were informed about the study protocol, and written informed consent was obtained.

Sample Size Calculation

The sample size was calculated using the formula for paired observations:

$$n = \left(\frac{Z_{\alpha/2} + Z_{\beta}}{d/\sigma}\right)^2$$

Where:

- $Z_{\alpha/2} = 1.96$ **(95% confidence level)**
- $Z_{\beta} = 0.84$ **(80% power)**
- σ **= standard deviation**
- d **= expected mean difference**

Based on previous studies [13, 14], the minimum sample size was estimated to be approximately 190 participants. To enhance statistical power and account for variability, 210 participants were included in the study.

Inclusion and Exclusion Criteria

Carefully defined inclusion and exclusion criteria were applied to minimize confounding factors known to influence reaction time. [2,6]

Inclusion Criteria

- Undergraduate students aged 18–25 years
- Apparently healthy individuals
- Normal or corrected-to-normal vision
- Willingness to participate and provide informed consent

Exclusion Criteria

- History of neurological or psychiatric disorders
- Musculoskeletal injuries affecting the upper limb
- Uncorrected visual or auditory impairments
- Current use of medications affecting reaction time
- History of substance abuse or sleep deprivation prior to testing

Ethical Consideration

The study protocol was reviewed and approved by the Institutional Ethics Committee. All procedures were conducted in accordance with ethical standards for human research. Written informed consent was obtained from all participants prior to data collection.

Assessment of Hand Dominance

Hand dominance was determined using self-reported preference for writing and performing routine daily activities, a commonly accepted method in reaction time studies. [10,15] Participants were classified as right-handed or left-handed based on their dominant hand usage.

Instrumentation and Apparatus

Visual reaction time was measured using RT Apparatus (Anand Agencies), standard reaction time instrument designed to assess sensory–motor response latency with millisecond accuracy.

The instrument consisted of:

- A visual stimulus display unit
- A response key/button
- An inbuilt timer capable of recording reaction time in milliseconds

The device was calibrated prior to testing to ensure accuracy and reliability of measurements.

Measurement of Reaction Time

Visual reaction time was assessed using RT Apparatus (Anand Agencies) in a quiet laboratoryto minimize distractions. [4,5]

Participants were instructed to:

- Sit comfortably in front of the apparatus
- Focus on the visual stimulus (a green dot) presented by the instrument
- Respond as quickly as possible by pressing the response key upon stimulus appearance

Each participant performed three trials for each hand, and the mean reaction time (in milliseconds) was recorded for analysis.

Adequate rest intervals of 2-5 seconds were provided between trials to prevent fatigue.

The average of the three trials was recorded as the reaction time for each hand.

Standardization of Testing Conditions

To ensure consistency and reduce variability:

- Testing was conducted at a fixed time of day at 1:30pm.
- Participants were instructed to avoid caffeine, alcohol, and heavy physical activity prior to testing
- Adequate rest was ensured before participation
- Instructions were standardized for all participants

Outcome Measures

The primary outcome measured was visual reaction time (milliseconds) for:

- Dominant hand
- Non-dominant hand

Secondary outcomes included:

- Gender-based differences in reaction time

Statistical Analysis

Data were entered and analyzed using Statistical Package for the Social Sciences (SPSS) version 25.0.

- Continuous variables were expressed as mean ± standard deviation (SD)
- Paired t-test was used to compare reaction times between dominant and non-dominant hands
- Independent t-test was used to compare reaction times between males and females

Additionally:

- Effect size (Cohen's d) was calculated to determine the magnitude of difference
- 95% confidence intervals (CI) were computed to assess precision of estimates

A p-value <0.05 was considered statistically significant**.**

RESULT

A total of 210 undergraduate students participated in the study. The majority of participants were right-hand dominant, indicating a typical distribution of handedness in the general population.

Table 1: Comparison of mean visual reaction time between dominant and non-dominant hands

Parameter	Dominant Hand	Non-dominant Hand	**p-value**
Mean VRT (ms)	238.6 ± 24.1	262.4 ± 27.9	<0.001*

Unpaired T- test

***Statistically significant**

Table 1 shows the comparison of visual reaction time (VRT) between dominant and non- dominant hands. The VRT was found to be significantly lower for the dominant hands with a p-value of <0.001

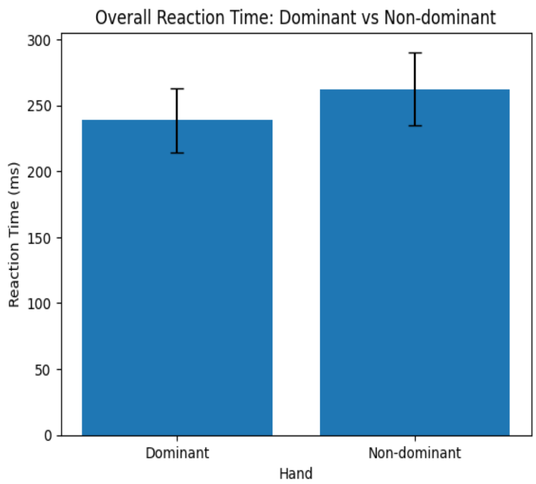

Figure 1- Visual reaction time of dominant & non-dominant hands

Figure 1. The dominant hands demonstrate significantly lower reaction time compared to the non-dominant hands ($p < 0.001$). The difference highlights improved sensory–motor efficiency of the dominant hands.

The mean visual reaction time for the dominant hands (238.6 ± 24.1 ms) was considerably lower than that of the non-dominant hands (262.4 ± 27.9 ms). This difference of 23.8 ms was found to be highly statistically significant ($p < 0.001$) .

The 95% confidence interval (20.1–27.5 ms) indicates that the observed difference is precise and consistent across the study population, suggesting high reliability of the findings.

In addition, the effect size (Cohen's d = 0.92) was found to be large, demonstrating that the difference between dominant and non-dominant hands is not only statistically significant but also clinically and practically meaningful.

The relatively higher standard deviation observed in the non-dominant hand (27.9 ms) compared to the dominant hand (24.1 ms) suggests greater variability in performance, possibly due to inconsistent motor control and reduced habitual use.

Table 2: Gender-based comparison of visual reaction time

Parameter	Hand	Male	Female	p-value
Mean visual reaction time (ms)	Dominant	232.1 ± 22.5	244.8 ± 25.7	<0.001*
Mean visual reaction time (ms)	Non-dominant	255.3 ± 26.8	269.2 ± 28.6	<0.001*

Unpaired T- Test
***Statistically significant**

Table 2 shows that males have significantly faster mean visual reaction times than females for both dominant and non-dominant hands, with all differences being statiscially significant ($p < 0.001$)

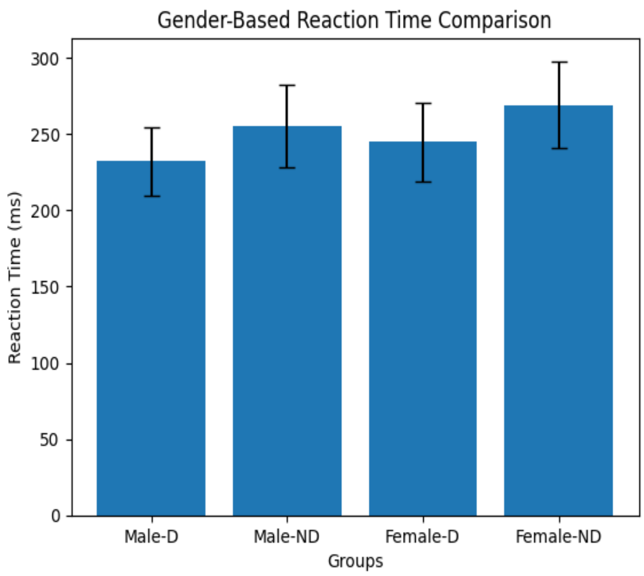

Figure 2- Bar graph illustrating visual reaction time differences between males and females for both dominant and non-dominant hands.

Male-D: Male dominant hands, Male –ND: Male non dominant hands

Female –D: Female dominant hands, Female ND: Female non-dominant hands

Figure 2 shows that males exhibit slightly faster reaction times than females. However, both groups show a consistent pattern of faster responses in the dominant hands compared to the non-dominant hands.

Male participants demonstrated faster visual reaction times than female participants for both dominant and non-dominant hands. Specifically, males had a dominant hand reaction time of 232.1 ms, compared to 244.8 ms in females, indicating a modest gender-related difference.

Similarly, for the non-dominant hands, males (255.3 ms) responded faster than females (269.2 ms). Despite these differences, the pattern of dominance remained consistent across both genders, with the dominant hand showing significantly faster responses in each group ($p < 0.001$).

The difference between dominant and non-dominant hands was:

- Males: 23.2 ms
- Females: 24.4 ms

This similarity suggests that hand dominance exerts a stronger and more consistent influence on reaction time than gender.

Additionally, slightly higher variability (SD) in females may indicate broader dispersion in response times, possibly reflecting individual differences in motor coordination or attention factors.

DISCUSSION

The present study demonstrated a statistically significant difference in visual reaction time between dominant and non-dominant hands among undergraduate students, with the dominant hands exhibiting faster responses. The use of a standardized reaction time instrument ensured reliable and objective measurement of sensory–motor response latency. This finding is consistent with previous studies that have reported superior performance of the dominant hand in visually guided motor tasks. [10,13,14]

Reaction time reflects the efficiency of sensory–motor integration, involving stimulus perception, central processing, and motor execution. [1,2,3] The significantly shorter reaction time observed in the dominant hand suggests enhanced neural processing efficiency and optimized motor output pathways. This may be attributed to greater cortical representation of the dominant hand in the contralateral cerebral hemisphere, leading to faster signal transmission and improved coordination. [8,9]

Frequent use of the dominant hand in daily activities such as writing, eating, and object manipulation likely contributes to neuroplastic adaptations, including strengthened synaptic connections and improved motor learning. These adaptations result in more efficient motor planning and execution, thereby reducing reaction time. [2,11,16,17,18] In contrast, the non-dominant hand, being less frequently used, may require additional neural processing and motor planning, resulting in relatively slower responses.[5,19]

The mean difference of 23.8 ms observed in the present study is not only statistically significant but also clinically relevant. The narrow 95% confidence interval (20.1–27.5 ms) indicates consistency of the findings across participants. Furthermore, the large effect size (Cohen's d = 0.92) suggests that the influence of hand dominance on reaction time is substantial and meaningful in practical terms. These findings reinforce the importance of considering hand dominance in studies evaluating motor performance.

Gender-based analysis revealed that male participants exhibited marginally faster reaction times compared to females, which is in agreement with earlier studies. [2,3,11,12,16] These differences may be attributed to physiological factors such as faster nerve conduction velocity, greater muscle mass and hormonal influences. However, the difference between dominant and non-dominant hands was consistently observed in both genders, indicating that hand dominance has a more pronounced effect on reaction time than gender alone.[15]

The findings of this study are in alignment with the concept of hemispheric specialization, where the dominant hemisphere is more efficient in controlling fine motor skills and rapid responses.[7,17]This specialization enhances the speed and accuracy of motor output, particularly in tasks requiring quick visual-motor coordination.

From a clinical perspective, reaction time serves as a valuable, non-invasive indicator of central nervous system function. Prolonged reaction time has been associated with neurological impairments, aging, fatigue, and cognitive decline. [2,6] Therefore, simple reaction time assessments can be used as screening tools in clinical practice to detect early signs of neurological dysfunction. In rehabilitation settings, understanding dominance-related differences can help clinicians design targeted bilateral training programs aimed at improving motor performance and restoring function. [17,18]

In sports science, faster reaction time is a critical determinant of performance, particularly in activities requiring rapid responses to visual stimuli. The dominance-related advantage observed in this study may be utilized in training programs to enhance performance and develop ambidexterity. Training the non-dominant hand may reduce asymmetry and improve overall motor coordination.

Despite its strengths, the present study has certain limitations. The use of convenience sampling may limit the generalizability of the findings. Hand dominance was assessed through self-report rather than standardized tools, which may introduce classification bias. Additionally, only visual reaction time was evaluated; inclusion of auditory and tactile modalities could provide a more comprehensive understanding of sensory–motor processing. Environmental factors such as fatigue, attention, and motivation, which can influence reaction time, were not quantitatively controlled.

Future studies should consider larger, randomized samples and employ validated handedness inventories to improve accuracy. Longitudinal studies evaluating the effects of training on non-dominant hand reaction time would provide further insight into neuroplasticity and motor learning. Research involving clinical populations, such as patients with neurological disorders, may help establish the diagnostic and therapeutic value of reaction time assessment.

Clinical Relevance

Reaction time assessment is a simple, non-invasive method to evaluate central nervous system function and motor coordination.[6] It may be useful in early neurological screening and rehabilitation. [17,18]

Future Recommendations

Future studies should use randomized sampling, larger populations, standardized handedness tools, and include multiple sensory modalities and clinical populations.

CONCLUSION

Visual reaction time is significantly shorter in the dominant hand compared to the non-dominant hand. This highlights the influence of hand dominance on sensory–motor integration and neural efficiency. Reaction time assessment may serve as a practical clinical tool.

Declaration by Authors

Ethical Approval: Letterno - SKNMC/ IEC/ Pharmac/ ND - 10253-33 dated 19/07/2022

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Conflict of Interest: The authors declare no conflict of interest.

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