NONLANGUAGE CEREBRAL MECHANISMS IN A VISUAL FIELD TASK

By

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In recent years, considerable literature has been devoted to laterality differences in visual perception. The basic rationale for these experiments is twofold. First, in vision, each visual half field (VHF) projects directly to the contralateral cerebral hemisphere. Second, clinical studies of brain-injured adults have demonstrated a dual functional asymmetry between the cerebral hemispheres in man, with the left hemisphere primarily subserving speech and language function, while the right hemisphere has been implicated in higher integrative nonverbal visual-spatial functions.

The demonstration and extension of these clinical findings, through examination of VHF asymmetries in normals, have been hampered by methodological inadequacies. Recently a new paradigm seemingly obviating these methodological shortcomings has been presented in two studies by Hines. This paradigm, incorporating the principle of simultaneity from the

previous approaches, has departed from them in two major ways. First, a new method to ensure macular fixation was devised. Second, a short-term memory variable was introduced.

The present study was designed to test the efficacy of the paradigm with a nonverbal stimulus, to investigate the type of errors made by the Ss, and to test what effect familial sinistrality had on these factors.

Fifty-one right-handed Ss were presented block design stimuli via a 16 mm. projector. Ten of these Ss were eliminated on the basis of their low performance level. The stimuli were presented 3° to the left or right of fixation. Fixation was maintained through sequential presentation and initial recall of four single digit numerals. The Ss were then required to identify the correct block design from a five-item multiple choice array. The array consisted of the correct choice, its lateral mirror image (LMI), its vertical mirror image (VMI), a different shaped design (DSD) occupying the same general area, and an unrelated design (URD).

A significant left visual field (LVF) superiority in terms of mean VHF differences ($F_{1,80} = 4.58$, $p \leq .05$) and the number of Ss with an overall LVF superiority werefound ($X^2 = 14.9$, $df = 1$, $p \leq .001$). Familial sinistrality was found to have no significant effect on the mean VHF differences.

The types of errors made on missed trials were found not to be distributed randomly ($X^2 r = 17.28$, $df = 3$, $p \leq .001$). There were more LMI and fewer URD type errors than there were VMI or DSD types.

Significantly more URD errors were made in the right visual field (RVF) than in the left ($Z = 2.03$, $p \leq .025$).

Those Ss with a positive history of familial sinistrality made significantly more VMI type errors ($Z=1.86$, $p \leq .05$) and significantly less URD type errors ($Z=2.02$, $p \leq .025$) than the other Ss.

The present findings, through demonstration of a LVF superiority for a nonverbal stimulus, lend support to the feasibility of the use of normal Ss to demonstrate brain laterality difference, and demonstrate the efficacy of a new technique.

The lower incidence of URD errors in the LVF provides evidence not only for the role of the right cerebral hemisphere in the processing of nonverbal stimuli but also for the viability of using types of errors to provide information about cerebral function. Thus, the lower rate of URD type errors related to a positive history of familial sinistrality suggests the possibility of a more diffuse cortical representation for nonverbal function in those Ss.

While the results offer a new contribution to our knowledge of brain-behavior relations, their primary significance relates to the viability of these new methodologies.

INTRODUCTION

The specialization of speech and language functions in the left cerebral hemisphere in man has in recent years focused attention on the role of other higher integrative functions which may be mediated by the right cerebral hemisphere. Clinical studies, using heterogeneous brain-injured populations, have suggested that the right cerebral hemisphere may be dominant for special visual-spatial functions (Teuber, 1962). Unfortunately, many of these studies are fraught with methodological problems (e.g. lesion specificity and variability, age, I. Q., and edema effects) which tend to obscure possible brain-behavior relationships. In an attempt to control for these methodological considerations the use of normal Ss to investigate brain-behavior relations has proliferated. A principal approach has been the use of laterality differences in visual perception as an indicant of underlying cerebral hemispheric differences. However, the use of normal Ss has introduced new methodological difficulties (principally habitual directional scanning effects and uncontrolled eye movements) which have again obscured possible brain-behavior relationships.

If these methodological considerations do tend to obscure the results, why bother to use the visual system? The primary advantages of the visual modality for investigation of laterality differences lie in the potential range of stimuli that may be investigated, the division of each retina allowing specificity of the hemisphere to which the material is projected, and the direct connections between the visual half fields (via crossed and uncrossed pathways) and the contralateral cerebral hemisphere.

The present paper shall present a rationale for a new methodological approach to the question of right cerebral hemispheric function. This rationale will be expurgated through a review of relevant clinical, experimental, and theoretical papers.

Two primary methodologies have been used in the visual research. The first, historically, was sequential tachistoscopic presentation (Type I) of verbal and nonverbal materials in the left (LVF) and right (RVF) visual fields. The second approach (Type II) has involved simultaneous presentation of disparate stimulus pairs to the visual half fields (VHF).

The Type I approach, in which Ss attend to a fixation point with the stimulus materials presented a few degrees of visual angle to the left or right of the fixation, has resulted in a predominant RVF superiority for verbal materials (White, 1969). The primary explanation for these findings has been that the RVF has more direct connections to the language centers in the contralateral left hemisphere. This finding would seemingly demonstrate, in normals, the efficacy of the technique and the predominant role of the left hemisphere in verbal processing. Unfortunately, the value of these results is called into question by the failure to demonstrate a corresponding LVF superiority for nonverbal materials. The major demonstration, within the technique, of a LVF superiority for "nonverbal materials" was by Kimura (1966). Attempts to replicate this finding have either failed (Kinsbourne, 1970) or been demonstrated only under special conditions (Van Nostrand, 1970).

Indeed, it has been questioned whether the task itself, enumeration of dots, constitutes a nonverbal task.

The Type II design, simultaneous visual half field stimulation, was based conceptually on analagous research in audition and on results obtained from some clinical lesion groups. The clinical studies found that patients with lesions of, for example, the right parietal lobe, would, under simultaneous stimulation, often fail to report the stimulus that was going to the right hemisphere (Teuber, 1962). As these patients were fully capable of responding to sequential stimulation it was reasoned that in the simultaneous condition somehow the "weaker" processor fails to respond or responds inadequately to the incoming signal. Demonstration of the phenomenon is then dependent on a "weaker" processor and the stimulus condition of the simultaneous presentation. This phenomenon, the extinction effect, has been demonstrated in all sensory modalities and is routinely used in the screening of patients for cerebral insult. It would then be expected, if in normals there are functional differences between the two cerebral hemispheres, that the simultaneous condition would tend to accentuate this difference. Indeed, this was found in the auditory research (Kimura, 1967; Satz, 1968). Simultaneous presentation of disparate auditory information resulted in a clear cut difference in accuracy of recall between the two ears. That is, when verbal materials were presented simultaneously to both ears in normal right handers, a significantly greater amount of the information that was presented to the right ear was recalled correctly. The Kimura (1967) study further demonstrated that when nonverbal materials (melodic patterns) were presented simultaneously to the two ears a significantly greater amount of the material presented to the left ear was recalled correctly. With the application of the simultaneous technique in audition we then find clear cut differences between the two ears (cerebral hemispheres), dependent upon type of stimulus materials, that have not been seen with sequential presentation (Kimura, 1967). The direct extension of the simultaneous technique to vision was not, however, particularly fruitful in the elucidation of underlying cerebral hemispheric differences. Almost invariably a LVF superiority has been found for verbal materials. This is directly counter to any central nervous system (CNS) hypothesis (White, 1969). This predominant LVF superiority for verbal materials has been primarily explained as due to the directional scanning effects (Heron, 1957), selective training of the right hemiretina (Orbach, 1967), and the intrinsic directionality of the stimulus (Orbach, 1967). Aside from these artifactual elements producing differences between the visual and auditory research another major difference is apparent. That is, the auditory research typically presents three to four digit pairs per trial thus introducing a short term memory (STM) variable that has typically not been a factor in the visual studies.

In an attempt to control for these factors and to introduce a STM variable, a new methodological approach (Type III) has been developed. While incorporating the principle of simultaneity from the Type II design, the Type III design deviates otherwise by ensuring more adequate control of macular fixation and by including an STM component. This approach has demonstrated, within a STM paradigm, a significant RVF superiority for verbal stimuli (Hines et al., 1969; Hines and Satz, 1970). Further, this RVF superiority was observed in over 80% of the right handed Ss that were tested. It remains to be seen, however, whether this technique is superior to the previous methodological approaches, as the demonstration of a RVF superiority for verbal materials is but half the task. Within this methodology a LVF superiority for nonverbal materials must also be demonstrated before its value in exploring functional cerebral laterality differences may be adequately assessed. The present study is designed to test the efficacy of this new paradigm for nonverbal materials.

From the above decision three immediate questions arise. What type of nonverbal materials should be used? How does one measure the performance of the Ss? Is it possible within the STM paradigm to demonstrate a LVF superiority for nonverbal stimuli? Each of these questions, of course, rests on the separate and more general assumption that the right cerebral hemisphere is differentially specialized for "nonverbal-spatial" functions.

Previous experimental and clinical literature can provide some guidelines for the type of nonverbal material used. The first criterion as negatively demonstrated by the Kimura (1966) study, is that other investigators should be in agreement that the stimuli are indeed nonverbal. The second guideline is provided by the research of Bryden and Rainey (1963), Wyke and Ettlinger (1961), and Glanzer and Clark (1964).

The first two experiments demonstrated that the use of highly familiar objects produces a RVF superiority. This RVF superiority is probably due to the Ss verbally identifying the stimulus, thus producing primarily a language mediated response for this obstensibly nonverbal task. Clinically, Kimura (1963) has further demonstrated the importance of the familiarity-nonfamiliarity dimension. In this study, using left and right temporal lobectomy patients, she found inferior performance for the right lobectomy patients (compared to the left lobectomy patients) on an overlapping nonsense figures recognition test, while the converse was seen on a familiar overlapping figures test. The Glanzer and Clark (1964) study suggests further that Ss often verbally encode the visual stimuli in "nonverbal visual memory" tasks. Therefore, the second guideline is that the nonverbal stimuli should be unfamiliar and not readily accessible to verbal codification.

An appropriate type of design matching the above criteria is the block design. Historically, block designs of varying complexity have been used in the detection of general non-specific cerebral insult (Satz, 1966). More recently, it has been shown that lesions invading the right cerebral hemisphere differentially impair performance on block design tasks (Parsons, 1970). It has also been demonstrated that patients with split brains (callosal disconnection) are able to construct design patterns significantly better with their left hands, presumably because of the "dominance" of the functions in the contralateral right hemisphere (Gazzaniga, 1967). Block designs have the advantage of professional accord with respect to their nonverbal loading and as stimuli represent objects low in familiarity. Technically, they provide the additional advantage of being a standard size stimulus of which specified manipulations may be made. How, then, using block design stimuli, can one measure the Ss performance? Three possible alternatives would appear to be available; recall expressed by describing the stimulus, recall expressed by drawing the stimulus, and finally, recall demonstrated through correct identification of the stimulus from a multiple stimulus array. The first alternative, through measuring a verbally encoded response, would defeat the purpose of or bring into question the value of the study. Requiring the Ss to draw the stimuli suffers from a number of drawbacks, the principal ones being the introduction of a subjective scoring element and the time consumed in drawing the stimuli. The third alternative is preferable as it interferes least with the non-verbal quality of the task, provides an objective scoring technique, and allows for investigation into the types of errors made when the correct stimulus is not identified.

Relatively uninvestigated, particularly with regard to the influence of functional cerebral laterality differences, is the question of what types of errors Ss make when they are wrong. That is, will different errors be made depending on the visual field to which the stimuli are presented? Are particular types of errors more common across visual fields than other types? Some suggestions as to possible factors to investigate are provided by the studies of Noble (1968), Goodnow (1969), and Mello (1965).

Noble (1968), using primates in the Wisconsin General Test Apparatus (WGTA), has investigated some of the possible types of errors. In this study, optic chiasm sectioned monkeys had one eye occluded and were trained on a two choice angular discrimination. The nonreinforced element of the discrimination was either a lateral mirror image (LMI) or a vertical mirror image (VMI) of the reinforced stimulus. In this condition, due to the chiasm section, one cerebral hemisphere receives direct visual input while the other receives visual information indirectly via the corpus callosum. After demonstrating that the discrimination had been learned, he then reversed which eye was occluded and, thereby, which hemisphere received direct visual stimulation. He found that the nonreinforced LMI was responded to at a higher level than the previously reinforced stimulus. Thus, the information which was transmitted via the corpus callosum during the training trials resulted in an orientational "confusion" of the correct stimulus during the test trials. This effect was not seen with the VMI.

Similarly, Mello (1965) found, after training pigeons on an angular discrimination with an opaque goggle over one eye, that upon switching eyes the pigeon responded maximally to the LMI of the reinforced stimulus. Goodnow (1969) and Boone and Prescott (1968) have reported in children that discrimination of changes in the vertical direction are easier than changes in the horizontal direction.

Finally, the misperceptions of the LMI and VMI as the correct stimulus are common errors in children learning to read (e. g. reporting or writing b for p (VMI) or d (LMI)).

The LMI and VMI errors both represent errors of direction (orientation). That is, the shape of the stimulus is preserved, but the directionality (angulation) of the stimulus is lost. This suggests, as does the research of Hubel (1963), that, possibly, the shape and direction of a stimulus are dissociable elements of the total perception. Hubel (1963) has demonstrated, in the cat, with single cell recording from the visual cortex, that there are cells that respond maximally to the shape of the stimulus while others respond maximally to its orientation. Thus an additional possible error is to correctly perceive the orientation (direction) of the stimulus and yet to have an incorrect perception of its shape. To test for this error it is necessary to have a different shaped design (DSD) occupying the same general area.

Two principal theories are relevant to the basic question of whether, within this paradigm, a LVF superiority for nonverbal materials can be demonstrated. Both theories (Kimura, 1966; Kinsbourne, 1970) are in agreement that in normal right handers language is predominately represented in the left cerebral hemisphere and that the right hemisphere plays a major role in nonverbal visual-spatial tasks. Kimura's (1966) theory further proposes that stimulus input transmitted on the most direct pathway will better maintain the integrity of the stimulus signal and will therefore be more efficiently processed. Her theory then predicts, barring artifacts of technique, a LVF superiority for non-verbal materials and a RVF superiority for verbal materials. Kinsbourne (1970) has recently proposed an alternative model: If a subject is engaged in language behavior, prior or during a test trial, a left hemispheric activation will take place and that accompanying this will be a directional bias to the RVF regardless of the nature of the stimulus input (e. g. verbal or nonverbal). "Such orientation will characterize not only overt language use, but also covert (subvocal) language behavior, including the state of expectancy to verbal response." His theory thus predicts that, as long as the left cerebral hemisphere is activated by any language behavior, verbal and nonverbal materials will be more accurately responded to when they are in the RVF.

An additional separate variable relevant to the basic assumption that the right cerebral hemisphere is "dominant" for nonverbal functions is the possibility of differences in the degree of cerebral lateralization of function in the Ss.

Clinical studies by Subirana (1958) and Zangwill (1960) have found, following cerebral insult, a more rapid remission of aphasia in right-handed patients with left-handed relatives. This finding suggests the possibility of a more diffuse representation of cortical function in those right-handed subjects with a positive family history (+FH) of left-handedness. Indeed, Hines and Satz (1970) have demonstrated, using the Type III design with verbal materials, a difference in VHF performance between those Ss with a +FH of left-handedness and those Ss with a negative family history (-FH) of it. This difference, an attenuation in the RVF asymmetry (i. e. superiority) in +FH Ss, is suggestive of a difference in degree of cerebral lateralization. A preliminary investigation of the influence of this factor on nonverbal materials will be included in this research.

The present experiment is designed to investigate the following questions. Will recall accuracy for nonverbal materials be influenced by the VHF to which the stimulus is presented? Are some type errors more common than other error types? Will right-handers with a +FH of left-handedness perform differently than right-handers with a -FH of left-handedness? That is, will the +FH Ss perform differently in regard to either VHF asymmetry or types of errors made?

METHOD

Subjects

Fifty-one right-handed Ss from introductory Psychology classes were used. The ages of the Ss ranged from 17 to 30 years with a mean age of 20.14 years. No Ss were used whose visual acuity was not at least 20/40 or who had a discrepancy of more than 1/2 minute of visual arc between the eyes. Visual acuity was established through use of a Snellen Eye Chart.

Materials

The stimuli were presented via a 16 mm. Kodak Analyst Projector onto a rear-view screen. The stimuli were presented at about eye level. All Ss had their heads positioned on a commercial chin rest. The test film was administered in a dimly illuminated room with a single light source directly behind the projector.

Procedure

All Ss were given a self-administered handedness questionaire. They were then screened for visual acuity and finally viewed the test film.

The test stimuli consisted of 56 trials with 4 numbers and 1 block design per trial. These numbers were the single digits 0 through 9. No number appeared more than once in a trial. At the beginning of each trial a central fixation point appeared for 606 msec. followed sequentially by the 4 digits at fixation with the block design appearing either to the left or right of the fixation digits. The exposure time for each digit was 182 msec. (no interstimulus interval). The block design was projected 3^{o} from the fixation numerals for a total exposure time of 606 msec. Each digit subtended approximately 45' of visual area in height and 30' in width. The block design subtended approximately 90' of visual area in height and 60' in width. The first digit of the sequence preceded the onset of the block design by 60.6 msec. with the last digit remaining on the screen 60.6 msec. after the block design was no longer present. This was done to insure initial fixation and to reduce shift in fixation from the last digit over to the block design. A between trials interval of 10 seconds was used, during which the Ss reported the digits from the preceding trial (fixation control) and then identified the design (dependent variable) from a 5 item multiple choice array. The 5 item multiple choice array consisted of the correct choice, its lateral mirror image (LMI), its vertical mirror image (VMI), a different shaped design (DSD) occupying the same general area, and an unrelated design.[1]

The first 12 trials were practice and included 6 trials in which the block design was in the LVF and 6 in the RVF. Of the remaining 44 trials, 10 were not included in the investigation of error types as it was not possible to make all the error types for those designs. There were 5 of these trials in each visual field.

If, on any trial, the center fixation digits were not reported correctly, the identification of the design was not subsequently counted. The Ss were told to respond to every trial whether or not they knew the

[1] See Appendix 1 for example.

correct response. A criterion of 23% correct (3% above chance) was chosen for inclusion in the study. Ten Ss were eliminated on this criterion. With the exception of their poor performance, they were not distinguishable from the other Ss.

Design Rationale

This paradigm, developed by Hines et al. (1969) and modified for this study, provides two major advantages over the previous approaches. (1) It insures fixation which the Type I and Type II designs could not adequately provide. (2) It utilizes STM processes which, in audition, have uncovered the most striking asymmetries. Finally, this modification offers a direct and timely test of Kinsbourne's (1970) model which predicts that verbal processing during or before a test trial will result in a directional bias to the RVF.

RESULTS

Recall by Visual Half Field

These analyses represent the major test of the present thesis. The first was concerned with the magnitude of the mean differences between the RVF and LVF. The second dealt with the directional frequency differences in recall between the VHFs among the Ss. The mean correct recall for designs in the RVF and LVF is presented in Table 1. An Analysis of Variance (Winer, 1962) based on the combined group of Ss revealed a significant LVF superiority ($F_{1,80} = 4.58$, $p \leq .05$).[1] The designs in the LVF were reported correct more often than those from the RVF in 33 of the 41 Ss. This frequency difference was significant ($\chi^2 = 14.9$, $df = 1$, $p \leq .001$).

VHF Recall by Family History

Inspection of Table 1 reveals that family history of left-handedness had no significant effect on the mean VHF differences.

VHF by Error Types

The following analyses were computed to see if error types were distributed randomly and if presentation of the stimulus to a particular VHF produced a difference in the relative incidence of the error types. Figure 1 presents a breakdown of types of errors made on missed trials. A Friedman Analysis (Hays, 1965) of the data revealed that the error types were not distributed randomly ($Xr^2 = 17.28$, $df = 3$, $p \leq .001$).

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1 See Appendix 2 for Summary Analysis of Variance.

Inspection of the figure reveals there were more LMI and fewer URD errors than there were VMI or DSD type errors.

The effect on error types of the VHF to which the design is presented is shown in Figure 2. The significance of the differences between the VHFs for the LMI errors and the URD errors was tested with the Wilcoxen Test for Matched Samples (Hays, 1965). The results of the first analysis for the LMI error type were nonsignificant ($Z = .45$, $p \leq .33$). The difference between the VHFs for the URD error type was significant, ($Z = 2.03$, $p \leq .025$).

Error Types by Family History

The difference in error types made by +FH *Ss* and -FH *Ss* is presented in Figure 3. The difference in incidence of VMI error types and URD error types between the two groups of *Ss* was examined with the Mann-Whitney Test (Hays, 1965). The VMI error was found to occur significantly more often in the +FH *Ss* than in the -FH *Ss* ($Z = 1.86$, $p \leq .05$). The URD error occured significantly less frequently in the +FH *Ss* than in the -FH *Ss* ($Z = 2.02$, $p \leq .025$).

TABLE 1

Mean Correct Recall by Visual Fields and Familial Handedness

	Left Field	Right Field
-FH (n 32)	13.06 (59.36%)	11.28 (51.27%)
+FH (n 9)	13.55 (61.59%)	11.66 (53%)

FIGURE 1

Distribution of Error Types

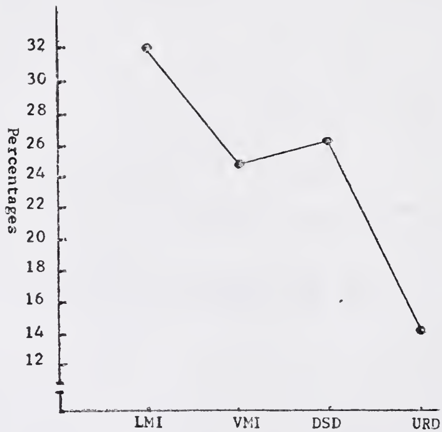
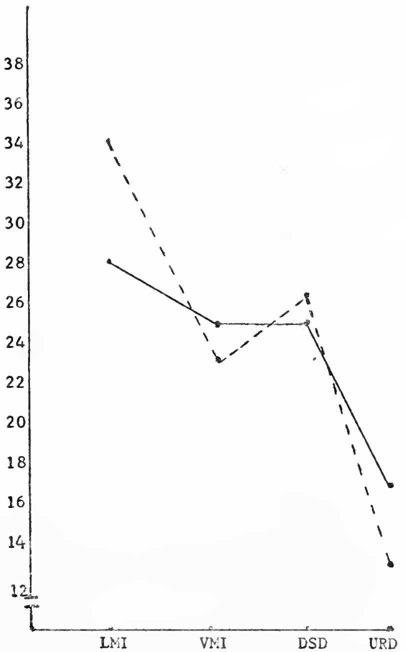


FIGURE 2

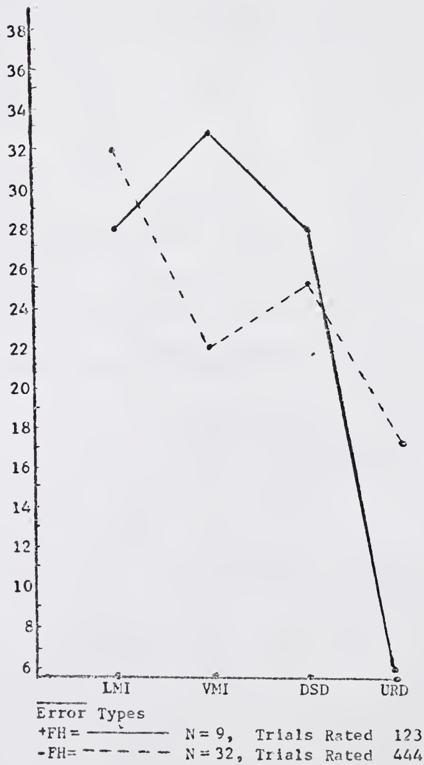
Percent Error Types by Visual Field



Error Types
Right Field = ——— N = 41, Trials Rated 295
Left Field = ------ N = 41, Trials Rated 272

FIGURE 3

Familial Handedness by Error Types



DISCUSSION

The present findings confirmed the hypothesis that recognition of nonverbal visual designs is facilitated by side of VHF input. Visual designs presented to the left VF were more accurately recognized than those presented to the right VF. This directional asymmetry, moreover, was observed in over 80% of the Ss. The fact that a reversal in the VHF asymmetry has been long reported for verbal stimuli (Kimura, 1966) strongly suggests that brain laterality mechanisms probably underlie the VHF asymmetry. This superior recognition for design patterns presented to the left VF suggests that the right cerebral hemisphere may be differentially specialized for processing visual-spatial information. Clinical studies on brain injured patients have already suggested this possibility (Milner, 1967).

This experiment, with the presentation during the test trials of the fixation digits, would appear to have been an ideal test of Kinsbourne's (1970) theory of VF asymmetries. His theory predicts a RVF superiority regardless of the nature of the VHF stimuli (verbal or nonverbal) whenever the subject is engaged in verbal activity concurrent with or immediately preceding the test trial. The LVF superiority seen in this study would then appear to disconfirm Kinsbourne's theory at least in its present form. It is, of course, possible that in the absence of adequate control of central fixation, Kinsbourne's theory would be maintained. A review of the evidence offered by Kinsbourne suggests that indeed this may be the case.

The failure to find a statistically significant difference, in terms of VHF recall, between those Ss with a +FH and those with a -FH, is at variance with the Hines and Satz (1970) study. That study, using the Type III design with verbal materials, found a decreasing difference between the two groups as the difficulty level of the task increased. At the speed of 177 msec. per digit pair they found no difference between the groups. It may be that the difficulty level, for nonverbal materials, in this study was similar to that of the Hines and Satz (1970) study with verbal material at its faster speeds. Alternatively, it may be that the influence of familial sinistrality upon cerebral lateralization of nonverbal function is more subtlely felt than are differences in degree of language lateralization. Consonant with this hypothesis is the difference in types of errors made by the two groups. A significantly lower incidence of URD errors among the +FH as compared to the -FH group is suggestive of the possibility of a more diffuse representation for nonverbal function in the +FH group. That is, the URD error is the only error that has no relationship to the original stimulus. Thus, when that error was committed no portion of the stimulus gestalt was utilized. This implies that the +FH group was able to utilize more consistently at least a portion of the stimulus gestalt. The greater incidence of VMI errors in the +FH group suggests that the more diffuse representation seen in this group is primarily related to some "recognition of shape" function rather than a directional or orientational factor.

The finding that the LMI error was the preferred error for all Ss supports the infrahuman research findings of Noble (1968) and Mello (1965). The demonstration, within this study, of a higher rate of LMI type errors does not represent a new discovery about humans. This, however, is the first study of types of errors made within the visual field research. The mechansim predisposing species ranging from humans to pigeons for this type error remains obscure. Speculatively, it is as if the synaptic signal for direction in the vertical dimension is somehow "weaker" or more tenuously linked to the total. We do know that in ontology discrimination in the vertical dimension is slower to develop and more difficulties are experienced with this dimension than with the horizontal dimension (Boone and Prescott, 1968). The lower incidence of URD errors, the error with no relationship to the stimulus, emphasizes that Ss, even when they do not correctly identify the stimulus, still have processed part of the stimulus gestalt. That is, if the Ss had no information about the stimulus, then the rate of response to the URD error should have been the same as that of the DSD and VMI type error.

This study represents the first investigation of the influence of the VHF upon types of errors made. The significantly lower incidence of URD errors in the LVF thus provides evidence not only for the role of the right cerebral hemisphere in the processing of nonverbal stimuli but also for the viability of using types of errors to provide information about cerebral function. Thus, even in the absence of a demonstrable LVF superiority for block designs, this evidence, that the Ss were able to utilize more of the stimulus information from the LVF, would have, alone, been indicative of the predominant role of the right hemisphere in nonverbal function.

This study, representing the fruition of several years of collaborative research, has demonstrated two new methodological breakthroughs in the investigation of cerebral laterality differences. While the results offer a new contribution to our knowledge of brain-behavior relations, their primary significance relates to the viability of these new methodologies. Thus, while the demonstration of a LVF superiority for a nonverbal stimulus represents the first unequivocal visual research showing the unique functional specialization of the right hemisphere in processing nonverbal stimuli in normal adults, its value is overshadowed by the potential contribution that this paradigm (Type III) offers in the study of cerebral mechanisms in perception. Similarly, the new information about brain function garnered through investigation of the types of perceptual errors has less significance as new data than it does as a demonstration of the feasibility of this approach to the question of cerebral laterality.

The potential extentions of these techniques to the investigation of cerebral laterality differences in normals are myriad. For example, through examination of the types of errors it would be possible to investigate the relative contribution of the orientation and shape of the stimulus to the gestalt and to assess the relative contribution of these two factors depending on the VHF in which the stimulus is presented. We have completed a preliminary investigation, using the Type III design with normal right-handed Ss, that demonstrated, in a single experiment, a dissociation between the VHFs for verbal and nonverbal stimuli between Ss. Currently we are attempting to demonstrate this VHF dissociation for verbal and nonverbal materials within Ss and to investigate the relative influence of varying degrees of left-and right-handedness on VHF performance. The role of familial history of left-handedness on performance is also being investigated in the current study. Projected future studies involve variations in the stimulus input and extension into new modalities.

The Type III design is, at present, the only approach with normal right-handed Ss in which a RVF superiority for verbal materials (Hines et. al., 1969) and a LVF superiority for nonverbal materials has been reliably demonstrated. These findings are thus consonant with empirical findings on hemispheric asymmetry in brain injured patients. The major factors unique to this design and, thus, probably responsible for the results, involved control of macular fixation, the introduction of a short term memory variable, and the fact that the experimental conditions were more analogous to a sensory overload situation than to a sensory threshold situation with its possible peripheral sensitivity factors.

SUMMARY

The present study investigated, through the use of two new methodologies, VHF recall and error differences to block design stimuli. Fifty-one right-handed Ss were tested, of which 10 fell below a 23% cutoff point (3% above chance) and were eliminated. These Ss did not fall into any definable group. The block designs were presented, via a 16mm. projector, 3° to the left or right of fixation. Fixation was maintained through sequential presentation and initial recall of 4 single digit numerals. The Ss were then required to identify the correct block design from a 5 item multiple choice array. A significant LVF superiority was observed. This finding casts doubt on Kinsbourne's activation theory of VHF asymmetries.

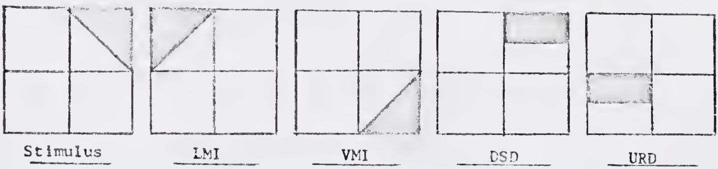
The types of errors made by the Ss were also analyzed. This analysis revealed that the majority of errors represented reversal orientations of the original stimuli. Further analysis of the error types revealed an effect attributable to the VHF to which the stimulus was presented and an effect due to familial history of left-handedness. Familial history of left-handedness was found to have no effect on the recall scores of the Ss.

The significance of these methodologies for the assessment of cerebral laterality mechanisms was discussed.

APPENDICES

APPENDIX 1

STIMULUS AND ERROR TYPES EXAMPLE



APPENDIX 2

SUMMARY ANALYSIS OF VARIANCE

Source	SS	df	ms	F
Method	66	1	66	4.58*
Error	1152	80	14.4	
Total	1218	81		

* $p \leq .05$

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BIOGRAPHICAL SKETCH

Bruce John Schell was born August 6, 1943, in El Paso, Texas. He graduated from Las Cruces High School in Las Cruces, New Mexico, in June, 1961. He obtained a Bachelor of Arts degree, majoring in Psychology, in June, 1966, from New Mexico State University. In June, 1968, he received a Master of Arts degree, with a major in Clinical Psychology, from the University of Florida.

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This dissertation was prepared under the direction of the chairman of the candidate's supervisory committee and has been approved by all members of that committee. It was submitted to the Dean of the College of Arts and Sciences and to the Graduate Council, and was approved as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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