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CONJUGATE LATERAL EYE MOVEMENTS AND PERCEPTUAL ABILITIES

by

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ABSTRACT

This study was carried out to test Bakan's model of the CLEM phenomenon. He has proposed (1969) that CLEM direction provides an index of hemispheric activation. One who characteristically gazes left during reflective thought (a "left-mover") relies primarily on his right hemisphere; one who gazes right (a "right-mover") on his left hemisphere. Based on this model, it was predicted that left-movers would perform better than right-movers on tasks requiring right-hemispheric perceptual abilities.

Two measures of such abilities were used: the Street Gestalt Completion Test (as modified by Thurstone, 1938) and the Perceptual Organization Test (El-Meligi and Cott, 1978). Each of these tests has previously been proposed as a measure of "appositionality", or right-hemispheric ability. CLEM was assessed with a set of questions requiring reflective thought. Handedness and sex were examined as possible moderating variables.

It was found that left-movers perform significantly better than right-movers on both perceptual tests. Neither handedness nor sex had a significant effect on this pattern of performance. This result clearly supports Bakan's model of the CLEM phenomenon and his CLEM-based typology.

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The Cerebral Lateralization Model

The human cerebrum manifests bilateral symmetry. It is divided into two anatomically similar hemispheres. In this respect it is not unlike the remainder of the human body: we have two legs, two arms, and two brains. Having ascertained the structural fact of the two cerebral hemispheres, one arrives at the question of function. Is hemispheric activity characterized by symmetry, complementarity, or some combination of these modes?

This question has been vehemently argued for decades. Scientific opinion has shifted from an assertion that the hemispheres are functionally identical to a general acceptance (by the late nineteenth century) that certain functions are hemispherically localized. Such a conclusion was necessitated by the accumulated evidence linking aphasic symptomatology with left hemispheric damage. The model of hemispheric function which achieved the widest acceptance was based on the concept of a "major" and "minor" hemisphere, with the left being major for language functions. This was subsequently elaborated to stress the dominance of the left hemisphere for all higher mental functions, so that the right hemisphere was relegated to a secondary status. Essentially, there was a major hemisphere (the left) which mattered, and a minor one (the right) which didn't.

More recent scientific thought has abandoned the classical dominance model for one in which each hemisphere is dominant for particular functions. In addition to the left hemisphere dominance for verbal functions, there is a right hemisphere specialization for certain nonverbal functions. This revision of the classical dominance model is attributable to the increasingly sophisticated information available with modern neuropsychological methods. First, the neurological examination has been augmented by an extensive battery of psychological tests which enable the precise delineation of subtle deficits. Second, modern surgical techniques have created a patient population with novel and theoretically instructive types of brain damage. This includes patients with sections of the corpus callosum (Bogen, 1969) and with surgical lobectomies (Milner, 1966). These advances have enabled a more detailed model of hemispheric function.

According to the current model, the left hemisphere is specialized for language functions: any operation which involves linguistic processing will rely primarily on the left hemisphere. Associated with this (perhaps underlying it) is a superiority for analytic processing: "the left hemisphere analyzes input sequentially, abstracting out the relevant details to which it attaches verbal labels" (Nebes, 1971, p.333).

The left hemispheric mode has variously been described as "verbal","discrete","logical",and "digital". The right hemisphere is specialized for nonverbal functions. This includes the perception and cognition of spatial relationships, faces, music, and other input which is difficult or impossible to verbally code. The ability to infer the whole from a part has also been associated with the right hemisphere (Nebes,1971). In general, the right hemisphere is specialized for nonverbal processing. Associated with this (perhaps underlying it) is a superiority for synthetic processing:"the minor hemisphere is seen to organize and treat data in terms of complex wholes, being in effect a synthesizer with a predisposition for viewing the total rather than the parts"(Nebes,1974,p.13). The right hemispheric mode has been described as "perceptual","diffuse", "visuospatial","holistic", and "gestalt".

The emergence of the cerebral lateralization model based on brain damaged populations has encouraged researchers to demonstrate similar phenomena with normal, brain-intact, individuals. Predictably enough, manifestations of lateralized hemispheric activity in normals are less ubiquitous than in brain damaged subjects. This has necesitated the use of rather elaborate experimental techniques, with equally elaborate rationales. The connections between observed behavioural asymmetries and "underlying" cerebral asymmetry are usually not intuitively obvious, but rely on theoretical bridges supported by empirical consistencies.

Methods used to demonstrate cerebral lateralization in normals include: 1) neurophysiological measurement; 2) lateralized response demand; 3) lateralized stimulus presentation; and 4) observation of lateralized behavioural preference. These are discussed below.

Neurophysiological measurement

This refers primarily to the use of EEG recording in conjunction with tasks designed to tap lateralized functions. For example, one line of research has attempted to demonstrate an enhancement of left hemisphere activity during a verbalization task. Unfortunately, the findings from this work are so enmeshed in controversy that no clear conclusions can be drawn (Grabow and Eliot,1975; McAdam and Whitaker,1971). A recent variation is the measurement of cerebral blood flow during performance of "hemispheric" tasks (eg. reading). Initial results are encouraging, in fact show clear patterns of cerebral activity corresponding to theoretical predictions(Carmon,Lavy,Gordon,and Portnoy,1975;Melamed,1977).

Lateralized response demand

This refers to the use of tasks for which the right and left hands (or,presumeably,feet) alternately control the response. As each hemisphere has preferential control over the contralateral response system, this should result in accuracy or reaction-time differences between the hands for tasks which tap lateralized functions. Positive results have been found by Witelson (1974).

Lateralized stimulus presentation

One form of this is the dichotic listening task, in which different auditory stimuli are presented simultaneously to the two ears. Thus, a subject will hear "2,5,7," in his left ear and "3,8,9," in his right ear. This stimulus competition results in more accurate report from the ear contralateral to the primarily activated hemisphere (Kimura,1961;Bryden,1969).Another form is the lateralized tachistoscopic presentation of visual stimuli. Various stimuli are flashed in the left or right visual field while the subject fixates on a central point. As each hemisphere receives visual information primarily from the contralateral visual field, there should be more accurate or faster response to information presented contralaterally to the "task-appropriate" hemisphere. There is strong evidence supporting this prediction (Kimura,1969; Geffen,Bradshaw,and Nettleton,1972).

Lateralized behavioural preference

This refers to the observation of individual predisposition towards asymmetrical behaviours. Unlike the "lateralized response" method, there is no attempt to prescribe a response mode. Rather, the individual is presented with a situation or task believed to tap a lateralized function, and his behaviour is observed. The prime example of this is handedness: individuals show a characteristic preference for one hand in performing most tasks. The thrust of research using this approach is to demonstrate that these preferences relate to cerebrally lateralized functions in theoretically predictable ways. For example, Nebes(1974) has tried to demonstrate that left-handers are inferior on right hemispheric tasks.

Also in this category is research investigating the Conjugate Lateral Eye Movement (CLEM) phenomenon. This work has its source in the observation of Day(1964) that individuals laterally avert their gaze while engaged in reflective thought. This aversion, the CLEM, is directionally consistent for a particular individual: thus, it is possible to classify subjects as "left-movers" or "right-movers" according to their characteristic CLEM direction. Bakan (1969) related the CLEM to laterality theory, proposing that the asymmetrical CLEM reflects the underlying asymmetry of cerebral function. Specifically, he suggested that the left-mover characteristically relies on his right hemisphere, the right-mover on his left hemisphere. When asked a reflective question, each will tend to initiate processing with the preferred hemisphere: the resulting cerebral activity will trigger the eye movement control system. As each hemisphere programs eye movement to the contralateral side, this will produce a CLEM contralateral to the preferred hemisphere.

CLEM research is primarily concerned with demonstrating theoretically consistent correlates of the CLEM typology.

As this is the method which will be utilized in the present experiment,I will explore the CLEM laterality model in more detail.

<u>The Laterality Model of CLEM</u>

Basic assumptions of this model are: 1) that individuals may be characterized as "left-hemispheric" or "right-hemispheric" with regard to their reliance on one or the other hemisphere's mode of processing; and 2) that CLEMs, as elicited by questions requiring reflective thought, are indicators of this hemispheric preference.

The first assumption may be empirically evaluated. One simply needs to classify groups of individuals as left- or right-hemispheric, then demonstrate a differential utilization of processing modes. This could manifest as performance superiority on tasks appropriate to the preferred hemisphere, or simply as a preference for certain processing strategies. This method of validation is employed in this study: it is an attempt to demonstrate performance differences on appropriate tasks. However, such validation depends on the plausibility of the second assumption.

One can safely assert that CLEMs are programmed in the hemisphere opposite to the direction of movement: electrical stimulation of the frontal eye-fields of one hemisphere will induce contralateral CLEMs (Penfield, 1959). It has been questioned whether voluntary CLEMs are programmed via the frontal eye-field system (Ehrlichman, 1978):work by Melamed (1977) with cerebral blood flow indicates that voluntary CLEMs are indeed associated with focused activity in the frontal eye field region. It is also known that inactivation of one hemisphere via barbituate injection (the Wada test) results in extreme lateral gaze aversion contralateral to the active hemisphere (Wada and Rasmussen,1960). From this it appears that the hemispheres are mutually inhibitory for CLEM control. A predominance of activity in one hemisphere causes a contralateral eye shift.

An area of research with some relevance to the CLEM phenomenon is the study of "hemi-inattention", or "unilateral neglect". This refers to an extreme inattentiveness to the side of space contralateral to a damaged hemisphere. As described by Friedland and Weinstein (1977) :

> Patients with hemi-inattention may fail to recognize the limbs on one side of the body as their own. They may attend to events and notice people only on one side or respond only when addressed from one side ...Details may be missing from one half of a drawing...Hemi-inattentive patients may deviate their head and eyes constantly to the good side ...(p.2).

In addition to the constant gaze aversion mentioned above, there is another symptom of particular interest. This is referred to as "eye shift" and is common in hemi-inattentive patients. To quote Friedland and Watson again:

> When the examiner presents a hand or some other object simultaneously in each visual field, the patient, without prior instructions to fixate, is asked to say what he sees. There is a marked conjugate deviation to the unaffected side i.e. side of the lesion, which is so consistent on repetition that Cohn emphasizes its "magnetic" quality. This eye-shift is observed in almost all cases of visual hemi-inattention and persists even after it is called to the patient's notice. (p.6)

There are several more points to be made about hemi-inattention before returning to the CLEM. First, it can occur independently of sensory deficits and cannot be explained in these terms. Rather, it appears to be an attentional-arousal deficit, i.e. there is a malfunction of the neural system which programs attentional orienting to the contralateral side (Heilman, 1977). Second, hemi-inattention (and the resulting gaze aversion phenomenon) occurs frequently without damage to the motor system controlling conjugate eye movements. As Heilman points out: "patients with unilateral neglect most often have their dysfunction in the inferior parietal lobule...The inferior parietal lobule appears to be a secondary association area" (p.95). He also notes that neglect may be produced by lesions in the tertiary association areas of the dorsolateral frontal lobes. Finally, it should be noted that the model best able to account for the hemi-inattention findings, the attention-arousal one, proposes an extensive corticofugal loop involving interconnections between areas of the cortex and the reticular formation (Heilman, 1977). This loop includes the frontal eye-field,as one would expect from the gaze aversion symptoms of hemi-inattention.

To summarize these findings with reference to the CLEM model, it has been shown that: 1) Stimulation of the frontal eye-fields in one hemisphere results in contralateral gaze aversion. 2) Inactivation of one hemisphere results in gaze aversion contralateral to the active hemisphere. 3) Damage to secondary and tertiary associational cortical areas can produce continuous gaze aversion and/or "eye shift" contralateral to the intact hemisphere.

This excursion into the neurology of hemi-inattention was intended to demonstrate the plausibility of a systematic relationship between lateralized cerebral activity and CLEM behaviour. The model suggested by these findings is one in which asymmetrical CLEM behaviour is a manifestation of an attentional shift contralateral to the primarily activated hemisphere. Such an attentional model of CLEM is presented by Kinsbourne (1977). He has tested its predictions with a series of experiments in which he manipulated subjects' cognitive set so as to induce lateralized cerebral activity. He has concluded that:

> The phenomena of lateral attending do not occur only in response to external stimulation. Rather, there is an intimate and lawful relationship between the laterality of the cognitive processor in use, and where one is looking. When normal right-handed subjects were given verbal problems to solve, they would look to the right when thinking of them, whereas they would look to the left when thinking about spatial problems. (p.45)

It must be noted that Kinsbourne's conclusion relating problem-type to CLEM direction is a controversial one. While some researchers have replicated this result (Galin and Ornstein,1974; Gur,1975; Shwartz,Davidson, and Maer,1975;Weiten and Etaugh,1974), others have found no relationship between CLEM and problem type (Crouch,1976; Hiscock,1977a; Rodin and Singer,1976). No attempt will be made here to resolve this controversy over situational determinants of CLEM behaviour. Rather, the focus will be on evaluating the hypothesis that CLEM behaviour may be considered an individual trait systematically related to indices of "hemisphericity".

Validation of the CLEM Model

This model of CLEM behaviour generates certain predictions. First, a comparison of left- and right-movers should reveal differential performance on tasks which tap cerebrally lateralized functions. This may take the form of superior performance or of a preference for certain processing strategies. It should be noted that large performance differences would not be expected, particularly with the population of college students usually studied. Academic selection tends to ensure high levels of cognitive ability, especially for left hemispheric functions. Nonetheless, it should be possible to demonstrate the predicted cognitive differences with adequately sensitive instruments. Second, one would expect some relationship between CLEM and other measures of lateralized attention. Third, one would also predict a relationship between CLEM and measures of lateralized physiological activity, such as the EEG.

Thus, validation of the CLEM laterality model relies on demonstrated relationships with cognitive, attentional, and physiological measures. Investigation of cognitive differences comprises the bulk of CLEM research, and will be discussed below. The second prediction, of attentional differences, has not been adequately investigated. One piece of research with direct relevance is that of Hines, Martindale, and Shulze (1974), who found that CLEM is related to lateral body sensitivity: left-movers showed more awareness of their left side, as measured by the Fisher Body Focus questionnaire. Also of relevance is a study by Nielsen and Sorensen (1976), who related CLEM to performance on a dichotic listening task with verbal stimuli. The normal right ear preference found with verbal material was significantly greater for the right-movers. The authors conclude that "the left movers in the present investigation attended to a greater degree to stimuli from the left side because of habitually enhanced right hemispheric and thereby lowered left hemispheric activity." While these results support the prediction, more evidence is required.

The third prediction, involving measures of lateralized physiological activity, has been investigated no more adequately. Several studies have demonstrated that left-movers manifest higher levels of EEG activity in the alpha band than do right-movers (Bakan,1969;Day,1967;Morgan, McDonald,and MacDonald,1971) , and have noted that the right hemisphere characteristically produces more alpha activity than does the left. Nonetheless, this work does not provide much support for the prediction. While the left hemisphere may produce less alpha activity than the right, it is doubtful that alpha activity per se could be considered as a right hemisphere function. More germane is a finding by Meyer (1977) that "Left eye movers utilized the right hemisphere more than right eye movers", based on interhemispheric comparison of EEG activity during problem solving tasks. Such a demonstration of lateralized neurophysiological activity associated with CLEM is consistent with the prediction.

A study by Padarowski, Brucker, Zaretsky, and Alba (1978) is indirectly related to the prediction. They examined the CLEM behaviour of left- and right-hemisphere damaged patients as well as a control group of non-brain-damaged chronic hospital patients. A set of reflective questions was administered and the CLEM behaviour of the three groups compared. One would predict from the CLEM model that the left-damaged group would show a reduced tendency to rightward CLEMs and the right-damaged group a reduced tendency to leftward CLEMs. The results were that the control and left-damaged groups showed a "consistent and significant preference for left-looking over right-looking ". The right-damaged group showed no such preference, clearly demonstrating a reduced frequency of leftward CLEMs. Results were not entirely supportive of the prediction, as the left preference of the left-damaged group was no greater than that of the control group: this may be attributable to the low absolute frequency of rightward CLEMs in the control group. A reduced right preference in left-damaged patients would best be demonstrated where the "baseline" frequency of right CLEMs is higher.

Overall, the results of these studies tend to support the predicted relationship between CLEM behaviour and lateralized physiological indicators. However, more evidence is needed to support a firm conclusion.

<u>Cognitive Differences and CLEM</u>

It is the first prediction, that of cognitive differences associated with CLEM, which has generated the most research. Before presenting these data, it is necessary to clarify the type of evidence most relevant to validation of the model.

Essentially, the problem with much of the research which attempts to validate the model lies in the definition of task "hemisphericity". By what criterion shall a task be considered to tap the unique cognitive abilities of one hemisphere? Most powerful as a validating technique is the demonstration that unilateral hemispheric damage is associated with performance deficit on a task. Such a demonstration provides relatively unambiguous evidence that the task does in fact tap functions of the damaged hemisphere. A somewhat less powerful method is to select tasks which tap hemispherically localized functions, although the task itself may not have been neuropsychologically validated. An example of this is the classification of a wide range of verbal measures as "left-hemispheric". Experimental studies using these two sorts of validation will be considered as useful tests of the model.

Another group of studies, which rely on intuitive relationships between certain variables and accepted hemispheric functions, will not be considered as useful tests of the prediction. Examples of these are studies of CLEM and: imagery (Richardson, 1977, 1978); "nonanalytic attending" (Stam and Spanos, 1979); "wide categorization" (Huang and Byrne, 1978); "internal focus" (Meskin and Singer, 1974); academic aptitude (Weiten and Etaugh, 1974); etc., etc. Such research examines functions whose hemispheric localization is so uncertain as to be of little use in evaluating the model. This criticism also applies to a function which has been investigated several times in CLEM studies, mathematical ability. Present data would not localize this function: rather, an interaction of both hemispheres is considered essential for mathematical operations (Dimond and Beaumont, 1972; Sperry, 1974).

Having specified the criteria for relevance of experimental data, I will present the evidence.

One of the earliest relevant studies is that of Bakan and Shotland (1969), who administered the Stroop colour-word interference test to left- and right-movers. They found that right-movers were faster at reading words in the non-interference condition (i.e. names of colours printed on a white background). Thus, it was shown that right-movers are superior on a verbal processing (left-hemispheric) task, as would be predicted by the CLEM model.

This finding is supported by that of Ogle (1972), who utilized a test of oral and silent reading speed. He found that right-movers read more rapidly than left-movers in both oral and silent modes.

Crouch (1976) compared left- and right-movers on a task designed to measure differential responsiveness to verbal and facial cues. A series of cartoon faces accompanied by verbal statements were presented to subjects, who were asked for mood ratings of each face. Since many of the face-statement combinations were incongruent, it was possible to assess the subject's preference for facial or verbal cues. As the right hemisphere has been shown to be specialized for face perception (Hecaen and Angelergues, 1962) and the left for verbal processing, one would predict that left-movers would be more responsive to facial cues, right-movers to verbal cues. This was the observed outcome, a finding which supports the CLEM model.

Bakan (1971) found that left-movers report more interest in music than do right-movers. This accords well with the right-hemisphere specialization for music processing (Milner, 1962; Shankweiler, 1966), and is consistent with the CLEM model.

Weiten and Etaugh (1973) presented left- and right-movers with a concept identification task: subjects were asked to find an adjective descriptive of four stimulus words. The right-movers were superior at this verbal (semantic) processing task, again supporting the CLEM model.

Tucker and Suib (1978) examined the relationship between CLEM and performance on the WAIS. They were interested in relative performance on the Verbal and Performance subscales, a measure often used for diagnosis of left versus right hemisphere damage (McFie, 1975). The right-movers showed a relative superiority on the Verbal tests, the left-movers a relative superiority on the Performance tests, a finding which supports the CLEM model.

The experimental findings presented to this point have been uniformly supportive of the CLEM laterality model. A group of studies which do not support the model will now be discussed.

DeWitt and Averill (1976) used the rod-and-frame test to compare left- and right-movers. This test measures field independence, the ability to make accurate judgements while ignoring contextual cues. A weakness in field independence has been associated with left hemisphere damage (Cohen, Berent, and Silverman, 1973; Russo and Vignolo, 1967): one would predict that right-movers would be more field-independent. No such difference was found, thus no support is provided for the CLEM model.

Similarly, Hoffman and Kagan (1977) administered several measures of field independence, including the rod-and-frame and embedded figures tests. No relationship was found between CLEM and field independence, again offering no support for the CLEM model.

Croghan (1975) examined several different functions using the Reference Kit for Cognitive Factors (French, 1951). This kit provides paper-and-pencil measures for a number of cognitive abilities. Croghan found no relationship between CLEM and the Flexibility of Closure (which is equivalent to field independence). There was also no relationship between CLEM and several spatial factors. As spatial ability has been shown to be a right-hemisphere function (Milner, 1971), this result does not support the CLEM model. Finally, there was no relationship between CLEM and several verbal factors. Again, this result does not support the CLEM model.

Hiscock (1977) found no differences between left- and right-movers on a vocabulary test. While this may reflect general intelligence, it is not obvious that it specifically measures verbal processing ability i.e. it is questionable whether a clear prediction could be made. He administered a measure of spatial ability and again found no differences. As noted above, the processing of spatial relations is lateralized to the right hemisphere: the CLEM model is not supported. He also administered a questionnaire to assess subjects' reported preference for verbal or imaginal thinking. There were no differences on this measure. However, a reported preference may not be the most accurate measure of actual preferred processing strategy. Also, the association of imaginal thinking with right hemisphere function, while intuitively appealing, is not backed up by neuropsychological research. The relevance of this finding to the CLEM model is doubtful.

Fischer (1976) compared left- and right-movers on the "A/P ratio". This is a measure of hemisphericity proposed by Bogen et. al. (1972). It compares performance on the Street Gestalt Test (a right hemispheric measure of perceptual closure, discussed below) with performance on the Similarities subtest of the WAIS (a left hemispheric measure of verbal ability). Fischer found no difference between the CLEM groups, a result which is inconsistent with the model being tested here.

Finally, Ehrlichman (1972) examined the relationship between CLEM and various cognitive measures. He selected from the Reference Kit for Cognitive Factors those tests which seemed likely to be associated with CLEM. These included tests of perceptual closure, flexibility of closure (as noted above, this corresponds to "field independence"), and vocabulary. Unfortunately, Ehrlichman's method of data analysis is such as to render his results irrelevant to this inquiry. This study will be discussed in detail below.

From these studies one may draw certain conclusions about the relationship between CLEM and lateralized cognitive functions: 1) The evidence tends to support the predicted relationship between CLEM and left hemispheric verbal processing. It must be stressed that the prediction was that there would be some difference between left- and right-movers in their performance of "lateralized-function" tasks, not that they would perform differently on all such tasks. A negative result with "Cognitive Factors" measures does not invalidate positive results with measures of reading speed, verbal cue preference, Verbal WAIS performance, and concept identification. Most informative would be replications of these results, using the same measures. From the present data, one must conclude that CLEM behaviour relates to verbal processing in the predicted manner. 2) Another left-hemispheric function, field independence, does not relate to CLEM as predicted. The evidence is uniformly negative and clearly does not support the model. 3) The right hemispheric specialization for processing of music and faces seems to be reflected in the left-movers' greater musical interest and preference for facial cues. While the evidence is scanty, it does tend to support the CLEM model. 4) processing of spatial relations, a right hemispheric function, does not relate to CLEM in the predicted way. 5) The right hemispheric "perceptual closure" ability seems not to have the predicted relationship to CLEM. This last conclusion will be critically evaluated.

It is notable that the bulk of the research relating left hemispheric functions to CLEM is supportive of the model, while right-hemispheric functions do not show the predicted relationship. The present study will re-examine the relationship between CLEM and right hemisphere function.

The Right Hemisphere Model

As noted previously, the various right-hemispheric functions share a holistic, gestalt-oriented character. This leads authors such as Levi-Agresti and Sperry (1968), Bogen (1969), and Nebes (1971), to propose that the uniqueness of right hemisphere function lies in the synthesis of complex perceptual/cognitive gestalts. It is this synthetic function which underlies the various abilities associated with the right hemisphere: "spatial perception" requires the synthesis of spatially isolated objects into a cognitive structure, with emphasis on the relationships between objects; "music perception" requires the synthesis of temporally isolated tones into a cognitive structure, with emphasis on the relationships between tones; etc.,etc. One would also assume that the right hemisphere is specifically involved in the utilization of gestalts, i.e. transformations and comparisons of pattern information. Generally, perceptual or cognitive processes in which pattern and relationship are primary will involve the right hemisphere. It must be noted that linguistic processes are excepted from this: as Nebes (1974) points out, the synthetic function accompanies a basic right hemisphere focus on nonverbal material.

Using this model, we can select an optimal measure of right-hemispheric processing for this study. First, it should be nonverbal, so that it does not involve left hemisphere functions. Second, it should tap the right hemisphere specialization for synthesis and utilization of gestalts (gestalt processing). Third, it should not rely on low-level functions which are neither perceptual nor cognitive (e.g. motor skills). A fourth consideration is its degree of sensitivity to individual differences. The ability difference between left- and right-movers is unlikely to be large, particularly in a highly selected college population. A measure should include a sufficient number and difficulty of items to detect these small differences.

Closure and the Right Hemisphere

A similar search for the optimal right hemispheric measure is carried out by Bogen,DeZure,Tenhouten, and Marsh (1972). They refer to it as a measure of "appositionality" (right hemisphere process):"to represent appositionality, we require a test as non-verbal as possible in both presentation and response, and which puts a premium on the right hemisphere's ability to infer a spatial whole from several parts"(p.53). They select the Street Gestalt Completion Test (Street,1931), a measure of the perceptual/cognitive ability known as "perceptual closure" or "gestalt perception" (French,1951). This is the ability to synthesize a complete figural entity from limited perceptual information, to "close" gaps in configurations. The stimuli of the Street test are fragmented drawings of objects: the subject must identify the represented object. In order to perceive this object, he must synthesize the isolated elements of the drawing into a complete perceptual structure.

It is not surprising that Bogen selected this ability as the index of right hemisphere function: the theoretical relationship is striking. Furthermore, there is ample evidence that the perceptual closure ability is a right hemisphere function. DeRenzi and Spinnler (1966) found that patients with unilateral right hemisphere damage were impaired on the Street test relative to a left- damaged group of patients. Lansdell (1970) factor-analyzed the performance of unilaterally brain damaged patients on the WAIS performance subtests and on a closure test. A closure factor emerged as the most reliable indicator of right hemisphere damage. Lansdell suggested that "with the factor for closure the asymmetry may be as predictable as with the verbal factor" (p.497). Warrington (1967) tested unilaterally brain damaged patients for "recognition of incompletely or partially drawn objects and letters" which require closure to be identified. She found that the right hemisphere damaged group was impaired relative to the left damaged group, who performed like a normal control group. Results demonstrating an impairment of closure ability from right hemisphere damage have also been reported by Ettlinger (1960) and Newcombe (1969).

The Street Gestalt Test

Although Bogen's choice of the perceptual closure ability as indicative of right hemisphere function is theoretically and empirically supported, the Street test itself is problematic. The test consists of twelve fragmented drawings of various people and objects, each of which is to be verbally identified by the subject, within a time limit. It has several drawbacks with respect to the present study. First, it does not include an adequate number of stimuli. As Bogen et. al. (1972) point out: "This is a serious difficulty and probably the principal methodological weakness in our research to date. Doubling (at least) the number of items is clearly required"(p.57). This is likely to reduce the reliability and sensitivity of the test. Such a loss of sensitivity is especially problematic for the present attempt to detect small differences in cognitive ability. Second, it relies on a verbal identification response. While the verbalization demand is a modest one, it remains possible that such a left hemisphere involvement will reduce the test's sensitivity to right hemisphere processes. A third difficulty is that no measure of response-time is possible. A subject is permitted to respond as frequently as desired within the time limit. For difficult items which are not identified in the time limit, one may arbitrarily assign a long response-time. This will add nothing to the accuracy data:the more misses, the longer one's "response-time" will be. One may utilize the time to first (incorrect) response: in a paradigm which encourages guessing, this is unlikely to yield useful information. Finally, one may use correct trials only:this will tend to exclude difficult items from the response-time score of low-accuracy subjects, thus artificially inflating the response times of highly accurate subjects. None of these methods will provide a useful measure of response time.

Some of the difficulty with the Street Gestalt test has been remedied in later modifications of the original test. Thurstone (1944) prepared an expanded form of the test (27 items) using additional material from Street. More recently, the

Figure Completion Test was included in the Kit of Reference Tests for Cognitive Factors (Hoffman, Guilford, Hoepfner, and Doherty, 1968). It is a paper-and-pencil version of the Street test composed of 40 representations of "entirely new and more common objects"(p.9). These tests overcome the main weakness of the Street, its small number of stimuli, but do not address the problem of the verbal response nor provide a response-time measure.

As noted above, there are two studies which have investigated the relationship between CLEM and perceptual closure ability: Fischer (1975) and Ehrlichman (1972). Fischer utilized the original Street test, with the methodological weaknesses discussed above. It is here suggested that these weaknesses (particularly the small number of stimuli) may account for the negative results of his study. Ehrlichman used the closure test of the Reference Kit for Cognitive Factors. His finding seems more reliable than that of Fischer, as this closure test includes a sufficient number of stimuli and thus overcomes the main weakness of the Street. However, the Ehrlichman study suffers from a serious weakness in its method of data analysis which brings into question its conclusions.

Ehrlichman sought to discover the relationship between CLEM and performance on a set of six cognitive abilities measures (including the closure test). In order to do this, he "ipsatized" the data:"cognitive abilities scores were converted to ipsative scores by first transforming raw data to z-scores for each test, second obtaining a mean z-score for each subject (across tests) and third subtracting this mean z-score from each of the subject's z-scores (one for each test)" (p.149). In other words, a subject's score on one test is adjusted according to his mean score across all the tests. This was done because "the main concern is with patterns of scores within subjects rather than performance differences between subjects". A subject's score for a particular test is now defined relative to his other test scores: the result is that his raw-score standing on a test (relative to the sample) may be considerably different from his ipsative-score standing on that test. This latter point should be kept in mind when examining Ehrlichman's analysis. Having ipsatized the cognitive scores, he proceeds to correlate these with CLEM direction scores. How may one interpret the resulting correlation between ipsatized perceptual closure scores and CLEM direction? It is not simply a correlation between CLEM and closure performance. Rather, it is a correlation between CLEM and closure scores expressed relative to a normative baseline defined by the set of cognitive measures. In deciding whether this is a correlation of interest, one must consider the nature of these cognitive measures: including the closure test among a different group of measures would have produced a different set of ipsative scores, thus a different correlation with CLEM. Is a meaningful baseline defined by these measures, such that closure performance should be considered relative to it? They were chosen by Ehrlichman as a group of "verbal and spatial cognitive abilities tests...which may be related to hemispheric functioning". The tests are:Embedded Figures (i.e. field independence); Gestalt Closure (perceptual closure);Vocabulary;Card Rotation ("the ability to perceive spatial patterns or to maintain orientation with respect to objects in space"); Necessary Arithmetic (numerical and general reasoning ability);and Line Estimation (ability to compare line lengths). According to the previous discussion, one would assume the first to be left-hemispheric, the second to be right-hemispheric, the third to be possibly left-hemispheric, the fourth to be right-hemispheric, and the remaining two to be of doubtful relevance to hemispheric function. In other words, these are a heterogeneous group of measures, which define a normative baseline of doubtful meaning. Essentially, the issue is whether it is meaningful to adjust a subject's relative standing on a measure of perceptual closure ability according to his mean performance on a heterogeneous group of cognitive measures. It seems reasonable to conclude that it is not. Therefore, the reported correlation between CLEM and "closure performance" (and Ehrlichman's conclusion that "lateral eye movements were not significantly correlated with any of the cognitive measures") is here considered to be so ambiguous as to be uninterpretable, and to shed no light on the present inquiry.

It is thus asserted that the relationship between CLEM direction and perceptual closure ability has yet to be adequately investigated. It is here proposed to administer the expanded form of the Street Gestalt Test published by Thurstone (1944), which includes more than double the number of stimuli. This expanded set of stimuli will be used with essentially the same test procedure as the original Street Gestalt. A proper test of the hypothesized association between CLEM direction and perceptual closure ability will be conducted.

The Perceptual Organization Test.

In addition to the Street Gestalt, a second measure of right-hemispheric cognitive/perceptual ability will be utilized. The Perceptual Organization Test (El-Meligi and Cott, 1978) has been proposed by its authors as a measure of right- hemispheric "appositional" process. Intended for neuropsychological use, it is designed so that it "focuses on a specific area of cognitive impairment; that is, the area of perceptual organization of visual stimuli" (p. 157). An examination of the stimulus material and task demands reveals that our definition of right hemisphere process ("the synthesis and utilization of gestalts") is quite appropriate to this test.

The Perceptual Organization Test (P.O.T.) takes as its starting point a set of nine "realistic drawings in black and white of well-defined and easily recognized objects". These original pictures are then subject to systematic distortion in three series of stimulus pictures. Stimulus pictures are presented on cards, with nine cards in each series. The subject is required to match each stimulus card to the original picture from which it was derived (placing the stimulus card beside the appropriate picture).

Stimulus Series 1 reduces the original picture to flowing lines and contours; "Internal details and shadings have been obliterated...Success in matching this series with original pictures depends on the subject's ability to identify objects on the basis of the essential properties of the gestalt" (p.158-159). Series 2 reduces the picture to discontinuous lines and dashes which suggest form, again without shading or detail: "Two opposite processes must work in concert in order to succeed in this task- breaking down the original pictures into their component parts and integrating the fragmented details of the series" (p.159). Series 3 reduces the picture to dotted outlines: "the dots preserve the overall gestalt of the original pictures... Most people are able to identify the objects through the process of closure" (p.159). These descriptions portray a task which requires the synthesis of perceptual gestalts from fragmented representations and the utilization of gestalt properties in matching stimulus pictures to the originals.

We may evaluate the P.O.T. as a measure of right hemisphere ability with respect to the criteria specified earlier. First, it does not rely on a verbal stimulus or response. Second, it taps the right hemisphere specialization for synthesis and utilization of gestalts. Third, it does not depend on non-cognitive skills. Fourth, it appears adequately sensitive: it includes 27 stimuli and permits a response-time measure (the time taken to place a stimulus card). The P.O.T. overcomes the weaknesses of the Street test: it uses a nonverbal response, includes sufficient stimuli, and permits a response-time measure.

It is suggested that the methodological superiority of the P.O.T. will render it more sensitive to individual differences in right-hemispheric cognitive ability than is the Street Gestalt. However, the P.O.T. has yet to be investigated neuropsychologically, thus is inferior to the Street Gestalt test in its empirical validation.

These two tests, each with certain advantages and disadvantages, will be used to investigate the relationship between CLEM direction and right-hemispheric cognitive ability. It is predicted that: 1) Left-movers will respond more accurately or more quickly than right movers on the P.O.T. 2) Left-movers will respond more accurately than right-movers on the Street Gestalt Test. 3) There will be a moderate correlation between the Street Gestalt and Perceptual Organization tests, as both tap the right-hemispheric gestalt processing function.

In addition to these main predictions, there will be a secondary investigation of two variables which have been related to hemispheric functioning: sex and handedness. Sex has been found to affect measures of hemispheric preference, although the actual pattern of results is controversial. The consensus appears to be that females are weaker in right-hemispheric skills than males, perhaps due to less lateralization of brain function in females (Witelson, 1977). Another relevant variable is handedness. Work by Nebes (1971,1972) and Levy (1969) indicates that left-handers are less proficient at right-hemispheric tasks than right handers. Again, this is controversial, but should be examined. The assessment of handedness will be done with a questionnaire which includes items on the preferred hand for writing, throwing, using scissors, drawing, using a toothbrush, etc. (Bryden, 1976).

B. Method

Subjects

The subjects in this study were undergraduate Psychology students who volunteered to participate in a "study of perceptual ability". 50 subjects were tested, of whom 5 were self-reported lefthanded writers. These 5 were excluded from analysis, except where otherwise noted. This left 45 subjects, including 21 males and 24 females.

Procedure

The subject sat facing the experimenter across a table. A plain wooden partition extended behind and to either side of the experimenter, so that the subject's visual field included only the experimenter and a homogeneous background.

CLEM direction was assessed with a set of 20 reflective questions (Appendix A). These were selected by Bakan, Coupland, Glackman, and Putnam (1975) so as to maximize sensitivity to individual CLEM style rather than to question type. The subject was told that he would be asked a series of general questions. The CLEM was the subject's first eye-movement after the question ("left-move" or "right-move"). If no movement was made, a "stare" was recorded. If the subject's eyes could not be properly observed, no score was recorded for that question. This yielded for each subject a CLEM ("Left-moving") score, defined as: Left-moves/(Left-moves + Right-moves) x 100.

Following this, the perceptual tests were administered in one of two orders. Order 1 had the Street Gestalt test preceding the P.O.T. ; Order 2 had the inverse. There were 22 subjects in Order 1 (10 male, 12 female) and 23 subjects in Order 2 (11 male, 12 female).

Instructions for the Street Gestalt test were: "I will now present a series of cards. Each card shows a black-and-white drawing of something: the drawings are broken up, so that they are difficult to identify. I will show each card and would like you to identify it." The subject was allowed a maximum of 30 seconds to respond to each stimulus card. He was permitted to guess as often as desired, until the correct answer was given or the time limit expired.

For the P.O.T., the instructions were: "Before you is a series of nine pictures: below each of these pictures is a blank space. Once you have examined the nine pictures, I will give you a series of cards. Each card shows a distorted version of one of the pictures. Your task is to match each card to the picture which it represents, by placing the card in the appropriate space. When I say "ready", hold each card face down. When I say "go", turn it over and place it in the correct space. I will time how long it takes you to place each card."

When the subject finished the perceptual tests, he was given a handedness questionnaire to fill out. (Appendix D).

C. Results

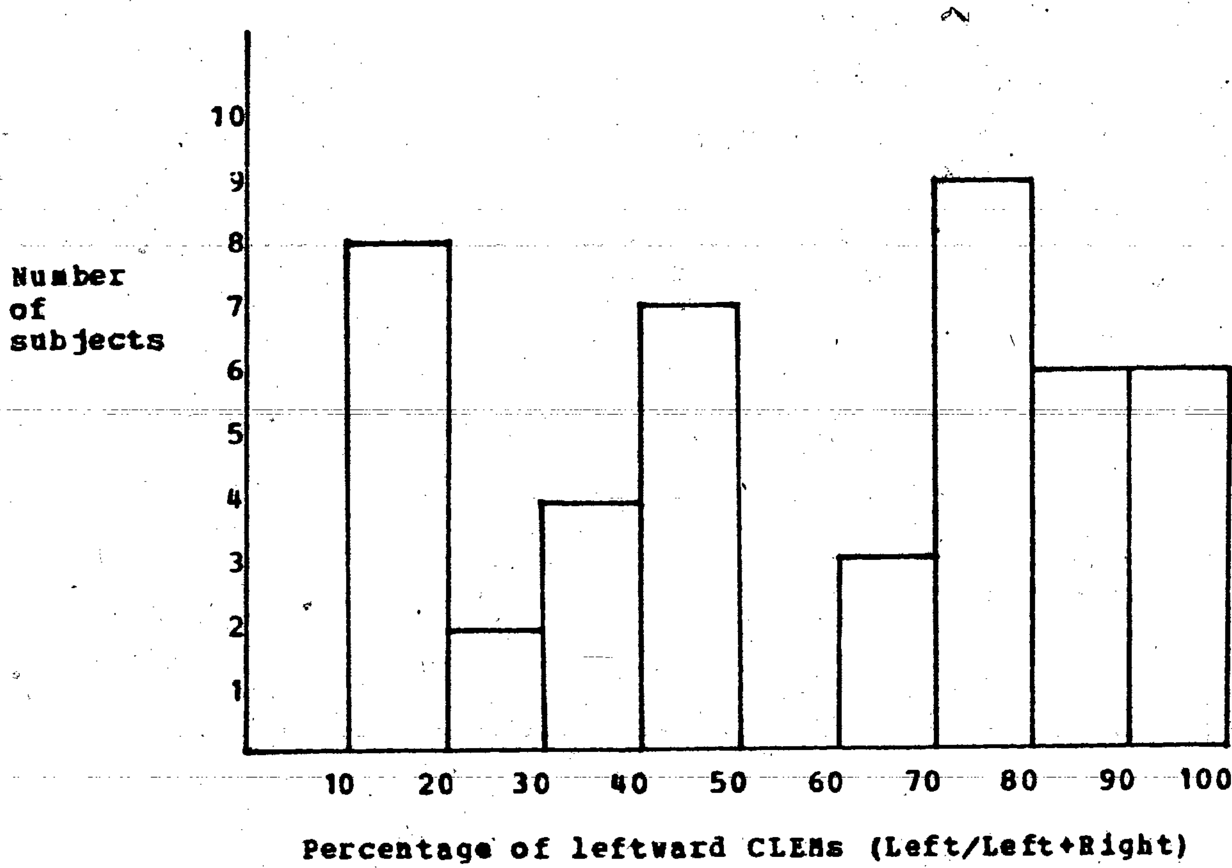
Order of Presentation

The initial analysis was to determine if the order of the perceptual tests affected subjects' performance. A Pearson's correlation between Order and P.O.T. Accuracy revealed no statistically significant effect ($r=-.10, p>.10$). Similarly, correlations between order and Street Gestalt accuracy ($r=.13, p>.10$) and P.O.T. response-time ($r=-.09, p>.10$) showed order of presentation to have no significant effect on perceptual performance. Therefore subjects in the two order conditions were considered together for all subsequent analyses.

Distribution of CLEM

The distribution of "left-moving" in this sample is presented in Figure 1. A preponderance of left-movers is evident. Defining a left-mover as one with more left than right eye movements, and conversely, there are 24 left-movers and 18 right-movers (3 subjects had equal numbers of left and right eye movements). This is consistent with previous studies in which a relatively greater number of left- than right-movers were found among college students in the Arts faculties (Bakan, 1969; Weiten and Etaugh, 1973).

Figure 1: Frequency distribution of CLEM.



Left-moving will be treated as a continuous variable in the correlational analyses to follow. This avoids the selection of an arbitrary cut-off point to distinguish "left-movers" from "right-movers", and allows a focus on CLEM variance within these groups.

CLEM and P.O.T. Performance

As there is evidence indicating sex differences in hemispheric function and in perceptual performance (Witelson,1977), the results of subsequent analyses are presented for males only, females only, and for all subjects combined. Correlations (Pearson's r) between left-moving and the perceptual measures are presented in Table 1. It is apparent from these results that CLEM is related to perceptual performance in the predicted manner.

The prediction was that left-moving would be associated with superior performance on the P.O.T. The correlation between left-moving and P.O.T. accuracy over all subjects is .29 ($p=.05$, two-tailed): for males, $r=.31$ ($p>.10$); for females, $r=.34$ ($p=.10$). A closer examination of the data shows that there is a significant association between left-moving and performance on Part 2 of the P.O.T. (overall $r=.33, p<.03$, two-tailed: for males, $r=.30$, $p>.10$; for females, $r=.41, p<.05$) and a marginally significant association on Part 1 (overall $r=.28, p=.06$,

Table I: Correlation of left-moving with perceptual measures.

	P.O.T. Accuracy	P.O.T. Response Time	Street Gestalt Accuracy
Males	.31	.32	.29
Females	.34	.35	.33
All	.29 *	.32 *	.30 *

* significant at the .05 level, two-tailed.

Table II: Correlation of left-moving with P.O.T. parts.

	Part 1	Part 2	Part 3
Males	.28	.30	.14
Females	.36	.41 *	.05
All	.28	.33 *	.09

* significant at the .05 level, two-tailed.

two-tailed: for males, $r=.28, p>.10$; for females, $r=.36, p=.08$). However, Part 3 shows no such association (overall $r=.09, p>.10$, one-tailed: for males, $r=.14, p>.10$; for females, $r=.05, p>.10$). While this suggests some essential difference between the first two parts and the third, no such distinction appears on examination of their intercorrelations (Table 3). Part 3 correlates .54 with Part 1 and .49 with Part 2; Part 1 and Part 2 show a correlation of .41.

Left-moving is significantly correlated with average response-time on the P.O.T. (overall $r=.32, p<.04$, two-tailed: for males, $r=.36$, $p=.10$; for females, $r=.35, p=.09$). Left-movers have a longer response-time. Had not the accuracy data demonstrated that left-moving accompanies superior performance, this would have been interpreted as counter to prediction. Given the accuracy data, one may interpret the response-time difference in several ways. It may be that left-movers are more accurate because they take more time to respond. This explanation is argued against by a lack of correlation between P.O.T. accuracy and response-time ($r=.05, p>.10$). Another explanation is that right-movers find the task more difficult, thus are more likely to respond impulsively: this also is argued against by the lack of correlation between accuracy and response-time. A final possibility is that left-movers respond more slowly quite independently of their superior performance on the task.

CLEM and Street Gestalt performance

The prediction that left-moving would be associated with superior performance on the Street Gestalt test is also borne out by the data in Table 1. Left-moving and Street Gestalt accuracy are significantly correlated (overall $r=.30, p<.05$: for males, $r=.29, p>.10$; for females, $r=.33, p>.10$). The Street Gestalt shows as much sensitivity to differences between left- and right-movers as does the P.O.T.

The P.O.T. and the Street Gestalt

The final prediction concerned the relationship between the perceptual measures. It was predicted that the P.O.T. and the Street Gestalt would show a moderate correlation due to a common reliance on the right hemispheric synthetic ability. The correlations between these tests are presented in Table 4. Contrary to expectation, the correlations between the tests fail to reach statistical significance (for accuracy, overall $r=.22, p>.10$, two-tailed: for males, $r=.26, p>.10$; for females, $r=.18, p>.10$). This indicates that any closure component in the P.O.T. is a small one. A closer analysis of accuracy on the P.O.T. (Table 5) shows that none of the parts have a statistically significant correlation with the Street Gestalt, over all subjects. Males and females show different patterns: for males, Part 2 shows a significant degree of association with the Street Gestalt ($r=.43, p=.05$); for females, none of the

Table III: Internal correlations of the P.O.T.

	Males		Females		All	
	Part 2	Part 3	Part 2	Part 3	Part 2	Part 3
Part 1	.33	.69 **	.45 *	.50 **	.41 **	.54 **
Part 2		.61 **		.40 *		.49 **

* significant at the .05 level, two-tailed.

** significant at the .01 level, two-tailed.

Table IV: Correlation of Street Gestalt accuracy with P.O.T. performance.

	P.O.T. Accuracy	P.O.T. Time
Males	.26	-.13
Females	.18	.03
All	.22	-.02

sections show much relation to the Street Gestalt. While this seems to reflect a sex difference in closure ability, the correlations between Street Gestalt and Part 2 accuracy for males and females are not significantly different (Fisher's $z=1.11$, $p>.10$). One may conclude from these data only that Part 2 of the P.O.T. is the most closure-related of the three parts.

Sex and Handedness

Correlations between these variables and left-moving are presented in Table 5. The five left-handed subjects were included for analyses involving handedness. There are no statistically significant correlations between right-handedness and left-moving (overall $r=.26$, $p=.08$, two-tailed; for males, $r=.34$, $p>.10$; for females, $r=.31$, $p=.10$). Table 6 presents the correlations between these variables and the perceptual measures: none of the correlations reaches statistical significance.

Table V: Correlation of Street Gestalt accuracy with P.O.T. parts.

	Part 1	Part 2	Part 3
Males	-.02	.43 *	.25
Females	.21	.09	.08
All	.14	.26	.16

* significant at the .05 level, two-tailed.

Table VI: Correlation of left-moving with handedness and sex.

	Handedness	Sex
Males	.34	
Females	.31	
All	.26	-.11

* significant at the .05 level, two-tailed.

Table VII: Correlation of perceptual measures with handedness and sex.

	Handedness			Sex
	Males	Females	All	
P.O.T. Accuracy	.21	-.09	.00	.21
P.O.T. Response Time	-.06	-.11	-.10	.01
Street Gestalt Accuracy	.20	.21	.12	.06

D. Discussion

Validation of the CLEM Laterality Model

The results of this study support Bakan's laterality model of the CLEM phenomenon. It has been demonstrated that preferred CLEM direction is related to performance of right-hemispheric perceptual tasks. As predicted, left-movers performed more accurately on these tasks than did right-movers.

It remains to be explained how it is that previous studies using right-hemispheric measures of spatial perception did not obtain similar results. It may be that the tests were not adequately sensitive, or that the CLEM groups actually do not differ in this aspect of right-hemispheric process. Resolution of this will require further investigation. However, it must be reiterated that the CLEM model does not predict that the CLEM groups will differ on all "hemispheric" measures, but that it will be possible to reliably demonstrate differences on some of these. Assuming that the present results can be reliably obtained, they offer support to the CLEM model. Perhaps the most persuasive aspect of this study is the incongruity of the independent and dependent measures. It is difficult to conceive of another explanation which would subsume events as disparate as direction of eye-movements and performance of perceptual tasks.

The finding that left-movers respond more slowly than right-movers to the stimuli of the P.O.T. is of doubtful relevance to the CLEM laterality model. As noted earlier, it cannot be interpreted as indicative of poor performance (the left-movers were more accurate), nor does it seem to be a cause or effect of the accuracy differences. The data suggest simply that left-movers respond more slowly, independently of their superior performance on the task. No clear prediction of response-time differences can be made by the model, unless response-time could be considered a measure of performance level.

One other study has compared the response-times of left- and right-movers. Croghan and Bullard (1975) examined latency of response to arithmetic problems, but found no difference between the CLEM groups. Obviously, no meaningful conclusion can be drawn from such limited evidence. It can only be suggested that further investigation be carried out to determine if CLEM is associated with response-time.

Comparison of the Perceptual Tests

Both the Street Gestalt and the P.O.T. have been proposed as indices of "appositional" right-hemispheric ability. It is thus informative to compare the results obtained with each of the tests.

The superior performance of the left-movers is manifest equally on the P.O.T. and the Street Gestalt test. Thus, the verbal component of the Street Gestalt (noted previously as a drawback of this test) did not reduce its sensitivity.

This suggests that either of these two tests would be appropriate measures of right-hemispheric ability. At the same time, it must be noted that there are situations in which the Street Gestalt might not be useful. For example, the verbal component of the Street Gestalt might pose a serious problem for brain-damaged subjects with aphasic symptomatology. In this case, the P.O.T. would be a more appropriate measure.

Although the predictions of the CLEM laterality model are supported, the two perceptual measures show only a slight correlation with each other. This is surprising, given the apparent similarity of the tests, their independent selection as measures of right-hemispheric perceptual/cognitive ability, and their similar performance in the present study. This result may be better understood by a closer examination of right-hemispheric cognition.

In previously considering the nature of right-hemispheric ability, it was proposed that it be defined by the "synthesis and utilization of perceptual/cognitive gestalts". The Street Gestalt clearly requires the synthesis of fragmented units into a meaningful gestalt (closure). The P.O.T. also presents fragmented patterns which must be synthesized into a perceptual gestalt. However, there is a further process required: the matching of the stimulus-pattern to a response-pattern. This latter process, the utilization of gestalt information to complete a pattern match, is an aspect of right-hemisphere cognition which is tapped only by the P.O.T. In fact, it may be that this is the major determinant of P.O.T. performance, with gestalt synthesis being of secondary importance. This would explain the observed results. As both tests are tapping the domain of right-hemispheric cognitive ability, they would both reflect differences in "hemisphericity". However, their respective focus on different components of this ability would explain their weak correlation.

Such a distinction between gestalt synthesis and utilization may be clarified via the cognitive factors model of Guilford (1967). He reviews cerebral lateralization research with reference to his model, and concludes: "the right hemisphere is associated with figural abilities or functions"(p.368). Within the figural area, he distinguishes the "Cognition of Figural Units" (i.e. closure) from the "Evaluation of Figural Units" (i.e. the comparison and matching of patterns). The Street Gestalt is primarily a measure of the former ability: it is here suggested that the P.O.T. is primarily a measure of the latter. As each of these is an aspect of "figural" ability, the tests would be expected to indicate right-hemispheric function.

Suggestions for Future Research

Validation of the CLEM laterality model might best be served by replicating the present result rather than attempting to demonstrate similar effects with other measures. The solid establishment of one such result would most powerfully support the model. The onus for those who consider the model untenable is to show that this result is not a reliable one or that it may be alternatively explained, rather than to discover "hemispheric" tests which do not discriminate the CLEM groups.

In fact, the author would recommend a greater emphasis on replication and consistent methodology in all laterality research. The present situation is one in which new experimental paradigms and measures are developed before old ones have been adequately explored. A wide acceptance of standard measures and methodologies would greatly facilitate the evaluation of theoretical issues.

Illustrative of such an approach is Bogen's proposed measure of hemisphericity, the A/P ratio, which compares an individual's ability on left- and right-hemispheric "marker" tests: the ratio is thus an index of one's relative ability in each of these hemispheric modes. The present study has utilized a similar approach: CLEM was validated via designated tests of "appositionality", including the one selected by Bogen.

The unique advantages of this approach may be elucidated via an analogy. The development of the standard intelligence-testing kit (eg.the WAIS) was a dramatic improvement over previous methods of intelligence assessment. Rather than having each investigator utilizing his/her own operational definition of intelligence, a standard set of operations was specified to measure intellectual functioning. It is worth noting that the theoretical definition of "intelligence" was not thereby made explicit: it remains a rather nebulous construct. Rather, a measure was developed which explicitly operationalized it, and which was validated by a combination of face (intuitive) validity and by its performance as a predictor. Similarly, the dimension of "hemisphericity" is a rather nebulous one. A measure is needed which will explicitly operationalize it, and which meets the requirements of face and predictive validity. The measures of right-hemispheric ability utilized in this study satisfy the former requirement: the present results begin to demonstrate their fulfillment of the latter requirement as well.

Finally, it is suggested that neurophysiological evidence may provide the most powerful validation of the CLEM laterality model. The model posits neurological events which connect the observed eye movements and the concurrent brain activity. Should it be possible to demonstrate lateralized neurophysiological events during CLEM behaviour, the model would be given firm empirical support. Detection of such lateralized brain activity might involve measurement of EEG, cerebral blood flow, or other such indices of hemispheric activity.

In conclusion, the validation of the CLEM laterality model requires evidence from the attentional, cognitive, and neurophysiological domains. The present study has reviewed the evidence from each of these, attempted to integrate them into a coherent body of research, and presented new evidence in the cognitive domain. While the question is far from settled, it is reasonable to expect that investigation of these domains with adequately sensitive instruments will determine the validity of the CLEM laterality model.

E. Appendices

Appendix A: The CLEM questionnaire.

1. What is the meaning of the proverb: a watched pot never boils.
2. What is the meaning of the proverb: it is an ill wind that blows no one good fortune.
3. Make up a sentence using two forms of the same verb.
4. Tell me two verbs beginning with "N".
5. What is the meaning of the proverb: a poor worker blames his tools.
6. Spell "therapeutic".
7. What is the meaning of the proverb: Call no man happy 'till he's dead.
8. List two adverbs.
9. What is the meaning of the proverb: Lend your money and lose your friends.
10. What is the meaning of the proverb: more than enough is too much.
11. List two prepositions.
12. What is the meaning of the proverb: words should be weighed, not counted.

13. What is the meaning of the proverb: he is rich who has few wants.

14. Define inflation.

15. What is the meaning of the proverb: a rolling stone gathers no moss.

16. Make up a sentence using two adverbs.

17. Tell me two verbs beginning with "R".

18. What is the meaning of the proverb: the hardest work is to go idle.

19. What is the meaning of the proverb: what saddens a wise man, gladdens a fool.

20. Define the word "economics".

Appendix B: The handedness questionnaire.

1. With which hand do you draw? Left; Right; Either.
2. With which hand do you write? Left; Right; Either.
3. With which hand do you remove the top card of a deck of cards in dealing? Left; Right; Either.
4. With which hand do you use a bottle opener? Left; Right; Either.
5. With which hand do you throw a baseball to hit a target? Left; Right; Either.
6. With which hand do you use a hammer? Left; Right; Either.
7. With which hand do you use a toothbrush? Left; Right; Either.
8. With which hand do you use a screwdriver? Left; Right; Either.
9. With which hand do you use an eraser on paper? Left; Right; Either.
10. With which hand do you use a tennis racquet? Left; Right; Either.
11. With which hand do you use scissors? Left; Right; Either.
12. With which hand do you hold a match while striking it? Left; Right; Either.
13. With which hand do you stir a liquid? Left; Right; Either.

14. With which hand do you carry your books or a book bag? Left; Right; Either.

15. Do you consider yourself: left-handed; right-handed; ambidextrous or mixed-handed?

Appendix C: The raw data.

Column 9-11: P.O.T. accuracy (Score/Maximum x 100).
Column 13-15: accuracy on P.O.T. parts (Part 1/Part 2/Part 3).
Column 17-19: P.O.T. average response-time (1/100 seconds).
Column 21-23: Street Gestalt accuracy (Score/Maximum x 100).
Column 25-28: Handedness (Right-Left/15 x 100).

Females: Order 1

010	080	096	989	765	085	+100
020	079	085	878	398	074	+093
030	080	085	887	962	081	+087
040	033	078	687	304	085	-087
050	088	100	999	320	085	+093
060	039	063	368	476	085	+093
070	045	096	899	251	081	+087
080	067	085	788	268	085	+093
090	061	093	889	437	063	-027
100	020	078	768	288	074	+007
110	013	078	678	322	067	+100
120	092	074	857	534	089	+087
130	050	081	868	370	085	+087
140	085	078	687	280	093	+086

Females: Order 2

150	050	093	979	380	096	+087
160	100	081	985	448	081	+080
170	035	074	866	186	089	+100
180	023	089	969	244	081	+100
190	100	089	978	353	089	+087
200	035	063	566	206	070	+073
210	030	081	886	514	081	-087
220	095	085	779	377	070	+093
230	090	081	778	233	096	+087
240	045	081	877	256	078	+073
250	044	074	767	263	085	+087
260	042	037	154	425	078	+087
270	050	093	979	518	078	-100
280	076	089	978	303	074	+093

Appendix C- continued.

Males: Order 1

291	074	078	867	335	085	+093
301	020	093	979	307	079	+087
311	093	093	988	427	085	+087
321	086	100	999	337	089	+093
331	000	081	778	451	089	-026
341	085	074	767	620	077	+100
351	015	078	867	344	081	+087
361	025	078	768	344	078	+080
371	071	089	888	355	089	+093
381	020	078	966	361	070	+087
391	043	093	979	293	078	+087

Males: Order 2

401	065	081	778	349	088	+080
411	035	096	989	310	071	+100
421	018	093	979	366	092	+073
431	075	093	898	317	093	+067
441	080	096	989	325	093	+093
451	013	078	687	286	096	+093
461	012	063	575	444	077	+073
471	069	100	999	591	074	+093
481	100	093	988	586	093	+080
491	074	070	757	344	078	+067
501	084	081	877	229	081	+067

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