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Revisiting the relationship between hand preference and lateral eye movement

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Abstract

The study examines the relationship between hand preference and conjugate lateral eye movements. The sample comprised of 224 persons. The hand preference was assessed using a handedness inventory. Conjugate lateral eye movements were elicited in response to verbal and spatial questions among left-, mixed- and right-handers. The left- and mixed-handers exhibit significantly greater number of conjugate lateral eye movements than the right-handers. On the verbal task, right-handers exhibit rightward conjugate lateral eye movements, and left- and mixed-handers exhibit leftward conjugate lateral eye movements. On the spatial questions, right-handers exhibit leftward conjugate lateral eye movements and left- and mixed-handers also exhibit leftward conjugate lateral eye movements. While right-handers show normal lateralization pattern, the left- and mixed-handers show right brain dominance irrespective of the nature of questions.

Key words: handedness, conjugate lateral eye movement, non verbal questions, verbal questions

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The pattern of gaze or the way people look at other persons and objects in the environment is often considered as a reflection of their minds. The study of conjugate lateral eye movement (CLEM), therefore, is expected to offer possible clues about brain functioning. Bakan (1969) advanced the idea that eye movements are related to hemispheric asymmetry, with relatively greater degree of cognitive and physiological activation (Kinsbourne, 1972, 1974) in the hemisphere contralateral to the direction of shift in eye movement. Also, left movers exhibit greater proportion of alpha activity during EEG recording than right movers (Bakan & Svorad, 1969) and are more susceptible to hypnosis (Gur & Gur, 1974). Contrarily, right movers focus on external stimuli (Bakan & Shotland, 1969) and are higher on verbal (Weiten & Etaugh, 1973) and mathematical ability (Bakan, 1969). Thus, CLEMs may furnish an index of the relative activity of the two hemispheres. Day (1964) drew attention to the fact that CLEM may be viewed as a stable trait and most of the people could be classified as either left movers or right movers. Against this backdrop this study reports fresh evidence examining the relationship between type of questions and direction of CLEMs in people varying in their hand preference.

Past research has indicated that CLEMs might be dependent on the stimulus material and hemispheric specialization. There is some evidence to suggest that the type of stimulus questions is linked with different eye movements (see Beaumont, Young & McManus, 1984; Ehrlichman, 1981; Ehrlichman & Weinberer, 1978). The CLEM found in the rightward direction is associated with left hemispheric activity and the CLEM found in leftward direction with right hemispheric activity. Early studies had reported more rightward CLEMs for verbal and numerical problems and more leftward CLEMs for spatial and emotional questions (Gur, Gur, & Harris, 1975; Kinsbourne, 1972; Schwartz, Davidson, & Maer, 1975). There are studies which question the sensitivity of CLEMs' direction as an index of lateralized cerebral processing (Hatta, 1984; MacDonald & Hiscock, 1992; Raine , 1991). Some studies indicate more CLEMS for verbal than spatial questions (e.g. De Gennaro & Violani; 1988; de Bonis, Freixa, & Baqué, 1983). Some studies have reported greater number of rightward CLEMs for verbal questions, and leftward CLEMs for spatial questions (Galluscio & Paradzinski, 1995; Raine, Christie & Gale, 1988). The CLEMs also depend on the distance. They are found unidirectional at a close distance from the experimenter (Lenhart, 1985). Also, shifting gaze in one direction is found to be associated with hemispheric asymmetries (San Martini, De Gennaro, Filetti, Lombardo, & Violani, 1994)

Keeping the variations in observed patterns of CLEMs, some researchers have pointed out that CLEMs are subject- specific than task specific (Deijen, Loriaux, Bouma, & Orlebeke, 1986; Jamieson & Selik, 1985; Zenhausern & Kraemer, 1991). Thus, the evidence about the relationship between type of question and direction of CLEM is mixed.

It may be noted that hemispheric specialization is based on the localization of functions in the brain, whereas hemispheric activation refers to the arousal in the Central Nervous System during an ongoing cognitive task. While measures such as dichotic listening and split visual field disclose hemispheric specialization, measures such as regional cerebral blood flow, EEG, and CLEM reveal hemispheric activation. Sackeim, Weiman, and Grega (1984) have proposed "activation asymmetry" as another aspect of functional

asymmetry independent of the degree of specialization of brain for different cognitive functions. By "activation asymmetry" they refer to the arousal in a particular hemisphere depending on the nature of the cognitive task. Charlton, Bakan, and Moretti (1989) have observed that the EEG pattern and blood flow that characterize high arousal are found more in the left hemisphere as compared to the right hemisphere in an ongoing verbal task performance. Similar EEG observations are also found using synonym tasks (Neubauer, Schulter & Pfurtscheller, 1988). It seems that CLEMs may reflect activation of the contralateral hemisphere mediated by the activity of the frontal eye fields.

Cerebral blood flow and EEG also indicate the hemispheric activation/arousal. In right-handed subjects, left hemispheric activation is found to be associated with enhanced verbal ability and reduced spatial ability. Also, right hemispheric arousal is initiated with increased spatial ability and reduced verbal ability (Dabbs & Choo, 1980; Gur & Reivich, 1980). This kind of relationship suggests that hemispheric specialization and hemispheric activation are complementary to each other. Complementarity implies that if a particular hemisphere is specialized for a given task then that task leads to greater activation in that hemisphere.

It has been noted that while around 95% of right-handers have speech centre located in left hemisphere and remaining 5% in right hemisphere, 60% of left-handers have speech centre located in left hemisphere, 20% in right hemisphere, and remaining 20% in both hemispheres (Hellige, 2001). This organizational difference of speech centre leads to individual variation in hemispheric asymmetry (Kim, Levine, & Kertesz, 1990; Levine, Banich, Kim, 1987; Levy et al., 1983a, b). Handedness is taken as a manifestation of the extent of anatomical/functional asymmetry in human brain organization (Schulter & Paousek, 1992) and, therefore, a relationship between handedness and CLEM is expected.

The present study tests the hemispheric asymmetry model of CLEM to see the relationship between the nature of questions and the accompanying CLEMs in response to questions. To this end, CLEMs of left-, mixed- and right-handers are examined with respect to verbal and spatial questions. It extends earlier research on CLEM-laterality relationship which so far has been confined to right-handers only (Baker & Ladner, 1990; Gur et al., 1975; Schwartz et al., 1975). There is evidence that only the right-handers have a normal lateralization pattern than the non-right-handers (e.g. Bishop, 1990; Higgenbottom, 1973; McKeever & VanDeventer, 1977; Piazza, 1980; Schmuller & Goodman, 1979). It is expected that gaze shifts to the right or left during an ongoing cognitive task would facilitate cerebral hemispheric activation, the pattern of which would vary in the three handedness groups.

This study extends previous studies by taking into account the entire range of hand preference and manipulating the type of question. If right-handers demonstrate a normal lateralization pattern but left- and mixed-handers show reduced or reverse lateralization pattern, then it is expected that the right-handers would show more rightward CLEMs to verbal questions and more leftward CLEMs to spatial questions. In contrast, the left- and mixed-handers would show a discrepant pattern.

Method

Sample

The school and college students at Kharagpur, and the locomotive drivers from South Eastern Railways, Kharagpur participated in this study. A total of 224 persons participated in the experiment (Male = 199; *M* age= 24. 47, *SD*= 8.33; Female= 25, *M* age= 16.90, *SD*= 5.98). Males dominated the sample because representation of females was lower in colleges and absent among locomotive drivers ($X^2 = 13.5$, $p<.001$). Males were older ($t = 4.39$, $p< .001$) and had more years of formal education than the females ($t = .031$, $p< .05$).

Measures

Hand preference. It was measured with the help of a 10-item self-report questionnaire. Ten items – using a knife, combing hair, picking up a book, picking up a heavy suitcase, brushing teeth, throwing a ball to hit a target, unscrewing jar lid, using an eraser on paper, hammering on a nail, and writing on paper – were culled from past studies to assess hand preference (Coren, 1993; Suar, Mandal, Misra, & Suman, 2007). The participants had to choose from a set of 5 possible alternatives for each item: always left (=1), usually left (=2), equally both (=3), usually right (=4), and always right (=5). The items had high internal consistency (Cronbach alpha = 0.97). The scores on handedness items were added and divided by the number of items (=10) to find out the mean of handedness scores.

The total handedness scores on the 10 items of the handedness questionnaire were added and divided by the number of items to estimate the extent of handedness. For classification of handedness groups, the mean handedness score of each individual ranging from 1 to 2.5 was considered as a left-handed, 2.51 to 3.5 as mixed-, and 3.51 to 5 as a right-handed person. Accordingly, there were 61 (27.23%) left-handed, 21 (9.37%) mix-handed, and 142 (63.3%) right-handed subjects. The inclusion of mixed-handedness was based on the consideration that it is an indirect indicator of undeveloped cerebral lateralization as compared to left and right-handedness and therefore helps covering the entire spectrum of handedness.

Question Types: Stimuli to elicit eye movements consisted of 10 verbal and 10 non-verbal questions. The verbal questions emphasized meaning or manipulation of words and symbols. The non-verbal questions involved visualization. Examples of verbal items included antonyms, synonyms, additions, comparisons, and logical questions. Sample of verbal items include, “Tell the synonym of the word initiate”, and “What is the spelling of the word exclamation?” Non-verbal questions involved places in map and image manipulation. Sample of non-verbal questions include, “How many edges are there in a cube” and “With Kharagpur as your reference point, in which direction is *Mumbai* located?”.

CLEM. For each question, an overall judgment was made whether the CLEM was rightward or leftward. The leftward and rightward CLEM was recorded for each question about the eye movements of the participant. The total CLEM score was calculated as a ratio for a given participant, unless observer was uncertain about the movements of the participant. To this end the absolute value of the difference between the number of left and right CLEMS was computed and the difference obtained was divided by the total score (CLEM = CLEM R- CLEM L / (CLEM R+CLEM L).The denominator excluded the questions after which the participant showed no motion, or where gaze was not shared at the end of the question, or where the experimenter was not sure how to score. A Laterality Quotient (LQ) was also computed using the following formula: Rightward Movement – Leftward Movement / Rightward Movement + Leftward Movement.

Procedure

The participant was seated in a comfortable chair in a small room which was free from distracting stimuli. The experimenter was seated facing the participant at a distance of 1.5 m with a table between them. The participant was instructed to voluntarily maintain a face forward posture. The experimenter sat directly opposite the subject, and orally presented the questions and recorded the CLEMs. The experimenter paused before reading a question, until the participant looked directly at him and established eye contact. Once eye contact was established, the participant rarely moved his/ her eyes until the end of the question. Initial direction of each CLEM was recorded. After each question the experimenter recorded the direction of CLEM as follows: right, left, and uncertain. A response was recorded as right or left only when participant shifted his/her gaze away from the experimenter in one direction at the end of reading each question and held gaze in one direction prior to responding. Taking lead from earlier research (Lenhart, 1985; Raine, 1991; Tucker & Suib, 1978) either leftward or rightward CLEM was recorded for each question. For each participant, numbers of CLEMs were recoded for 10 verbal and 10 non-verbal questions separately. The recordings of CLEMS were observed and analyzed by two investigators who shared high agreement (90%) indicating high inter-rater reliability.

Results

The descriptive statistics on CLEMs are given (Table 1).

On verbal questions, right-handers showed more rightward CLEMs than leftward CLEMs and left- and mixed-handers showed more leftward CLEMs than rightward CLEMs. Contrarily, on non-verbal questions, while right-handers displayed significantly more leftward CLEMs than rightward CLEMs, the left- and mixed-handers showed more leftward CLEMs than rightward CLEMs. The extent of leftward CLEMs elicited by left- and mixed-handers was quite similar. These two groups did not show any difference in

Table 1:
Descriptive Statistics on Leftward and Rightward CLEMs to Verbal and Spatial Questions in three Handedness Groups

Handedness	Leftward CLEMs	Rightward CLEMs
	M (*SD*)	*M* (*SD*)
CLEMs on verbal question		
Left	5.85 (2.19)	3.81 (2.06)
Mixed	5.33 (2.72)	3.66 (2.30)
Right	3.28 (2.41)	4.11 (2.68)
CLEMs on spatial question		
Left	5.26 (2.00)	4.27 (1.89)
Mixed	4.95 (1.59)	4.09 (2.04)
Right	4.93 (2.56)	2.79 (2.51)

the number of CLEMs across the two types of questions. It was noted that the left- and mixed-handers showed greater number of CLEMs than right-handers. In general there was greater number of leftward CLEMs than rightward CLEMs.

A 3 (between group: left-, mixed- and right-handers) x 2 (repeated measures condition: non-verbal question vs. verbal question) ANOVA was performed on the Laterality Quotient (LQ) based on the CLEM scores. The results showed that the main effect of handedness was not significant, F, (1, 221) = .28, $p>.05$. The effect of type of question was also not significant, F (1, 221) = 1.71, $p>.05$. The Group x Type of Question interaction was significant, F (2, 221) = 12.28, $p<.01$. It was found that the left-handers made more leftward CLEMS for verbal than non-verbal questions. The mixed-handers showed almost similar leftward CLEMS for verbal and non-verbal questions. The right-handers were slightly rightward for verbal questions and clearly leftward for the non-verbal questions. Thus the type of question had maximum effect on the direction of CLEMS of the

Table 2:
Descriptive Statistics on Laterality Quotients (LQ) of CLEMs to Verbal and Spatial Questions in three Handedness Groups

Handedness Groups x Question Type	LQ *M* (*SD*)
Verbal questions	
Left	-.20 (.43)
Mixed	-.15 (.55)
Right	.08 (.65)
Spatial questions	
Left	-.10 (.40)
Mixed	-.11 (.38)
Right	-.29 (.60)

right-handers. Also, the left- and mixed-handers showed relatively more leftward CLEMS than the right-handers for verbal as compared to non-verbal questions (Table 2).

Discussion

This study examines the pattern of CLEM as an indicator of the pattern of differential hemispheric activation as exhibited in disparate responses to verbal and non-verbal questions in the three handedness groups. The results reveal that left- and mixed-handed participants exhibit significantly greater number of CLEMs than their right-handed counterparts. On the verbal task, right-handers exhibit rightward CLEMs, and left- and mixed-handers exhibit leftward CLEMs. On the non-verbal questions, right-handers exhibit leftward CLEMs, and left- and mixed-handers exhibit leftward CLEMs. The participants report greater number of leftward CLEMs than rightward CLEMs.

The direction of the shift in CLEM observed in the present study indicate the linkage between hand preference. Right-handers have shown more rightward CLEMs to verbal questions and more leftward CLEMs to non-verbal questions (Ehrlichman, 1981; Gur et al., 1975; Neubauer, Schulter, & Pfurtscheller, 1988; Schwartz et al., 1975). The pattern of CLEMs found in left- and mixed-handers are similar and they have shown more leftward CLEMs irrespective of the type of questions asked.

It has been found that CLEMs of the subject are unidirectional at a close distance from the experimenter (Lenhart, 1985). In this study, distance was kept optimum. San Martini et.al. (1994) have noted that shifting gaze in one direction is associated with hemispheric asymmetries. It is observed that reflective thought induced by the non-verbal questions produces more leftward CLEMs and verbal task produces more rightward and upward eye movements (Galluscio & Paradzinski, 1995).

The present findings are consistent with a task-specific brain-hemispheric activation model of contralateral CLEMs during an ongoing cognitive activity. The direction of CLEMs shows that there exists a difference in hemispheric processing of stimuli between left-, mixed-, and right-handers. It has been noticed that the organization of language centre in left-handers and right-handers is different. While speech centre in a vast majority of right-handers is located in left hemisphere about 60% of left-handers are found to have speech centre in left hemisphere, 20% in right hemisphere, and remaining 20% in both hemispheres (Hellige, 2001). This organizational difference of speech centre results in individual variation in hemispheric asymmetry (Kim et.al.1990; Levine et.al.1987). The right-handers have shown rightward CLEMs on verbal questions indicating the activation of left hemisphere and leftward CLEMs on non-verbal questions indicating the activation of right hemisphere. Thus, right-handers have exhibited a normal lateralization pattern. Because of the contralateral connection of the eye to the brain, left- and mixed-handers have shown the leftward CLEMs irrespective of the type of question suggesting the activation of right hemisphere. So the left- and mixed-handers have shown a reduced or reverse lateralization pattern. The greater number of CLEMs exhibited by the left- and mixed-handers may be due to the reason that they are right brain dominated persons.

The study has certain limitation that must be acknowledged. Females are disproportionately lower in number than that of males. Therefore, we have not considered gender as a factor that can influence CLEMs. However, a balanced design having equal representation of males and females will be more informative about the influence of gender on CLEMs. Also, the assessment of CLEMs by an observer poses many challenges as tracking the eye movement requires monitoring of the eye movement of the participants. Also, the presence of observer might influence the eye movement and lead to biased observations. Future work would require more sophisticated techniques to assess CLEMS.

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This study investigated the validity of lateral eye movements (LEM) as a measure of the individual differences and task demands aspects of LEM by comparing eye movements to information questions that had no clear hemispheric locus with eye movements to rhyme questions that demanded specific left hemisphere involvement. Fifty subjects were asked to respond to the two types of questions and the initial direction of their eye movement was recorded. The results indicated that LEM are a reliableâ€¦ CONTINUE READING.Â Revisiting the relationship between hand preference and lateral eye movement. I. Misra, D. Suar, M. Mandal. Psychology. Annett, M. (1975) Hand preference and the laterality of cerebral speech. Cortex 11: 305â€“28. [MA].Â Kimura, D. & Vanderwolf, C. H. (1970) The relation between hand preference and the performance of individual finger movements by the left and right hands. Brain 93: 769â€“74. [aPFM]. Koff, E., Naeser, M. A., Pieniadz, J. M., Foundas, A. L. & Levine, H. L. (1986) Computed tomographic scan hemispheric asymmetries in right and left handed males and females.Â LeMay, M. (1977) Asymmetries of the skull and handedness. Phrenology revisited. Journal of the Neurological Sciences 32: 243â€“53. [ML].Â Seth, G. (1973) Eye-hand co-ordination and â€œhandednessâ€: A developmental study of visuomotor behaviour in infancy. British Journal of Educational Psychology 43: 35â€“49. Knowing oneâ€™s laterality pattern (dominance of eye, hand, and foot) makes it possible to suggest situations adapted for learning skills more efficiently, to detect and guide young talents, to optimize the work of limbs for each side of the body and to achieve powerful coordination (Laborde et al., 2009).Â Considering sports like shooting, it seems that interaction between hand preference and eye dominance is an effective factor on performance.Â It seems that eyeâ€“hand dominance quality (unilateral and cross lateral) can affect the accuracy of performance in many sports but there are many results that show disagreeing results. ABSTRACT The study examines the relationship between hand preference and conjugate lateral eye movements. The sample comprised of 224 persons. The hand preference was assessed using a handedness inventory. Conjugate lateral eye movements were elicited in response to verbal and spatial questions among left-, mixed- and right-handers. The left- and mixed-handers exhibit significantly greater number of conjugate lateral eye movements than the right-handers. On the verbal task, right-handers exhibit rightward conjugate lateral eye movements, and left- and mixed-handers exhibit leftward conjugate l...