

# Conjugate Lateral Eye Movements (CLEMs) as an Index of Cerebral Functional Laterality

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## Abstract

*Background:* Conjugate Lateral Eye Movements (CLEMs) may determine the extent of the relative activity of the two cerebral hemispheres during an on-going cognitive task. Several studies have documented more rightward CLEMs for verbal questions with left hemispheric activity and more leftward CLEMs for spatial questions with right hemispheric activity, while others have suggested CLEMs to be individual-specific independent of the questions. Thus previous findings are mixed and uncertain. This study questions the validity of CLEMs as a measure of functional laterality. *Methods:* The subjects were 400 healthy students in the age group 10-19 years. The subjects were required to orally respond to 10 verbal and 10 spatial questions. During each on-going cognitive process, the first observable CLEM direction was noted and categorised into rightward or leftward CLEM. Then whether this dependent on the type of question or was it an individual-specific stable trait was established. *Results:* In this study, majority of the subjects exhibited CLEMs pattern independent of the type of question (indicating subjects as either right- or left-movers) and was statistically significant. There was no statistical significant difference between genders for the CLEMs pattern. *Discussion:* This suggests that the direction of gaze shift when people are thinking during different types of questions does not reflect the lateralization of underlying cerebral activity. This reflects that during an on-going cognitive task, CLEMs do not depend on preferential hemispheric activation, are independent of question type and is subject-specific stable trait. Thus concluding that though CLEMs may have other neurophysiological implications, is not a valid index of functional laterality. The CLEMs pattern in future studies should be evaluated along with cerebral blood flow, positron emission tomography, etc.

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## Introduction

The cerebral cortex is divided into left and right hemispheres. Though the two cerebral hemispheres are roughly symmetrical in appearance, there is asymmetry in their structure and more so with functions. The left hemisphere is concerned with language and logical processing whereas the right hemisphere is involved in spatial recognition, aspects of directed attention and emotional expression. The functional asymmetries can be assessed by central and peripheral measures. This study is concerned with one of the peripheral measures - conjugate lateral eye movements.

## Conjugate Lateral Eye Movements (CLEMs) and Functional Laterality

When subjects are posed a question that requires reflective thought, their gaze shifts either to the right or left. This is referred to as conjugate lateral eye movement (CLEM) [1]. It is proposed the side the eye deviates during a thought process implies the cerebral hemispheric activity [2].

There are two concepts of CLEMs found in neurophysiology and neuropsychology literature.

The first suggests that CLEMs vary with the type of question. Earlier studies have shown that verbal problems elicit rightward CLEMs since verbal tasks are processed by the left cerebral hemisphere,

whereas spatial problems elicit leftward CLEMs since spatial tasks are processed by the right cerebral hemisphere [3].

According to the second concept, CLEMs is considered as a trait that reflects individual subject differences in hemispheric specialization. Such that regardless of question type, subjects predominantly move their gaze to right side (right movers) or subjects often shift their gaze to the left (left movers).

The observed patterns of CLEMs are at variance [3] and there are discrepancies about CLEMs being an index of hemispheric asymmetry and the nature of CLEMs has not been unambiguously established. Thus there is lack of consensus regarding CLEMs and this study tries to clarify the issue of whether CLEMs is a valid index of functional lateralization. Against this background, this study attempts to broaden the findings of previous studies and report new evidence.

The implications of this present study can be used in neurophysiological, neuropsychological and other clinical and experimental work.

## Aims and Objectives

### *Aims*

To measure the functional lateralization of underlying cerebral activity during an on-going cognitive task using CLEMs, thereby assessing its validity as an index of functional laterality.

### *Objectives*

To evaluate whether conjugate lateral eye movements (CLEMs) can be used as a valid measure of cerebral functional laterality.

## Materials and Methods

### *Source of Data*

- School students and college student from Krishna district, Andhra Pradesh, India.
- Number of students randomly selected – 400
- Both male (200) and female (200) students were included.
- Students belonged to the age group of 10 to 19 years.

### *Inclusion Criteria*

- Healthy school and college going students.
- Both boys and girls in the age 10-19 years

### *Exclusion Criteria*

- All unwilling students/ unwilling parents of students.
- Age <10 years and >19 years.
- No history of any neurological, psychiatric diseases and head trauma.
- No history of long term medication.

### *Methods of Collection of Data*

Institutional ethical committee clearance was obtained. Informed written consent were obtained from the parents of the minor students, and directly from the students in age group 18 and 19 years. It was stressed that no invasive method was being used and confidentiality of the subjects would be maintained.

The school and college students were instructed that few verbal and spatial questions would be posed to them and were required to orally answer them. The test was not demonstrated to the students since CLEMs pattern had to be observed without the knowledge of the subjects.

### *Conjugate Lateral Eye Movements (CLEMs)*

Ten verbal and 10 spatial questions, intended to elicit CLEMs were used in accordance with the age and educational curriculum of the children. The verbal questions involved definition of words, synonyms and antonyms, interpretation of proverbs, spelling. Examples are, "Tell the antonyms of the words BEGIN and SIMILAR", and "What is the spelling of the words UMBRELLA and CREATE". The spatial questions included visualization, places in map and image manipulation, spatial relationships. Examples are, "How many edges are there in a cube?", "With Vijayawada as your reference point, in which direction is Hyderabad located?", "How many left turns do you have to take from your house to the school/college?" The subject was required to sit on a stool. The investigator sat facing the subject 1.5m away. A table was placed between them. Precaution was taken that there was nothing in the room to distract the subject. The questions were orally posed by the investigator facing the subject and the first

observable CLEM for each question was monitored without the knowledge of the subjects. CLEMs were scored using the response categories: rightward CLEMs, leftward CLEMs. The subjects showing CLEMs that depended on question type would have right-CLEMs to verbal questions (indicating left-hemispheric activation which is concerned with verbal/ analytical tasks) while left-CLEMs to spatial question (indicating right-hemispheric activation which is concerned with non-verbal/ intuitive). And the subjects showing an individual-specific stable CLEMs pattern irrespective of question type (either only right-movers or only left-movers) were recorded. The total number of such subjects showing lateralization pattern of CLEMs depending on question types and those showing CLEMs patterns irrespective of question type were determined.

**Results**

Of the 400 children, 236 subjects showed subject-specific CLEMs lateralization pattern regardless of question type and 164 subjects showed question type specific CLEMs pattern. Thus 59% of the subjects were either right - or left- movers irrespective of the questions, while in only 41% of the subjects CLEMs were dependent on the type of question. To compare the data for statistical significance, one sample t-

test was used for Table 1 and Table 2, whereas two sample t-test was used for Table 3. Conventional p value < 0.05 was considered as statistically significant. In Table 1, a one sample t-test between proportions was performed and a significant difference was found between the percent showing question type specific CLEMs and subject-specific CLEMs. Table 2 also shows a significant difference between the number showing each CLEMs pattern for both male and female students. Thus, statistically majority of subjects showed subject specific CLEMs irrespective of the question type (where either right-movers or left-movers with respect to CLEMs). A two sample t-test between male students and female students for each CLEMs pattern was not statistically significant suggesting no gender difference for CLEMs patterns exhibited in this age group.

**Discussion**

This study questions the validity of CLEMs as an index of functional cerebral laterality. In that it explores whether the pattern of CLEMs are dependent to question’s type (indicating differential hemispheric activation during ongoing cognitive activity) or they are subject specific regardless of question type (indicating subjects as either right- or left- movers). The outcome of this study shows that

**Table 1:** Number of Question specific and Subject specific lateralization patterns of CLEMs

N	Conjugate lateral Eye Movements(CLEMs)		t	P
	Question Type specific (Task specific)- N (%)	Subject Specific- N (%)		
400	164 (41%)	236 (59%)	3.66	0.0003

Task specific= normal lateralization pattern for verbal and special questions.  
Subject specific= either right or left movers irrespective of question type.

**Table 2:** Number of Question specific and Subject specific lateralization patterns of CLEMs according to males and females

N	Question type specific CLEMs- N(%)	Subject specific CLEMs- N(%)	t	P
Male (200)	85(42.5%)	115(57.5%)	2.146	0.033
Female (200)	79(39.5%)	121(60.5%)	3.038	0.002

**Table 3:** Number of men and women showing each CLEMs pattern

CLEMs pattern	Male (200) -N (%)	Female (200) - N (%)	t	P
Question type specific CLEMs-	85(42.5%)	79(39.5%)	0.610	0.542
Subject specific CLEMs	115(57.5%)	121(60.5%)		

in majority of subjects, there is no association between CLEMs and question type and they are categorised as either right- or left- movers.

The findings of this study with regards to CLEMs are in contrast to earlier studies by Gur [4], Kinsbourne [2], Ehrlichman et al. [5], Schwartz et al. [6], Crouch WW [7], Shevrin H et al. [8], Galluscio EH et al. [9] who have reported more right-CLEMs to verbal and more left-CLEMs to spatial questions. Several studies have implied right-CLEMs with left cerebral hemispheric activity and left-CLEMs with right cerebral hemispheric. The left hemispheric blood flow pattern was also found to be high during a verbal assignment.

The present study is in agreeing with a subject-specific brain hemispheric specialization model of CLEMs laterality and is individual specific. This is in support of the study by Day [10] who argued that CLEMs is a steady trait, and people grouped as either right- or left-movers. Taking into account the mixed and uncertain noticed patterns of CLEMs, Deijen et al. [11], Jamieson et al. [12], Reynolds CR et al. [13], Zenhausern et al. [14], Hatta T [15], De Gennaro L et al. [16] have suggested that CLEMs are individual specific rather than question type specific. Initially it was Day who classified his subjects as either right- or left- movers and suggested that CLEMs are a stable trait. Hiscock showed when subjects are questioned (i.e., verbal and spatial questions), they can reliably be differentiated into those who predominantly shift their gaze to the right (right movers) and to the left (left movers) [17]. Gur RE found that when facing the questioner, the same subjects moved their eyes predominantly in only one direction, either right or left, regardless of problem type. Thus he concluded that the cerebral hemispheres, though specialized for problem type, are preferentially activated within the same individual [18]. Reynolds CR investigated the lateral eye movement phenomenon in children aged 2-8 to 9-11, using both spatial and verbal-analytic questions. CLEMs have been proposed to be an individual specific constant trait of usage of hemisphere regardless of each question type [19,20].

However, other studies have shown left-movers with greater EEG alpha activity than right movers [21] and are also more prone to hypnosis [22], while the right movers are higher on verbal [23] and mathematical ability [24].

Though CLEMs have neuropsychological implications, the present study concludes that CLEMs is not a valid measure of underlying cerebral hemispheric processing and CLEMs are subject-

specific rather than question type-specific. This implies that the eye gaze during thought process according to the nature of question does not suggest the cerebral hemispheric laterality of ongoing activity. Thus implying that CLEMs is a individual-specific unchanging trait.

Future studies should explore the relationship of handedness with CLEMs and functional laterality since handedness is also considered to be peripheral measure of functional asymmetry, also with the right-handers having a normal cerebral laterality pattern while the left-handers showed discrepant pattern. Future studies while observing model of CLEMs should include EEG pattern, regional cerebral blood flow, anatomic MRI diffusion tensor imaging and positron emission tomography ,etc. that would typically indicate hemispheric activation based on question type or subject specific hemispheric reliance.

#### *Limitation*

Since every task demands the integrated functioning of the whole brain, the results may be overgeneralizing. CLEM patterns observed and reported by the examiner by directly monitoring may not be always reliable. Hence, CLEMs pattern should be monitored by more sophisticated techniques like infrared eye tracking device.

#### **Conclusion**

The question type dependent normal lateralization pattern of CLEMs were seen in only 41% of the sample, whereas the remaining 59% showed subject specific CLEMs lateralization pattern independent of the type of question. There is no gender difference for the CLEMs pattern exhibited .It indicates subject-specific mode of CLEMs which are independent of question type. Our study proves CLEMs to be individual-specific and thus an invalid index of functional laterality.

This suggests that in majority of the subjects, there is no differential hemispheric activation during an on-going cognitive task. So it can be considered that CLEMs are a stable trait reflecting individual differences in hemispheric reliance. Thus CLEMs do not reveal the underlying cerebral hemisphere which is active. The present study included only healthy children. Further studies should explore CLEMs with right- left handedness, also in clinical populations and can be linked with imaging studies

investigating development patterns in children. Also CLEMs should be assessed along with cerebral blood flow, EEG, positron emission tomography, etc.

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