https://doi.org/ 10.33472/AFJBS.6.9.2024.990-999

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

Memory in Motion: The Enchanting Dance of Hand Clenching and Recall

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Article History

Volume 6,Issue 9, 2024

Received:21 Mar 2024

Accepted : 22 Apr 2024

doi: 10.33472/AFJBS.6.9.2024.990-999

Abstract

Background: Unilateral hand clenching activates the frontal lobe in the opposite hemisphere, correlating with increased awareness of cognitive processes. These supports using hand clenching as a test for cerebral hemisphere specializations, aligning with the Hemispheric Encoding/Retrieval Asymmetry (HERA) paradigm. In HERA, left prefrontal areas encode episodic memories, and right prefrontal regions handle retrieval. **Objective:** We looked into this idea by analyzing how Unilateral Hand Clenching would affect short-term memory by using verbal and non-verbal materials for stimulation of visual and auditory routes of memorization. **Method:** To record the results of memory recall tests, 200 healthy participants between the ages of 18 and 24 were separated into control and different clenching condition groups. Clenching groups were given a 5-cm rubber ball to clench in order to observe how memory recall tests were altered by clenching in right-handed people. **Result:** In all the visual and auditory recall subtests, right encoding, left t recall [R/L] clenching condition group showed superior recall results compared to other clenching and non-clenching conditions. **Conclusion:** Our outcomes validated the HERA model, furthermore disregarded hemispheric lateralization specific to material type used. We infer that hand clenching activates the auditory and visual circuits of short-term memory for spoken and non-verbal information. Furthermore, the HERA brain asymmetry paradigm is consistent with both strategies.

Introduction

Unilateral hand clenching, a unique method, activates the opposite hemisphere's frontal lobe and is linked to heightened emotional processing[1]. A brief 90 seconds of left-hand clenching boosts right hemisphere activity, while the same duration of right-hand clenching increases left hemisphere activity[2,3]. This approach can be a valuable tool to examine cerebral hemisphere specializations in intact humans, potentially enhancing performance in tasks requiring distinct brain resources. Unilateral hand clenching holds promise for basic research into functional variations and therapeutic applications, considering the differential involvement of brain hemispheres in various activities like language, emotion, spatial processing, and information processing[4].Unilateral hand clenching has been utilized by researchers to manipulate hemispheric activation, particularly in assessing asymmetrical contributions to perceptual processing[5]. While the impact of hand clenching on emotional states is well-documented[3], few studies have explored its effects on cognition, especially short-term and working memory. The Hemispheric Encoding/Retrieval Asymmetry (HERA) model suggests that right hand clenching (left hemisphere activation) prior to encoding and left-hand clenching (right hemisphere activation) prior to recall may enhance episodic memory recall. Some studies propose a refined HERA model applicable to both verbal and nonverbal materials[6]. Recent electrophysiological research indicates increased prefrontal cortical activity contralateral to the clenched hand. While PET and fMRI investigations generally support the HERA pattern, exceptions exist, with a few studies reporting neutral results, possibly influenced by material type (verbal/nonverbal stimuli)[7,8]. A few studies reported neutral results, not supporting HERA model, depending on the material used (verbal/ nonverbal stimuli) [9]. Very few studies explore how unilateral hand clenching affects cognition, particularly short-term memory. Hence, we propose testing the HERA model's precision using varied verbal and non-verbal materials. Hand Clenching may predispose processing toward the activated hemisphere, and we aim to assess its impact on short-term memory, exploring visual and auditory routes in young adults. This simple technique holds promise for enhancing cognitive functions, especially in students.

Materials and methods

Ethics Statement

This research was conducted with the approval of the Institute Ethical Committee at NIMS University, Jaipur, and Rajasthan.

Participants

The participants in this observational study were 200 healthy, right-handed first-year MBBS students, aged 18 to 24 years, with an equal distribution of 100 male and 100 female subjects. The study took place at the Department of Physiology, National Institute of Medical Sciences

and Research, Jaipur. Informed consent was obtained from all subjects. Purposive sampling was employed to select the sample population.

Inclusion criteria for the study encompassed subjects aged 18-25 years, of both sexes, who were cooperative and willing to provide consent. Exclusion criteria comprised individuals with neurological disorders or a history of head injury, chronic systemic diseases or chronic pain that might affect cognitive function, smokers, alcoholics, individuals with upper limb musculoskeletal disability, and those with visual/auditory diseases impacting cognitive functions. The study involved five condition groups for hand clenching, as shown in the table-1 each consisting of 40 subjects. These groups were assigned different hand clenching protocols during encoding and recall as shown in table-1.

Group	Hand clenching protocol followed during encoding and recall	Represented as
1	40 subjects with no hand clenching.	[N/N]
2	40 subjects with Right hand clenching before encoding and recall.	[R/R]
3	40 subjects with Right hand clenching before encoding and Left hand clenching before recall.	[R/L]
4	40 subjects with left hand clenching before encoding and recall.	[L/L]
5	40 subjects with left hand clenching before encoding and right hand clenching before recall.	[L/R]

Materials

Memory test

The materials used in the study included a battery of memory tests comprising visual and auditory memory subtests. Visual memory tests included Visual Word Memory (VWM), Colored Picture Memory (CPM), and Black-White Picture Memory (BPM), while the auditory memory test included Auditory Word Memory (AWM). Memory stimuli consisted of 30 PowerPoint slides with common and unrelated words, colored pictures, and black-white pictures [10].

Clenching stimuli

Clenching stimuli involved participants clenching a 5 cm diameter rubber ball before encoding and recall.

Procedure

'Memory Test' planned was neutral in character i.e. for both male and female subjects to figure out equally. Subjects were made familiar with the process of tests to be performed. At a time one subject was tested for visual & auditory memory in a noise free research lab, in the Department

of Physiology, NIMS&R. Half of the subjects of each group were asked to perform the visual memory test first, followed by auditory memory test; the other half performed these tests in the reverse fashion, in order to eliminate any possibility of bias. After each subtest, a rest time of 60 seconds was given Group-1(no-Hand-clenching) Objects of each subtest were shown to a subject one after another at a gap of 3 seconds by a slide show of laptop screen and subjects were instructed to focus on the point X in the center of the laptop screen and this process of visual presentation took almost 30 seconds, then after the delay of about 2 minutes, (during this time, there was a light conversation being done with the subject without talking of the words, which was just shown to the subject) the participants were then asked to recall as many words from the list they saw earlier as they could within 30 seconds, in any order on a preprinted- 10 squares sheet of a paper. The subject was asked to wait for 60 secs before attempting the next subtest. Andin case of auditory subtest, Items of one subtest were played to a subject one after another with a gap of 3 seconds the whole process of this presentation took almost 30 seconds After the gap of two minutes, the subject was asked to write the names of these objects within 30 seconds, in any order on a preprinted- 10 squares sheet of a paper again.

Group2,3,4 and 5 (Hand-Clenching): After the completion of hand clenching pre-encoding, objects of each subtest were shown to the participants one after another at a gap of 3 set by a slide show of laptop screen and subjects were instructed to focus on the point X in the center of the laptop screen in the same manner as it was shown to the Group-1, this process of visual presentation took almost 30 sec. In this case, during two minute delay, the participants were asked to continue the hand clenching for 45 seconds twice pre recall, (during this time, there was a light conversation being done with the subject without talking of the words, which was just shown to the subject, along with hand-clenching) then after the delay of two minutes, the participants were then asked to recall as many words from the list they saw earlier as they could within 30 seconds, in any order on a preprinted- 10 squares sheet of a paper. In the case of auditory recall test, after the completion of hand clenching pre-encoding, Items of one subtest were played to a subject one after another with a gap of 3 secs; the whole process of this presentation took almost 30 sec. Now again the participants were asked to continue the pink ball squeezing during the two-minute gap and complete the hand clenching stimuli for 45 seconds twice with a 15 second rest in between, just before the recall test. After the gap of two minutes, the subject was asked to write the name of these objects within 30 seconds, in any order on a preprinted- 10 squares sheet of paper. The participants were asked to wait for 60 secs before starting the next clenching stimuli for another subtest. Each subtest of VMT and AMT were scored on a scale of 10 and the correct responses in each case were calculated that provided the data for the statistical work.

Statistical analysis: was done by SPSS and Microsoft excel. Univariate analysis of variance, one-way Anova Tests and post hoc (Tukey) were applied. Significance criteria: p value: < 0.05 was taken as significant

Observations: One-way analysis of variance (ANOVA; Hand Clenching Condition: No Encoding/No Recall [N/N] vs Right Encoding/Right Recall [R/R] vs Right Encoding Left Recall [[R/L] vs Left Encoding Left Recall [L/L] vs Left Encoding Right Recall were conducted on the total number of words correctly recalled for visual and auditory recall test

RESULTS

One-way analysis of variance (ANOVA; Hand Clenching Condition: No Encoding/No Recall [N/N] vs Right Encoding/Right Recall [R/R] vs Right Encoding Left Recall [[R/L] vs Left Encoding Left Recall [L/L] vs Left Encoding Right Recall were conducted on the total number of words (visual and auditory) and images (color and black-white) correctly recalled for visual and auditory recall tests.

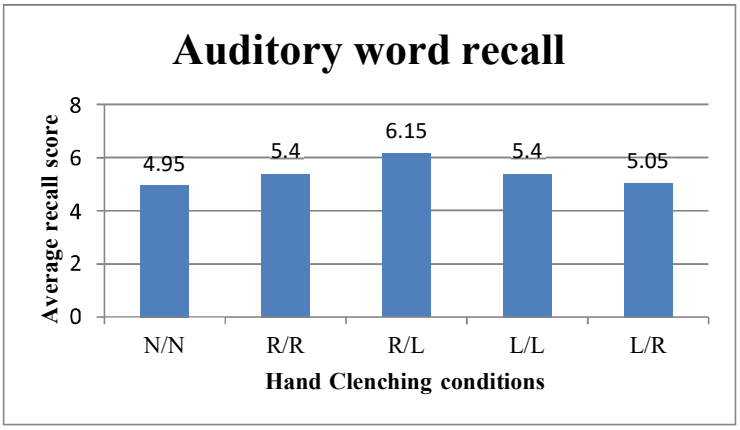

Figure1: Correctly recalled score for auditory word recall test as a function of hand clenching:

The ANOVA examining total correctly recalled words was significant for auditory word recall test as the f-ratio value was 6.45151. The p-value was .000068. Hence the result is significant at $p < .05$. Post hoc examination of effects revealed that Right Encoding/ Left Recall [R/L] was > Left Encoding/Left Recall [L/L] > Right Encoding/Right Recall [R/R] > Left Encoding/Right Recall [L/R] >No Encoding/No Recall [N/N] for auditory word recall test.

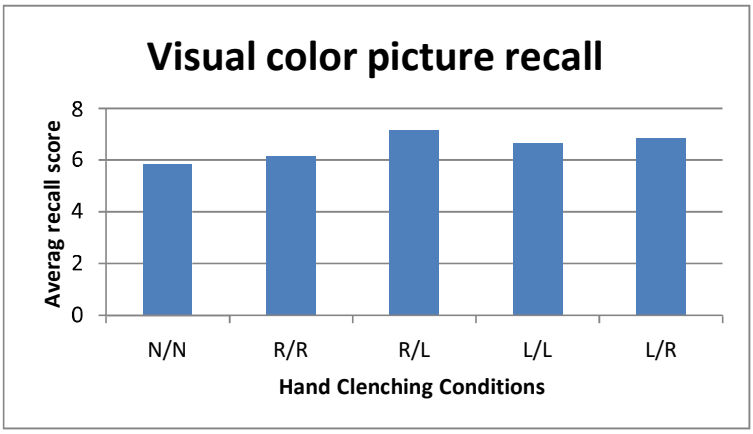

Figure 2: Correctly recalled score for Visual color picture as a function of hand clenching:

Visual Color Recall

The ANOVA examining total correctly recalled color picture images was significant for visual color picture recall test as the f-ratio value was 7.58812. The p-value was .000011. Hence the result was significant at $p < .05$. Post hoc examination of effects revealed that Right Encoding/ Left Recall [R/L] was > Left Encoding Right Recall [L/R] > Left Encoding/Left Recall [L/L] > Right Encoding Right Recall [R/R] > No Encoding/No Recall [N/N] for color picture memory recall test

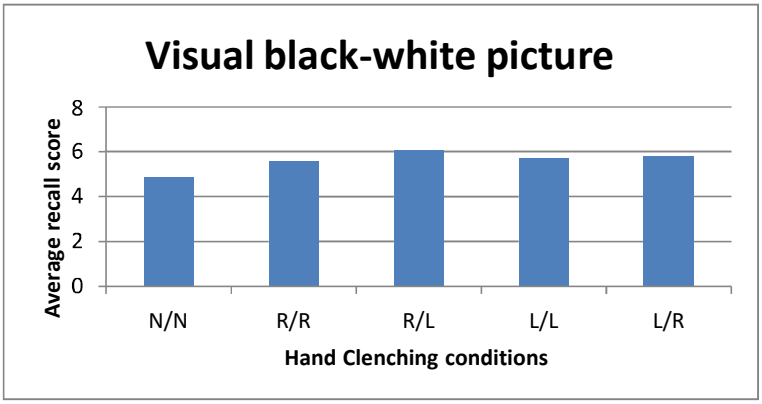

Figure 3: Correctly recalled score for Visual black-white picture as a function of hand clenching:

Also, The ANOVA examining total correctly recalled black-white picture images was significant for visual black-white picture recall test as the f-ratio value was 5.92966. The p-value was < .00016. Hence the result is significant at $p < .05$. Post hoc examination of effects revealed that Right Encoding/ Left Recall [R/L] was > Left Encoding Right Recall [L/R] > Left Encoding/Left Recall [L/L] > Right Encoding/Right Recall [R/R] >No Encoding/No Recall [N/N] for black white memory recall test.

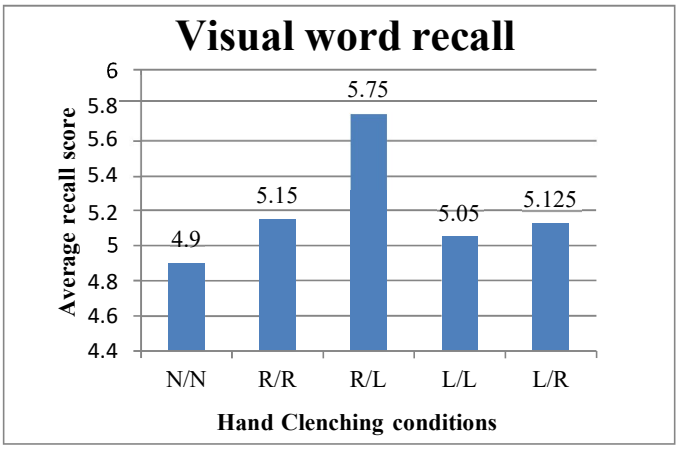

Figure 4: Correctly recalled score for Visual word recall as a function of hand clenching

Finally the ANOVA examining total correctly recalled VISUAL WORD was significant for visual word picture recall test as the f-ratio value was 3.61024. The p-value was .007288. Hence the result is significant at $p < .05$. Post hoc examination of effects revealed that Right Encoding/ Left Recall [R/L] was > Right Encoding/Right Recall [R/R] > Left Encoding Right Recall [L/R] > Left Encoding/Left Recall [L/L] >No Encoding/No Recall [N/N] for visual word memory recall test.

DISCUSSION

The ability to memorize and recall information is a fundamental cognitive function that is essential for learning and performing various activities. Short-term memory is the ability to hold a limited amount of information for a short period. Various factors affect short-term memory, including attention, repetition, and stimuli type. Recent studies have investigated the effect of physical actions on memory, particularly hand clenching, on the visual and auditory routes of memorization in young adults. This thesis aims to investigate the effect offhand clenching on visual and auditory routes of memorization for short-term memory in young adults by means of two-minute recall tests.

In all of the visual and auditory memory recall tests, people who encoded the supplied information immediately after right hand clenching (left hemisphere activation) and recalled such information immediately after left hand clenching (right hemisphere activation) outperformed those who did not. It's important to note that this condition was also significantly superior to the no hand clenching control condition in all the visual and auditory memory subtests. This finding was quite similar to the earlier studies of Ruth E- Propper[11] as they performed a study on " Getting a grip on memory, unilateral hand clenching alters episodic recall" in which they concluded that Individuals who encoded language-based information immediately following right hand clenching (left hemisphere activation), and recalled such information immediately following left hand clenching (right hemisphere activation), demonstrated superior episodic memory compared to the other hand clenching conditions and their post hoc examination of simple effects (Fisher's

PLSD) revealed that R/L was greater than L/L greater than R/R and greater than L/R. There were strong trends for N/N to be greater than L/L and L/R for word recall test. However in our study, there was no trend for N/N to be greater than L/L and L/R but in case of Visual picture recall for both Color picture and black-white picture, L/L and L/R both were significantly greater than N/N and also for Word recall, (both visual and auditory) L/L/and L/R both were non-significantly greater than N/N.When material-specific hemisphere asymmetries are taken into account, Nylberg et al.[12] Claim that material-specificity can occur regardless of process specificity and that there is a general pattern of encoding and retrieval in the brain that is consistent with the HERA model. The HERA model of asymmetry is supported by a sizable body of data. The right PFC is biased towards retrieval of verbal contents solely, as shown by Fletcher et al. And according to certain studies, the right PFC is biased when it comes to retrieving of non- verbal information also, as Lee et al.[13] have mentioned it in their study. Same is the case with the functioning of left PFC during memory consolidation as Tulving E et al.[14] argued that left PFC is biased for encoding of verbal materials only during memory consolidation but Owen, A.M. et al. (1996)[15] concluded that the left PFC is biased for encoding of non- verbal materials as well. And in contrast to all the studies above, our suggestion was a more precise formulation to test the HERA model of brain asymmetry during memory consolidation, particularly for short term memory using both verbal and non-verbal stimulations. Our findings indicate that left PFC is differentially more involved in memory encoding for short-term memory and that this involvement is unaffected by the type of material used for stimulation. In addition, regardless of the type of memory stimuli used, the right PFC is differentially more involved in retrieval of encoded information for short-term memories, as depicted by the results of the recall tests shown in figures above. Although hemisphere activation was not specifically quantified in the current analysis, but some recent researchers like research done by CK Peterson et al.[16] revealed that the identical hand clenching activates the contralateral prefrontal cortex by increasingthe neuronal activation, points to a mechanism by which the results reported here areexplained. Hence findings in our study are overall startling, especially considering how easilythe used manipulation—a total of 90 seconds of unilateral hand clenching pre-encoding and pre-recall—can be applied to a range of experimental, clinical, and real-world scenarios and the intriguing idea that straightforward unilateral hand clenching can be utilized to study and possibly modify the functional specialization of the cerebral hemispheres to real-world settings is offered by the findings presented here. Hence our data offers strong support against material-specific hemisphere activations and therefore, we draw the conclusion that Verbal as well as non-Verbal materials are consistent with the HERA paradigm of brain asymmetry during memory formation.

CONCLUSION

Our study concludes that hand clenching causes the increase in short-term memory for both verbal and non-verbal information by the auditory and visual routes of memorization and is best with Right hand clenching before encoding and left-hand clenching before retrieval in right handed people.

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