Original Article

Unveiling the Recall Dynamic: Exploring the Neurological Link between Hand Clenching and Memory Retention

Nosheen Wasee[1], Akbar Mughal[1], Laiba Saher[1], Sahar Haseeb[1], Laiba Ghauri[1], Areeba Asif[2], Minahal Waseem[1]
[1]Karachi Medical and Dental College, Karachi Metropolitan University, Karachi, Pakistan; [2]Jinnah Sindh Medical University, Karachi, Pakistan.
Correspondence to: Sahar Haseeb, Email: saharhaseeb20@gmail.com

ABSTRACT

Background: The essential cognitive process influenced by several neural and physiological factors is memory retention. Former studies indicate that hand clenching activates the particular regions of the brain, such as the prefrontal cortex, which is specially associated with memory encoding and retrieval. The scope of this study was to examine the relationship between hand clenching and memory retention. And also to determine that either the left hand clenching is more effective or the right hand clenching using the recall scores.

Methodology: This cross-sectional study included 384 right-handed undergraduate students. Participants performed a word-recall task followed by right-hand clenching, and the procedure was repeated with left-hand clenching. All participants reported no neurological or psychological disorders. Data were analyzed using SPSS version 26. As the data were non-normally distributed, non-parametric tests were applied. The Wilcoxon signed-rank test was used to compare recall scores between right- and left-hand clenching, while the Mann–Whitney U test was used for gender-based comparisons.

Results: The Wilcoxon signed rank test determined significant difference between both hand clenching recall scores ($Z = -13.816$; $p < 0.001$), indicating that right hand clenching was associated with more word recall scores. The Mann-Whitney U test showed no significant difference between male and female clenching scores (right hand recall; $U= 16975.50$, $p = 0.136$; left recall; $U= 18091.00$, $p = 0.531$), respectively.

Conclusion: The right hand clenching in the right-handed participants was associated with improving the memory as high recall scores were observed while clenching the right hand over the left hand.

Keywords: Grip Strength; Hand; Cerebral Hemispheres; Memory

INTRODUCTION

Memory forms the foundation of learning, identity, and decision-making, allowing humans to integrate past experiences into present and future behavior. In contemporary neuroscience, memory is viewed not as a static repository but as a dynamic and reconstructive process shaped by neural plasticity, attention, and emotional context. Recent findings highlight that physical and emotional states can modulate memory performance through complex brain–body interactions, reflecting the growing recognition of sensorimotor influences on cognition.[1,2]

ARTICLE INFO

Article History
Received 10.01.2026 | Revised 27.06.2026 | Accepted 10.08.2026
Conflict of Interest: The authors declared no conflict of interest exists.
Funding: None
Copyright: © 2026 Wasee et al. This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0), which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original author and source are properly credited.
Citation: Wasee N, Mughal A, Saher l, Haseeb S, Ghauri I, Asif A. Unveiling the recall dynamic: Exploring the neurological link between hand clenching and memory retention. J Fatima Jinnah Med Univ. 2026;20(3):146-151.

DOI: https:// https://doi.org/10.37018/FAWH2384

Extending this perspective, studies suggest that specific motor actions, such as unilateral hand clenching, can influence hemispheric activation patterns that underpin various cognitive and affective processes. Clenching one hand increases neuronal activity in the contralateral frontal and motor cortices, thereby enhancing that hemisphere mode of processing.[3] Human memory is fragile and unpredictable.[4] In a process known as "ecphory," stored memory traces, or engrams, interact with external sensory stimuli or internally created cues to retrieve memories.[5] According to the HERA model, the association parietal cortex, cerebellum, and posterior cingulate areas are predominantly right-sided during retrieval, whereas temporal and posterior cingulate regions are left-sided during encoding.[6] Functional imaging and electrophysiological evidence indicate that unilateral hand clenching increases activation within the contralateral prefrontal and motor cortices, thereby enhancing the dominant hemisphere's cognitive mode. Such lateralized activation has been shown to modulate attentional control and memory-related neural circuits, providing a basis for exploring hemispheric specialization in memory encoding and retrieval.[7] According to HERA expectations, the results showed that hand-clenching pre-activation may be linked to a selective pre-activation of the brain circuits involved in the grapheme-morpheme

conversion cognitive pathway, which underlies the cognitive processes underlying verbal stimulus recognition. Therefore, depending on the process involved and the kind of input to be remembered, the current work expands the range of potential interpretations for the impact of hand-clenching on memory.[8] Recent neurobehavioral evidence suggests that unilateral hand movements can transiently alter hemispheric activation, providing a non-invasive tool to study lateralized brain functions such as attention, emotion, and spatial processing.[9] According to the hemispheric Encoding/Retrieval Asymmetry (HERA) paradigm, episodic memory encoding is linked to left prefrontal areas, whereas retrieval is linked to right prefrontal regions. Building on this hypothesis, it has been suggested that hemispheric pre-activation can improve memory performance through right-hand clenching (which activates the left hemisphere) before encoding and left-hand clenching (which activates the right hemisphere) before recall.[10]

Perceptual processing and affective/motivational states are altered by prolonged unilateral hand clenching, which is thought to be caused by increased hemisphere activity opposite the side of muscular movement.[11] According to a study conducted, unilateral nostril breathing, unilateral gaze, unilateral hand clenching, bilateral eye movements, unilateral or bilateral auditory presentation, and body position are among the sensory experiences that are investigated for their capability to refine hemispheric interaction or activity.[12] These findings align with the broader understanding that the brain operates as an integrated yet specialized network. Functionally, differentiation and integration are the two primary organizational principles of human brain function. While different regions of the brain are specialized for specific functions, even the simplest tasks require the association and collaboration of multiple brain areas, which together form a unified network. The most suitable way of studying neural and functional relations between various regions of brain is the utilization of graph theory (complex network analysis) and this has notably advanced our understanding of the human brain's organizational patterns and is a key focus of current neuroscience research.[13] Recent research emphasizes that functional specialization and integration across brain regions underlie complex cognitive functions such as memory and emotion. A review of 24 studies revealed that unilateral clenching influences multiple domains, including memory, language, and emotion, though results varied across hemispheric conditions.[14] By spreading activation, unilateral hand clenching can change the relative level of activation in the right hemisphere compared to the left hemisphere by increasing activation in the contralateral hemisphere's motor cortex.[15]Additionally, it may enhance performance on tasks that uniquely rely on the neural resources of one hemisphere over the other. Given the distinct roles of the two cerebral hemispheres in functions such as language, emotion, spatial processing, and local/global information integration, unilateral hand clenching could prove valuable in investigations spanning from fundamental research to clinical applications. In a recent study, varying grip strength produced an inverted-U relationship between clenching intensity and memory performance, suggesting that optimal activation levels differ among individuals.[16] Therefore, this study explores how unilateral hand clenching affects memory encoding and retrieval, aiming to determine whether right or left-hand activation plays a greater role. It may offer insights into enhancing recall and have practical implications for education, aging, and rehabilitation.

METHODOLOGY

This cross-sectional study was conducted at the Karachi Medical and Dental College, Karachi Metropolitan University, Karachi between April and August 2025. A total of 384 undergraduate students of ages between 18 and 25 years (Table 1) participated in this cross-sectional study. Because this was a cross-sectional study conducted at a single time point, baseline measurements for each participant were not applicable. Both right-hand and left-hand clenching tasks were performed within the same session; therefore, no pre-clenching baseline recall score could be established. Instead, recall performance was directly compared between the two conditions using a within-subject design. Physically healthy and right handed individuals (as verified through Handedness Questionnaire) became part of the study, left handed ones were excluded to maintain uniformity of motor dominance. Participants with a history of neurological, psychiatric disorders and recent hand injury were also not included. Subjects consented after being informed about the study and before data collection commenced.

The research was approved by the Karachi Medical and Dental College, KMU Institutional review board (IRB) [Ref: IRB/KMDC/KMU/07/2025]. Participants signed the informed consent to participate in the study. Each participant was tested individually. At the beginning, each

Table 1: Overview of demographic profile of participants (n=384)

Variable	Frequency (n)	Percent (%)
Age groups (years)		
18-19	98	25.5
20–21	126	32.8
22–23	87	22.7
24–25	73	19.0
Gender		
Female	187	48.7
Male	197	51.3

participant was explained about the general purpose of the study. Then they were asked to complete the Edinburgh handedness inventory.[17] which included some questions related to everyday activities like writing, drawing, throwing and opening a box in order to assess hand dominance. Only participants who demonstrated consistent right handedness were included in the study. As a memory stimulus, two word lists (60 words total) were created each with thirty words. The words were randomly selected from English vocabulary. Each list ensured an equal proportion of simple, moderate and hard words. These two lists were created for counterbalancing purposes.

Following this, each participant was first presented with a list of 30 words. The word list was displayed for approximately one minute, during which participants were instructed to memorize as many words as possible. After one minute instructions were given to the participants via experimenter, to squeeze a physiological ball (rubber ball) as clenching stimulus which was approximately 6 cm in diameter as hard as possible for about 30 seconds. This task was performed by right and left hand separately in order to provide a standardized clenching stimulus for both hemispheres. Initially the right hand was supposed to be clenched so this right hand clenching process continued for 30 seconds meanwhile while the opposite hand remained relaxed. Participants were encouraged to maintain steady pressure on the ball for full duration while the experimenter supervised the task going smoothly. After the clenching task, participants were asked to recall and write down as many words from the list as they could remember. Responses from the participants were recorded on the Google forms and each participant was provided with sufficient time to recall and write the words. The same procedure was done with the other hand (left hand) as well using the second list of 30 words so that each participant completed both right and left handed clenching conditions. Total responses were then scored for the number of correctly recalled words. Due to the small sample size and non-normal outcomes of memory scores, the Mann Whitney test was used as a replacement of independent-t-test and Wilcoxon sign test as an alternative of paired t-test.

RESULTS

The majority of participants were aged between 20-21 years followed by 18 to 19 years (Table 1). Among the participants the percentage of female and male was 48.7% and 51.3%, respectively. The mean number of words recalled after right hand clenching (N=384) was 11.08 ± 4.19 between the range of 4-25 words and after left hand clenching (N = 384) was 7.13 ± 3.26 between the range of 2-20 words. The bar charts in Figure 1 and 2 illustrate the distribution of right hand recall performance and left hand recall performance respectively.

These graphs visually demonstrate that the recall score for right hand clenching was higher than the Left hand clenching. A test of normality Shapiro Wilk test was performed for both right and left hand recall scores but the distribution deviated significantly from the normality ($p < 0.001$). Hence non parametric tests were used to analyze the results. In order to identify the statistical difference between right hand recall and left hand recall scores, Wilcoxon Signed Rank test was performed which indicated the statistical difference of ($Z = -13.82$, $p < 0.001$), following the higher recall with right hand clenching. A majority of participants (N = 314) showed more words recalled by right hand clenching distinguished by (N= 50) participants who performed better in recalling words with left hand clenching (Table 2). It showed that right hand clenching was more effective than left hand clenching. Furthermore, gender wise comparison for recall scores was performed to analyze the difference by Mann-Whitney U test. The results revealed no statistical difference in recall scores between males and females for right hand ($p = 0.136$) and left hand clenching ($p = 0.531$), as summarized in Table 3.

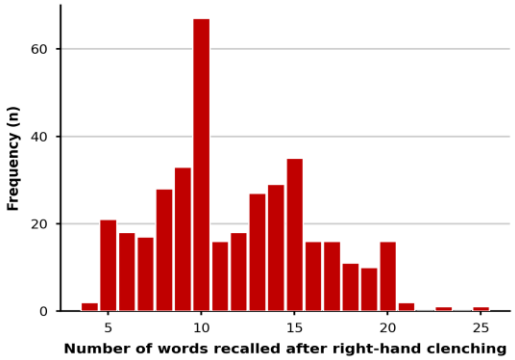


Figure 1: Right hand word recall distribution

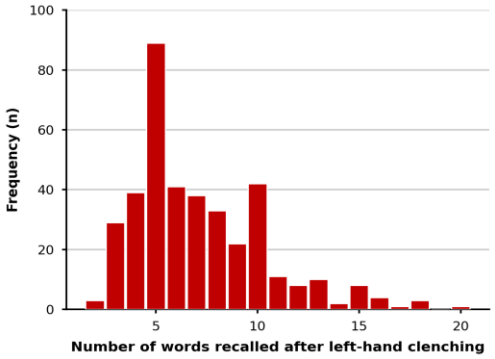


Figure 2: Left hand word recall distribution

Table 2: Comparative analysis of memory recall scores between right and left hand clenching (n = 384)

Comparison	N	Mean Rank	Sum of Ranks	Z-value	p-value*
Negative ranks (left-hand recall < right-hand recall)	314	194.08	60,940.50		
Positive ranks (left-hand recall > right-hand recall)	50	109.79	5,489.50	– 13.816	< 0.001
Ties (left-hand recall = right-hand recall)	20	-	-		

*p < 0.05 considered significant;

Table 3: Gender-based influence on memory recall performance

Variable	U (Manns-Whitney test)	Z-value	p-value*
Right hand Recall	16975.50	-1.490	0.136
Left Hand Recall	18091.00	-0.626	0.531

*p < 0.05 considered statistically significant

DISCUSSION

This study investigates whether hand clenching has an influence on memory retrieval and to explore the possible neurological mechanisms underlying this effect. The findings showed a statistically significant difference in recall ability between right and left hand clenching conditions. Participants recalled a higher number of words following right-hand clenching as compared to left-hand clenching. These findings indicate that unilateral motor activation through right-hand clenching significantly enhances recall ability, thereby suggesting a functional link between motor activity and memory processes.

The Hemispheric Encoding/Retrieval Asymmetry (HERA) model, suggests that the right prefrontal cortex is more active during retrieval processes and the left prefrontal cortex is primarily involved during memory encoding. The current study suggests that encoding-related neural processes may have been reinforced by right-hand clenching, which activates the contralateral left hemisphere and improves recall performance. In contrast, clenching the left hand causes activation of the right hemisphere, which might not be as advantageous for verbal encoding. The idea that temporary activation of particular hemisphere networks can differentially modulate memory functions based on the type of motor input and cognitive demand is thus supported by the observed asymmetry, which is consistent with the HERA model.[18]

Moreover, this study supports findings from Propper and colleagues and previous work, who demonstrated that unilateral hand clenching can lead to changes in hemispheric activity and influence cognitive performance such as right-hand clenching improving verbal recall performance as well as motor action with dominant hand improves motor memory consolidation. Right handed individuals performed better with right dominant hand and left handed performed better with left hand.[3,19] Moreover, unilateral muscle contraction is associated with self-infiltration effect where misattributed tasks are taken by individuals further outcasing the influence of hemispheric activation on memory.[20] Results of this study strengthen these earlier observations, emphasizing that simple motor acts can act as cognitive primers by influencing the neurophysiological states of the two hemispheres. However, in contrast, study of handedness shows individuals who are right-handed (non-strongly) indicated better memory performance due to enhanced hemispheric interaction and collaboration.[21] Another paper does not address the relationship between cerebral hemispheric dominance and memory performance in individuals with unilateral motor actions, focusing instead on the role of conscious awareness in motor memory consolidation.[22]

There are different hypotheses that can explain what we see with the improvement in free recall after right-handed clenching. From a neurocognitive standpoint, motor activation may induce a transient state of arousal which has been positively correlated with attentional focus and can therefore enhance working memory capacity for the encoding and retrieval of information. Hand clenching may also induce an increase in neural synchrony in the prefrontal cortex, allowing for better encoding and retrieval of information during free recall. Neurochemical variables, including a transient release in catecholamines (dopamine and norepinephrine) may also support arousal processes by increasing cortical excitability and strengthening cognitive alertness during tasks. These interpretations of the findings support the idea that both hemisphere activation and general arousal mechanisms are functions of a complex relationship between motor priming and typical memory performance.

These findings can be potentially implied on non - pharmacological methods of improving learning and memory. Particularly in therapeutic and educational domains, incorporating quick motor activation exercises like right hand clenching before studying or recall tasks could be affordable and efficient to improve cognitive function. This approach may also hold therapeutic potential for individuals with mild cognitive impairment or attentional deficits by regulating hemisphere activation which may enhance cognitive outcomes. Despite the strengths of these applications including a large and gender balanced sample, the current study has certain limitations. The cross-sectional design restricts causal inference, and the sample consisted solely of university students, limiting

generalizability to other populations. Additionally, the study design did not allow for baseline (pre-clenching) recall measurements, as all assessments occurred within a single session without a pre–post structure. Furthermore, advanced regression analysis was not performed because the study sample intentionally included only right-handed individuals. Since more than 90–95% of the population is naturally right-handed, our sampling closely reflects the true population distribution, and no left-handed participants were encountered during data collection.[23] Due to the absence of variability in handedness, this variable could not be incorporated into a multivariable regression model, and additional regression analyses would not provide meaningful adjustment. Similar distributions have been documented in global handedness research. Moreover, only a single verbal word list paradigm was used for the recall tasks which might have not captured other forms of memory such as spatial or procedural recall. Furthermore, manual data coding may induce slight response bias, and the study did not include neuroimaging measures to directly verify hemisphere activation patterns. Future research would strengthen the conclusions if these constraints were addressed.

Therefore, the goal of future studies should be focused on reproducing these results in bigger and more varied cohorts including diverse age groups and educational levels. incorporating neuroimaging methods like functional MRI or EEG could provide clarity to temporal dynamics of motor memory interaction and concrete proofs of hemisphere activation. Moreover, whether persistent hand clenching over time results in long-lasting cognitive gains or neuroplastic changes could be ascertained by experimental or longitudinal designs. Such research may help develop novel approaches to cognitive improvement and rehabilitation by deepening our understanding of the neurofunctional connections between motor activation and memory.

CONCLUSION

Verbal memory recall was significantly enhanced by right-hand clenching compared with left-hand clenching, likely due to preferential activation of the left hemisphere, consistent with the HERA model. This effect was observed in both males and females, indicating no gender-related differences. Simple motor actions such as hand clenching may therefore represent non-invasive strategies to enhance memory performance. Overall, the findings underscore the importance of hemispheric specialization for future research and potential therapeutic or educational applications.

Author Contributions

NW: supervision of manuscript, review, conceptualization. AM: supervision, reviewing, analysis. LS: data collection, manuscript writing, analysis, editing. SH: data collection, manuscript writing, literature review, editing. LG: data collection, manuscript writing. AA: statistical analysis, manuscript writing. MW: Data collection, manuscript writing

AI Disclosure

An artificial intelligence tool was used for language editing, grammar correction, and clarity improvement. The authors verified all content and take full responsibility for its accuracy.

REFERENCES

1. Buzsáki G, McKenzie S, Davachi L. Neurophysiology of remembering. Annu Rev Psychol. 2022;73:187-215. doi:10.1146/annurev-psych-021721-110002.
2. Sridhar S, Khamaj A, Asthana MK. Cognitive neuroscience perspective on memory: overview and summary. Front Hum Neurosci. 2023;17:1217093. doi:10.3389/fnhum.2023.1217093.
3. Propper RE, McGraw SE, Brunyé TT, Weiss M. Getting a grip on memory: unilateral hand clenching alters episodic recall. PLoS One. 2013;8(4). doi:10.1371/journal.pone.0062474.
4. Naim M, Katkov M, Romani S, Tsodyks M. Fundamental law of memory recall. Phys Rev Lett. 2020;124(1):018101. doi:10.1103/PhysRevLett.124.018101.
5. Frankland PW, Josselyn SA, Köhler S. The neurobiological foundation of memory retrieval. Nat Neurosci. 2019;22(10):1576-1585. doi:10.1038/s41593-019-0493-1.
6. Desgranges B, Baron JC, Eustache F. The functional neuroanatomy of episodic memory: the role of the frontal lobes, the hippocampal formation, and other areas. Neuroimage. 1998;8(2):198-213. doi:10.1006/nimg.1998.0359.
7. Lubben N, Ensink E, Coetzee GA, Labrie V. The enigma and implications of brain hemispheric asymmetry in neurodegenerative diseases. Brain Commun. 2021;3(3). doi:10.1093/braincomms/fcab211.
8. Andreau JM, Torres Batán S. Exploring lateralization during memory through hemispheric pre-activation: differences based on the stimulus type. Laterality. 2019;24(4):393-416. doi:10.1080/1357650X.2018.1531422.
9. Habib R, Nyberg L, Tulving E. Hemispheric asymmetries of memory: the HERA model revisited. Trends Cogn Sci. 2003;7(6):241-245. doi:10.1016/S1364-6613(03)00110-4.
10. Ocklenburg S, Güntürkün O. Hemispheric asymmetries: the comparative view. Front Psychol. 2012;3:5. doi:10.3389/fpsyg.2012.00005.
11. Propper RE, Dodd K, Christman SD, Brunyé TT. Relationship between sustained unilateral hand clench, emotional state, line bisection performance, and prefrontal cortical activity: a functional near-infrared spectroscopy study. Laterality. 2017;22(6):671-689. doi:10.1080/1357650X.2016.1268148.
12. Propper RE, Teasley MD, Lynch E. Half-decided: bilateral or unilateral stimulation and susceptibility to persuasion. In: Decision-making in life and work: foundations, strategies, and current neuroscience. Cham: Springer Nature Switzerland; 2025. p. 99-122. doi:10.1007/978-3-031-88415-3_6.
13. Xiong X, Fu Y, Chen J, Liu L, Zhang X. Single-trial recognition of imagined forces and speeds of hand clenching based on brain topography and brain network. Brain Topogr. 2019;32(2):240-254. doi:10.1007/s10548-018-00696-3.
14. Schierenbeck S, Propper RE. Integrative research review of the impacts of unilateral hand clenching on behavior: clinical implications. In: InPACT 2022 book of abstracts. InPACT Psychology Conference; 2022. p. 230-234. doi:10.36315/2022inpact055.

15. Turner CE, Hahn ME, Kellogg RT. Semantic processing in the left versus right cerebral hemispheres following unilateral hand contractions. Laterality. 2017;22(2):219-232. doi:10.1080/1357650X.2016.1154861.
16. Prunier S, Christman S, Jasper J. The effects of varying levels of hemispheric activation on episodic memory. Laterality. 2018;23(4):409-421. doi:10.1080/1357650X.2017.1369985.
17. Oldfield RC. The assessment and analysis of handedness: the Edinburgh inventory. Neuropsychologia. 1971;9(1):97-113. doi:10.1016/0028-3932(71)90067-4.
18. Johansson J, Salami A, Lundquist A, Wåhlin A, Andersson M, Nyberg L. Longitudinal evidence that reduced hemispheric encoding/ retrieval asymmetry predicts episodic-memory impairment in aging. Neuropsychologia. 2020;137:107329. doi:10.1016/j.neuropsychologia.2019.107329.
19. Dehkordi PS, Dinan PH, Heydari M, Meysamnejad F. Effect of hemispheric asymmetry and sleep on motor memory consolidation. J Motor Control Learn. 2025;7(7).
20. Baumann N, Kuhl J, Kazén M. Left-hemispheric activation and self-infiltration: testing a neuropsychological model of internalization. Motiv Emot. 2005;29(3):135-163. doi:10.1007/s11031-005-9439-x.
21. Lyle KB, McCabe DP, Roediger HL 3rd. Handedness is related to memory via hemispheric interaction: evidence from paired associate recall and source memory tasks. Neuropsychology. 2008;22(4):523-534. doi:10.1037/0894-4105.22.4.523.
22. Boutin A, Badets A. Conscious awareness of actions shapes motor memory consolidation [Preprint]. OSF Preprints. 2025. doi:10.31234/osf.io/gs8ac_v1.
23. Papadatou-Pastou M, Ntolka E, Schmitz J, Martin M, Munafò MR, Ocklenburg S, et al. Human handedness: a meta-analysis. Psychol Bull. 2020;146(6):481-524. doi:10.1037/bul0000229.