HEMISPHERIC FUNCTIONAL ASYMMETRY AND LATERAL DIFFERENCES IN GALVANIC SKIN RESPONSE

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Thesis presented to the School of Graduate Studies of the University of Ottawa as partial fulfillment of the requirements for the degree of Master of Arts

Ottawa, Canada, 1975

ACKNOWLEDGEMENTS

This thesis was prepared under the supervision of Dr. William Barry, Chairman of the Department of General-Experimental Psychology of the Faculty of Psychology of the University of Ottawa. The writer gratefully acknowledges his interest and assistance throughout the study.

The author also wishes to thank Mr. Edwin Achorn, Senior Technical Officer of the Faculty of Psychology for his technical assistance in systems engineering and computer analysis; and Mr. Wayne Helfrich and Mr. Bayne Logan for their help in procuring subjects for the study.

CURRICULUM STUDIORUM

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INTRODUCTION

The investigation of hemispheric functional asymmetries has progressed considerably since Broca's post-mortem discovery of a left hemisphere lesion in an aphasic patient. Clinical observations of language deficits in patients with left hemisphere damage and of perceptual deficits in cases of right hemisphere dysfunction have generally been supported by the findings with split-brain subjects and psychometric data from brain damaged samples. More recently, experimental results with normal subjects using dichotic listening and visual tachistoscopic presentation techniques to ensure stimulus delivery to a selected hemisphere, have confirmed this basic functional asymmetry.

The following study addresses itself to the question of whether differential hemispheric involvement in the processing of in-coming tachistoscopically presented visual stimuli may be related to a physiological index, the galvanic skin response (GSR). The GSR has, until the last two decades, been regarded as a unitary manifestation of physiological arousal. The discovery that electrodermal events recorded simultaneously from left and right body sides may differ in both amplitude and latency of response has led to speculation concerning the significance of these differences. Since the GSR is known to be under considerable cortical control, the possibility arises that lateral differences may represent an important behavioral sign reflecting differential hemispheric engagement in cognitive activity.

In this study, subjects are randomly assigned to one of six experimental treatments according to the type of stimulus presented and the visual field of presentation. Two types of stimuli are employed, and these are cautiously labelled as verbal and nonverbal. Three loci of presentation are the right, left, and center visual fields, with their target delivery areas being left, right, and both hemispheres, respectively. Simultaneous and independent recording of basal resistance and changes in basal resistance from right and left palmar sites is maintained over a series of twenty trials per subject and responses are quantified in resistance, conductance, and change in log conductance. The study addresses itself, first to the existence of lateral electrodermal response differences, and secondly, to the interaction of these differences with stimulus type, and visual field of presentation (hemisphere of stimulation).

The first chapter begins with a presentation of relevant findings of hemispheric functional differences with split-brain and brain damaged samples. Following this is a review of supportive findings with normal samples using the dichotic auditory and visual hemifield techniques as a means of routing stimuli to a single hemisphere. Finally, pertinent information on the galvanic skin response is put forth, with particular emphasis on findings of lateral differences. A summary and statement of the basic hypothesis concludes the chapter.

Chapter two presents the methodology of the experiment. First, a description is given of the subject sample used in the study, followed by an account of the preparation of the experimental stimuli and the apparatus used in stimulus presentation. Next, the technique used in recording the GSR is described followed by the presentation of the experimental design and method of statistical analysis. Chapter two concludes with a statement of the specific null hypotheses to be tested.

The third chapter contains the results of the analyses of the physiological and other subject data. This is followed by a summary and discussion of the results and a consideration of possible avenues for future research.

CHAPTER I

REVIEW OF THE LITERATURE

This chapter presents a discussion of the research findings and various theoretical issues which led to the hypotheses to be tested in this study. Section one introduces the concept of hemispheric specialization as it has evolved from observations and investigations of brain damaged and split-brain patients. Section two relates the extension of these findings in experimental studies of normal subjects and presents the rationale underlying the choice of a stimulus presentation technique and the experimental stimuli used in the present investigation. Finally, the third section introduces the physiological measure of interest, the galvanic skin response, and reviews findings relevant to the bilateral recording of this index. The chapter concludes with a summary of the ideas presented and a statement of the basic hypothesis to be tested.

1. Hemispheric Specialization

The essentially symmetrical structure of the nervous system which characterizes most animals extends in mammals to the most highly developed brain structures, the cerebral hemispheres. Peculiar to man, however, is the asymmetrical assignment of certain functions to a particular hemisphere, and the contralateral connections which predominate between each hemisphere and the opposite body side.[1] As early as the time of Hippocrates clinical observations were recorded of correlates between unilateral head wounds and contralateral convulsions, between temporal lesions and contralateral hemiplegia, and between right hemiplegia and aphasia.[2] It was not until 1861, however, that Broca introduced the idea of localization of function with his discovery of left hemisphere lesions in an aphasic patient.

By 1865, it had been established that corresponding lesions in the right hemisphere did not interfere with language abilities.[3] Specialization of the left hemisphere for language functions was further confirmed in 1874 by Carl Wernicke's discovery of a second language center situated between Heschl's gyrus and the angular gyrus, the dysfunction of which resulted in a qualitatively different aphasia from that described by Broca.[4]

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1 D. Kimura, " The Asymmetry of the Human Brain," Scientific American, Vol. 228, 1973, p. 70-78.

2 D. Giannitrapani, "Developing Concepts of Lateralization," Cortex, Vol. 3, 1967, p. 353-370.

3 N. Geshwind, "Language and the Brian," Scientific American, Vol. 226, 1972, p. 76-83.

4 Ibid., p. 76.

Since the initial mapping of these primary speech centers considerable data has accumulated from observations of dysfunction resulting from disease, accident, and surgery, allowing some elementary statements regarding the division of labor between right and left hemispheres in all but a small percentage of the normal population. Two major sources of information in this area have been from split-brain patients and from psychometric studies of brain damaged samples.[5,6,7] The split-brain technique in which severing of the corpus callosum and other commissural connections effectively isolates the cerebral hemispheres, provides a unique opportunity for the delineation of functional differences. In their contact with these patients, Gazzaniga and Sperry reported no notable changes in temperament, personality or general intelligence following commissurectomy. However,

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5 M.S. Gazzaniga, "The Split Brain in Man," Scientific American, Vol. 217, 1967, p. 24-29.

6 M.S. Gazzaniga and R.W. Sperry, "Language After Section of the Cerebral Commissures," Brain, Vol. 90, 1967, p. 131-148.

7 A. Yates, "Psychological Deficit," Annual Review of Psychology, Vol. 17, 1966, p. 111-144.

interesting results were obtained when information was restricted to a single hemisphere. Visual, auditory, and tactile stimuli projected to the left hemisphere were accurately recognized and verbally reported in the usual manner; however, subjects proved totally unable to give either an oral or written report of even the simplest stimuli presented to the right hemisphere. That the right hemisphere was, indeed, capable of some degree of verbal comprehension was evident only when a nonverbal response modality such as a somatosensory recognition was employed. The authors concluded that, while linguistic expression is confined to the left hemisphere, both hemispheres demonstrate verbal comprehension:

> We do know that the right hemisphere is decidedly inferior to the left in its overall command of language. We have established, for instance, that although the right hemisphere can respond to a concrete noun such as "pencil" it cannot do as well with verbs; patients are unable to respond appropriately to simple printed instructions such as "smile" or "frown" when these words were flashed to the right hemisphere, nor can they point to a picture that corresponds to a flashed verb. (...) In general, then, the extent of language in the adult right hemisphere in no way compares with that present in the left hemisphere.[8]

Moreover, certain functions appeared to be more efficiently

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8 M.S. Gazzaniga, op. cit., p. 27-28.

performed by the right hemisphere. These included drawing a three-dimensional form involving complex spatial relations, and arranging blocks to match a pictured design.

The first extensive use of psychological tests of intelligence and ability in the investigation of hemispheric specialization of function was carried out by Weisenburg and McBride.[9] The authors reported lowered language intelligence scores in patients with left-sided lesions, while those with right-sided injuries displayed intact language functions but impaired visuo-spatial performance. An extension of these findings by McFie and Piercy[10] related deficiencies in certain intellectual functions to more localized lesions. In particular left hemisphere temporo-parietal lesions were associated with lowered Verbal I.Q. (Wechsler-Bellevue Scale) while poor performance on the Block Design subtest accompanied right hemisphere parietal lobe dysfunction. Similarly, Reitan[11]

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9 T.H. Weisenburg and K.E. McBride, Aphasia, New York, Commonwealth Fund, 1935.

10 J. McFie and M.F. Piercy, "Intellectual Impairment with Localized Lesions," Brain, Vol. 75, 1952, p.292-311.

11 R.M. Reitan, "Certain Differential Effects of Left and Right Temporal Lobe Lesions in Human Adults," Journal of Comparative and Physiological Psychology, Vol. 48, 1955, p. 474-477.

and Kløve[12] found lowered Verbal I.Q. scores with left-sided lesions and lowered Performance I.Q. with right-sided lesions. Moreover, Kløve found a positive correlation between unilateral EEG abnormality and selective impairment of verbal and performance functions. Other psychometric studies have associated left temporal lobe lesions with lowered scores on the verbal subtests of the Wechsler Memory Scale,[13] as well as with impairment in vocabulary, right-handed performance on the Purdue Pegboard, writing, verbal paired associate learning, and drop in scores on the AGCT.[14] Right-sided lesions, on the other hand, have been linked to visuo-spatial and subsequent visuo-constructive deficits resulting in impaired performance on the McGill Picture Anomaly Series,[15] the Mooney Closure Faces test,[16] the Benton Visual Retention test,[17] and the Kohs

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12 H. Kløve, "Relationship of Differential Electro-encephalic Patterns to Distributions of Wechsler-Bellevue Scores," Neurology, Vol. 9, 1959, p. 871-876.

13 B. Milner, "Psychological Defects Produced by Temporal Lobe Excision," Proceedings of the Association for Research in Nervous and Mental Diseases, Vol. 36, 1958, p. 244-257.

14 Yates, op cit., p. 122.

15 Milner, op cit., p. 250.

16 H. Lansdell, "Effect of Extent of Temporal Lobe Ablations on Two Lateralized Deficits," Physiology and Behavior, Vol. 3, 1968, p. 271-273.

17 A.B. Heilbrun, "Psychological Test Performance as a Function of Lateral Localization of Cerebral Lesions," Journal of Comparative and Physiological Psychology, Vol 49, 1956, p. 10-14.

Block Design test.[18]

The conclusions drawn from split-brain studies and from psychometric data are in general agreement with the clear-cut symptom aggregates associated with selective damage to the right or left hemisphere. The occurence of receptive, expressive and verbal memory deficits with left hemisphere impairment implicate it in certain verbal symbolic and linguistic functions while observations of topographical disorientation in familiar settings and disruptions of constructional abilities including dressing apraxia in right hemisphere lesions indicate its importance in certain perceptual functions, in particular, the manipulation, ordering, and effecting of spatial relations.[19]

The confirmation of this general division of labor into what may be labelled "verbal" and "nonverbal" functions has, until recently, been confined to clinical studies of patient samples. The development of new experimental techniques which allow selective delivery to a single hemisphere have made possible a more rigorous examination of the effects of cerebral damage as well as an extension of the findings of these studies to normal samples. The application

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18 J. McFie, M.F. Piercy, and O.L. Zangwill, "Visual-Spatial Agnosia Associated with Lesions of the Right Cerebral Hemisphere," Brain, Vol. 73, 1950, p. 167-190.

19 Ibid., p. 188.

and results of these innovative techniques is the subject of the following section.

2. Techniques in the Experimental Investigation of Hemispheric Functional Asymmetries

Among recurring problems which complicate the understanding of hemispheric specialization is the non-specific nature of the cerebral damage, and the related difficulty of defining more precisely the stimulus characteristics for which hemispheric differences are evident. Both questions require the control of experimental observation, a condition made possible by the development of two techniques of stimulus presentation. The use of dichotic listening and visual tachistoscopic methods allow selective channeling of stimuli to the designated hemisphere, at the same time permitting systematic manipulation of stimulus parameters, presentation variables, and response requirements.

The development by Broadbent[20] of a technique for the simultaneous (dichotic) presentation of different auditory stimuli to each ear paved the way for a series of inquiries into the differential auditory perception of verbal and

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20 D.E. Broadbent, "The Role of Auditory Localization in Attention and Memory Span," Journal of Experimental Psychology, Vol. 47, 1954, p. 191-196.

nonverbal stimuli. Kimura[21], employing this technique with left and right temporal lobe damaged groups reported greater deficits in digit recall in left-damaged subjects. A follow-up study indicated a reverse effect in right damaged patients with speech localized in the right hemisphere.[22] In all of the patient groups studied, the observed deficit was greatest for the ear contralateral to the injured hemisphere, a finding which is attributable to the loss of the normally superior contralateral auditory connections. Subsequent studies using normal subjects have confirmed a right ear (left hemisphere) superiority for dichotically-presented digits, words, and nonsense syllables.[23]

Similar investigations have lent support to the contention that the right hemisphere subserves certain aspects of nonverbal perception. Thus a left-ear (right hemisphere) superiority has been demonstrated for dichotically-presented melodies[24] as well as for a number of familiar environmental

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21 D. Kimura, "Some Effects of Temporal Lobe Damage in Auditory Perception," Canadian Journal of Psychology, Vol. 15, 1961, p. 156-165.

22 --------, "Cerebral Dominance and the Perception of Verbal Stimuli," Canadian Journal of Psychology, Vol. 15, 1961, p. 166-171.

23 --------, "Functional Asymmetry of the Brain in Dichotic Listening." Cortex, Vol. 3, 1967, p. 163-178.

24 --------, "Left-Right Differences in the Perception of Melodies," Quarterly Journal of Experimental Psychology, Vol. 16, 1964, p. 355-358.

sounds.[25] Kimura's findings with normals agree with Milner's observations of deficiencies in the discrimination of tonal patterns on the Seashore Measure of Musical Talents among patients having right temporal lobectomies.[26]

While studies of auditory perception employing the dichotic listening technique are consonant with the body of psychometric and clinical evidence, it is probable that the ear does not provide the most adequate vehicle for the clarification of hemispheric differences since auditory pathways from each ear have both ipsalateral and contralateral cerebral connections. Kimura has indicated that the visual system is superior in this regard since crossed connections are not from each eye to the opposite half of the brain, but from each half of the visual field to the visual cortex of the opposite hemisphere.[27] Hence stimulation to the right of a fixation point (right visual field) is received by the left hemiretinae and transverses neural pathways terminating in the left hemisphere. A diagram of the visual pathways is presented in Figure 1 on the following page. Using rapid

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25 C. Knox and D. Kimura, "Cerebral Processing of Nonverbal Sounds in Boys and Girls," Neuropsychologia, Vol. 8, 1970, p. 227-237.

26 Milner, op cit., p. 252.

27 Kimura, 1973, op. cit., p. 72.

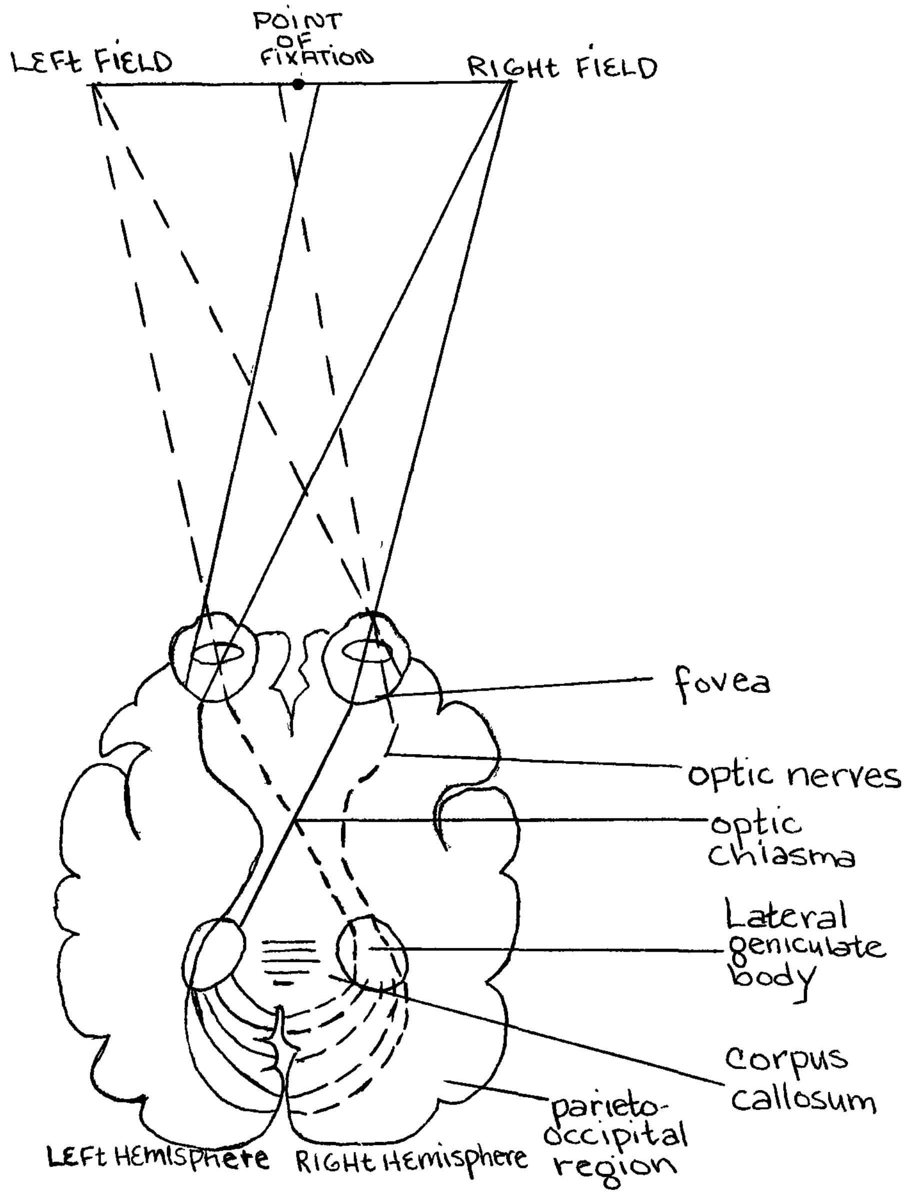

Figure 1.- Visual Pathways are completely crossed when eyes are fixed on a point so that all of the field to the left of the fixation point excites the visual cortex in the right hemisphere and stimuli from the right visual field excite the left visual cortex.[1]

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1 D. Kimura, "The Asymmetry of the Human Brain," Scientific American, Vol. 226, 1972, p. 73.

tachistoscopic presentation in which fixation on a central point is ensured, stimuli presented in the right or left visual field are delivered directly to the opposite hemisphere.

Mishkin and Forgays[28] pioneered the first experiment using this technique and found recognition more accurate for words presented in the right visual field. Their findings have generally been supported by later studies using words[29,30] and single letters.[31] Exceptions to this right-field effect have been reported under two conditions: when stimuli are Yiddish words presented to bilingual subjects,[32] and when presentation is bilateral (simultaneous) rather than unilateral (successive).[33]

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28 M. Mishkin and D.G. Forgays, "Word-Recognition as a Function of Retinal Locus," Journal of Experimental Psychology, Vol. 43, 1952, p.43-48.

29 H.S. Terrace. "The Effects of Retinal Locus and Attention on the Perception of Words," Journal of Experimental Psychology, Vol. 58, 1959, p. 382-385.

30 W.F. McKeever, and M.D. Huling, "Left-Cerebral Hemisphere Superiority in Tachistoscopic Word-Recognition," Perceptual Motor Skills, Vol. 30, 1970, p. 763-766.

31 W. Heron, "Perception as a Function of Retinal Locus and Attention," American Journal of Psychology, Vol. 70, 1957, p. 38-48.

32 Mishkin and Forgays, op. cit., p. 44.

33 Heron, op. cit., p. 44.

Three major hypotheses have been employed in explaining the right visual field effect and the interaction between hemifield differential accuracy, type of stimulus, and method of presentation. The first two invoke the concept of trained reading habits and "set" while the third is a cerebral dominance interpretation.

Mishkin and Forgays[34] hypothesized that English reading experience in which the reader is persistently presented with the next word in the right visual field results in a more efficient neural organization in the left hemisphere due to a selective retinal training process. The opposite effect occurs in subjects reading Yiddish words which are organized from right to left. Heron[35] includes a second set of eye movements which operate from right to left at the end of a line of print in his explanation of visual field data. Under conditions of successive presentation, a right visual field superiority results for English words since both sets of eye movements act in accord. With simultaneous exposure, however, the tendency to fixate at the beginning of a line predominates, resulting in a left field superiority.

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34 Mishkin and Forgays, op. cit., p. 47.

35 Heron, op. cit., p. 46.

The third hypothesis offered to explain visual field differences, and the one most relevant to the present study, is that of hemispheric specialization, or cerebral dominance. Proponents of this interpretation argue that while reading habits and attentional sets may operate under certain conditions their effects may be systematically teased out to reveal a basic right visual field superiority based on a left hemisphere dominance for verbal stimuli.

To this end Barton, Goodglass, and Shai presented Yiddish words in a vertical rather than horizontal display and found superior recognition for words presented in the right visual field.[36] The consistent finding of a right visual field superiority for single letters has also been cited as support for a cerebral dominance interpretation. Bryden[37] used single letters and their mirror images to reverse any operative scanning tendency and thus produce a left field bias. No such effect occurred, leading the author to conclude that this mechanism played no significant role in the perception of single letters.

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36 M.I. Barton, H. Goodglass, and A. Shai, "Differential Recognition of Tachistoscopically Presented English and Hebrew Words in the Right and Left Visual Fields," Perceptual and Motor Skills, Vol. 21, 1965, p. 431-437.

37 M.P. Bryden, "Left-Right Differences in Tachistoscopic Recognition: Directional Scanning of Cerebral Dominance?" Perceptual and Motor Skills, Vol. 23, 1966, p. 1127-1134.

Likewise, Bryden[38] tested Harcum's[39] conclusion that a scanning process operated with asymmetrical but not with symmetrical letters. Bryden argued that if a left-to-right scanning tendency were present in the perception of asymmetrical letters, then letters following them in an horizontal display would be more accurately recognized than those following symmetrical letters. As a comparable right field superiority was observed under both conditions, the author concluded that scanning influences were negligible.

The findings of visual field studies with nonverbal stimuli are somewhat less consistent, although some general statements are possible. Four types of nonverbal stimuli have been employed: pictures of familiar objects, geometric forms, nonsense forms, and random patterns of dots. Wyke and Ettlinger[40] report a right field superiority for familiar objects as do Bryden and Rainey.[41] However, no differences

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38 M.P. Bryden, "Symmetry of Letters as a Factor in Tachistoscopic Recognition," American Journal of Psychology, Vol. 81, 1968, p. 513-524.

39 E.R. Harcum, "Effects of Symmetry on the Perception of Tachistoscopic Patterns," American Journal of Psychology, Vol. 77, 1964, p. 600-606.

40 M. Wyke and G. Ettlinger, "Efficiency of Recognition in Left and Right Visual Fields," Archives Neurology, Chicago, Vol. 5, 1961, p. 659-665.

41 M.P. Bryden and C.A. Rainey, "Left-Right Differences in Tachistoscopic Recognition," Journal of Experimental Psychology, Vol. 66, 1963, p. 568-571.

in visual field accuracy of recognition were found for geometric forms[42] or for nonsense forms.[43] Both Kimura and Bryden relate the right field effect with readily-labelled familiar objects to a left hemisphere superiority for verbal conceptual material.

Using random patterns of dots, Kimura[44] found subjects were able to ennumerate dots presented in the left visual field more accurately than those presented in the right visual field. Likewise, ennumeration of geometric forms was superior in the left visual field when the requirement of perception of shape was eliminated.[45] Furthermore, a left visual field superiority also emerged when subjects were required to locate the position of a single dot on a spatial map after it had appeared in a random position to the right or left of the fixation point.[46] Kimura hypothesizes that

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42 Ibid., p. 571.

43 D. Kimura, "Dual Functional Asymmetry of the Brain in Visual Perception," Neuropsychologia, Vol. 4, 1966, p. 275-285.

44 Ibid., p. 278.

45 Ibid., p. 280.

46 D. Kimura, "Spatial Localization in Right and Left Visual Fields," Canadian Journal of Psychology, Vol. 23, 1969, p. 445-458.

the left field effect with ennumeration and localization of dots is related to a more developed spatial-coordinate system in the right hemisphere and cites findings of disturbances in the appreciation of external space with right-sided lesions.

Experimental findings with normal subjects which have been reviewed in this section are generally supportive of the hemispheric functional differences seen in studies of patient samples. With regards to the present study, the superiority of the visual over the auditory system in directing stimuli to the target hemisphere is noted. The necessity of controlling for reading habits and attentional sets indicates the choice of a single alphabet letter as the appropriate verbal stimulus, while the desireability of avoiding verbal labels for nonverbal stimuli prompts the use of a meaningless dot configuration as the nonverbal stimulus.

While visual field studies have utilized recall and recognition paradigms in assessing hemispheric asymmetries, and/or visual field differences, this study proposes the use of a physiological measure, the galvanic skin response (GSR) as a possible index of differential hemispheric functioning.

The following section presents research findings relevant to the bilateral recording of the GSR.

3. The Bilateral Galvanic Skin Response

The relationship between psychological phenomena and electrodermal activity has been the focus of speculation for over a century. Féré was the first to call attention to the interdependence of "affective variations" and changes in skin resistance.[47] More recently, however, electrodermal events have come to be regarded as reflective of changes in general activation which occur in response to a variety of novel, sudden, or intense stimuli. Hence changes in electrical resistance (GSR) are included by Sokolov and his co-workers as one of a number of measureable events which constitute the orienting response, and which reflect the nervous system's attempts to deal with incoming environmental stimuli.[48]

The majority of psychophysiological studies have reported electrodermal responses from a single extremity, under the assumption that the measure represents a centrally organized, symmetrical discharge of the sympathetic nervous system. Recently, however, evidence has been offered of significant lateral differences. The possibility thus arises that these differences convey psychophysiologically-relevant

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47 C. Landis and H.N. DeWick, "The Electrical Phenomena of the Skin (Psychogalvanic Reflex)," Psychological Bulletin, Vol. 26, 1929, p. 64-119.

48 R. Lynn, Attention, Arousal and the Orienting Reaction, Oxford, England, Pergamon Press, 1966.

information.

Lateral electrodermal differences were first cited by Baitsch[49] who observed differences in skin resistance levels in sixty to eighty per cent of his sample, with higher values generally recorded from the right side. Since this initial discovery, a number of studies have reported similar findings using a variety of electrodermal recording techniques, stimulus conditions, and theoretical explanations. A brief overview of current research will serve to illustrate the lack of agreement which presently characterizes this newly-explored phenomenon.

A systematic, though somewhat speculative attempt to relate lateral electrodermal differences to body image variables has been made by Fisher who postulates a developmental projection process wherein values and roles (e.g. male-female, weak-strong) are assigned to left and right body sides as part of the organism's adaptive effort at self-organization and impulse integration.[50] This association of body image attitudes with body sides is then reflected in patterns of physiological activity.

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49 V.H. Baitsch, "Uber Geschlechts-und Seitendifferenzen im Niveau Elektrodermatogramm," Confina Neurologica, Vol. 14, 1954, p. 88-100.

50 S. Fisher, "Body Image and Asymmetry of Body Reactivity," Journal of Abnormal and Social Psychology, Vol. 57, 1958, p. 292-298.

Fisher concludes that the "normal" electrodermal pattern is one of greater reactivity on the left. This pattern, he observes, is most often exhibited by right-handed subjects with stable and highly lateralized body images, and seldom by left-handers or right-handers who do not clearly distinguish left and right body sides on a number of body image indices.[51] The left-reactive pattern emerges in the course of the developmental process, when the right hand assumes an executive monitoring function and insures the integrity of its set for directive action by chaneling excess surges of excitation to the left hand.

Fisher extends his theory in a series of experiments from which he concludes: that right-handed, left-reactive subjects made fewer errors in detecting figure drawing distortions,[52] and received lower Body Disturbance scores on the Draw-A-Person test[53] than did other right-handers and the majority of left-handers; that the left-reactive pattern becomes apparent around age twelve or thirteen and that its

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51 Ibid., p. 295.

52 S. Fisher and J. Abercrombie, "The Relationship of Body Image Distortions to Body Reactivity Gradients," Journal of Personality, Vol. 26, 1958, p. 320-329.

53 S. Fisher, "Body Reactivity Gradients and Figure Drawing Variables," Journal of Consulting Psychology, Vol. 23, 1959, p. 54-59.

appearance is related to indices of male-female role differentiation;[54] and, that groups in which body image has been shown to be disrupted such as schizophrenics and subjects under the influence of LSD exhibited the left-reactive pattern less frequently than right-handed normals.[55]

While Fisher's evidence is considerable, his conclusions await reformulation in light of an important methodological error.[56] In none of his studies is the law of initial values taken into account when analyzing electrodermal data. Hence, although the left side appeared more reactive, it was also the side of higher resistance. Nevertheless, Fisher's treatment of the phenomenon of lateral differences emphasizes several important considerations including a concern for their adaptive significance, the possible influence of handedness, the existence of developmental differences, and the significance of deviations from a "normal" pattern in special groups.

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54 S. Fisher and R.L. Fisher, "A Developmental Analysis of Some Body Image Reactivity Dimensions," Child Development, Vol. 30, 1959, p. 389-402.

55 S. Fisher and S.E. Cleveland, "Right-Left Reactivity Patterns in Disorganized States," Journal of Nervous and Mental Disease, Vol. 128, 1959, p. 396-400.

56 S. Fisher, "Right-Left GSR Reactivity Differences: A Methodological Note," Perceptual Motor Skills, Vol. 15, 1962, p. 150.

Obrist[57] tested the reliability of lateral differences in baseline skin resistance and changes in baseline (GSR) in five subjects over a twenty-four to thirty-six day period, using stimulus conditions of rest and serial learning. Significant and reliable differences in baseline levels were observed in three subjects in which left side exceeded right side measures under both stimulus conditions, the differences being most marked during rest. Significant differences were also observed between right and left GSR's in two subjects.

Varni, Doerr and Franklin[58] recorded basal levels of skin resistance and vasomotor activity from right and left body sides. Although no relationship was found between handedness or body side and electrodermal or vasomotor variables, a consistent autonomic pattern emerged in which lower basal skin resistance and lesser vasomotor constriction occurred on the same body side. The authors point out the discrepancy between this pattern and the traditional sympathetic-parasympathetic model in which increased sympathetic arousal is reflected in lowered skin resistance and greater vasomotor constriction. Furthermore, they argue for the

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57 P.A. Obrist, "Skin Resistance Levels and Galvanic Skin Response: Unilateral Differences," Science, Vol. 139, 1963, p. 227-228.

58 J.G. Varni, H.O. Doerr, and J.R. Franklin, "Bilateral Differences in Skin Resistance and Vasomotor Activity," Psychophysiology, Vol. 8, 1971, p. 390-400.

necessity of observing individual patterns of autonomic response with recordings from various body sites and under a variety of stimulus conditions.

The role of central and spinal cord mechanisms which may be inferred from the existence of lateral electrodermal differences has been the focus of investigations by Culp and Edelberg,[59] Fuhrer and Kilbey,[60] and Fuhrer.[61] Using a constant voltage system, they have obtained recordings under several stimulus conditions. Culp and Edelberg recorded changes in electrical conductance from two palmar and two plantar sites using three stimuli: a central startle stimulus consisting of a flash of light or a bell; a symmetrical muscle stimulus such as a sharp sniff or a clenched jaw; and a localized muscle stimulus such as flexing of fingers or toes.[62] The authors reported augmented responses on the side

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59 W.C. Culp and R. Edelberg, "Regional Response Specificity in the Electrodermal Reflex," Perceptual and Motor Skills, Vol. 23, 1966, p. 623-627.

60 M.J. Fuhrer and M. Kilbey, "Effects of Spinal Cord Transections on Electrodermal Activity in Man," Psychophysiology, Vol. 4, 1967, p. 176-186.

61 M.J. Fuhrer, "Effects of Unilateral Stimuli on the Magnitude and Latency of Bilaterally Recorded Skin Conductance Responses," Psychophysiology, Vol. 8, 1971, p. 740-748.

62 Culp and Edelberg, op. cit., p. 625.

ipsalateral to the localized muscle activity, and conclude that, given the diffuse nature of the spinal electrodermal reflex demonstrated by Richter,[63] the responsibility for selective outflow probably resides in central inhibitory mechanisms. In support of this hypothesis they cite the findings of Schwartz[64] that lesions in Brodman's area six of the cortex resulted in cessation of electrodermal responses in the contralateral limb.

Replication of Culp's and Edelberg's findings is offered by Fuhrer who expanded the original design to include shock as the unilateral stimulus, and latency of skin conductance responses as a dependent variable.[65] Both shocks and unilateral flexion resulted in greater magnitude of response on the side ipsalateral to stimulation. Shocks also produced shorter latencies on the stimulated side.

In considering the brain and spinal cord mechanisms responsible for the observed effect, Fuhrer draws upon information derived from studies of patients with transected spinal cords.[66] Since lateralized shocks resulted in an

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63 C.P. Richter, "Galvanic Skin Reflex From Animals with Complete Transection of the Spinal Cord," American Journal of Physiology, Vol. 109, 1934, p. 593-604.

64 H.H. Schwartz, "Effect of Experimental Lesions of the Cortex on the Psychogalvanic Reflex in the Cat," Archives of Neurology and Psychiatry, Vol. 38, 1937, p. 308-320.

65 Fuhrer, op. cit., p. 741.

66 Fuhrer and Kilbey, op cit., p. 185.

increase in the incidence and magnitude of ipsalateral electrodermal responses in subjects with functionally isolated spinal cords, Fuhrer disagrees with Culp and Edelberg and suggests "that there are pathways within the human spinal cord for preferentially routing afferent input to sympathetic motoneurones serving the side of the body which is stimulated."[67] Furthermore, he hypothesizes a dual-routing of cutaneous and proprioceptive afferent volleys, first to the brain which bilaterally activates arrays of sympathetic motoneurones separately innervating the body; and secondly, by intraspinal pathways directly to the arrays of motoneurones serving the side of stimulation. Thus:

> Since motoneurones ipsalateral to the stimulus site would receive input from two sources, they would be expected to discharge more massively. This hypothesis accounts not only for the lateral augmentation of response magnitude to unilateral stimuli, but also for the latency effects of such stimuli. Since the intra-spinal pathways are considerabley shorter than the ones conducting to and from the brain, responses would be expected to occur more quickly from ipsalateral recording sites.[68]

In contrast, Wyatt and Tursky[69] observed no relationship between unilateral visual, auditory, and tactile stimuli

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67 Fuhrer, op. cit., p. 748.

68 Ibid., p. 748.

69 R. Wyatt and B. Tursky, "Skin Potential Levels in Right- and Left-Handed Males," Psychophysiology, Vol. 6 , 1969, p. 133-137.

and lateral differences in skin potential levels, with higher levels being obtained from the right hand under all conditions. The authors point out that the deciding factor may be one of cerebral dominance for speech in the contralateral (left) hemisphere.

While several of the above studies have been concerned with the effects of lateralized stimulation on the GSR, it is noteworthy that in all cases stimulus lateralization has been with respect to body side rather than cerebral hemispheres. Furthermore, the use of muscular lateral stimuli such as flexing of fingers or toes introduces confounding movement artifacts into the GSR record. Nor have any of the reviewed studies attempted to control for the nature of the experimental stimuli since most have included a combination of written or oral instructions presented simultaneously with tones, clicks, flashes of light and shocks.

Interestingly, hemispheric asymmetries in other physiological variables such as EEG alpha and auditory evoked response from homologous sites have been shown to be task dependent in a number of studies. Galin and Ornstein[70] found that the ratio of right to left EEG whole band power was higher for verbal than for spatial tasks; that is power was

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70 D. Galin and R. Ornstein, "Lateral Specialization of Cognitive Mode: An EEG Study," Psychophysiology, 1972, Vol. 9, p. 412-418.

found to be less in the hemisphere primarily engaged in the task. Doyle, Ornstein and Galin[71] found this effect to be strongest in the alpha band which was observed to reflect the differential engagement of the hemispheres in verbal-analytic and spatial-musical problems. This finding has since been replicated by a number of authors.[72,73,74,75] Likewise, auditory evoked responses have been found to be greater in the left hemisphere for words, while clicks produced larger right hemisphere responses.[76] That GSR asymmetries may likewise depend upon cerebral involvement when stimuli are preferentially routed to a single hemisphere is the primary question set forth in this study.

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71 J.C. Doyle, R. Ornstein, and D. Galin, "Lateral Specialization of Cognition Mode II: EEG Frequency Analysis," Psychophysiology, Vol. 11, 1974, p. 567-578.

72 A.H. Morgan, H. MacDonald, and E.R. Hildegard, "EEG Alpha: Lateral Asymmetry Related to Task and Hypnotizability," Psychophysiology, Vol. 11, 1974, p. 275-282.

73 A.H. Morgan, P.J. MacDonald and H. Mac Donald, "Differences in Bilateral Alpha Activity as a Function of Experimental Task, with a Note on Lateral Eye Movements and Hypnotizability," Neuropsychologia, Vol. 9, 1971, p. 459-469.

74 G. McKee, B. Humphrey and D.W. McAdam, "Scaled Lateralization of Alpha Activity During Linguistic and Musical Tasks," Psychophysiology, Vol. 10, 1973, p. 441-443.

75 L.K Morrell and J.G. Salamy, "Hemispheric Asymmetry of Electrocortical Responses to Speech Stimuli," Science, Vol. 174, 1971, p. 164-166.

76 R. Cohn, "Differential Cerebral Processing of Noise and Verbal Stimuli," Science, Vol. 172, 1971, p. 599-601.

4. Summary and Statement of Basic Hypothesis

Considerable evidence of hemispheric specialization has been advanced from clinical observation and psychometric studies of brain damaged and split-brain patients. The division of labor between the hemispheres with left hemisphere superiority for verbal functions and right hemisphere dominance for certain perceptual functions has been extensively supported in experimental studies of normals using auditory and visual stimulus presentation techniques which permit stimulus routing to a single hemisphere. More precisely, visual tachistoscopic presentation has been indicated as a superior method for the study of cerebral functional asymmetries, and single alphabet letters and nonsense dot configurations have been designated as verbal and nonverbal stimuli least affected by learned eye movements and confounding verbal labels.

While the majority of cerebral dominance studies have used a recognition or recall paradigm, this study adopts a physiological index, the GSR. Recent technical developments permitting lateral recording of electrodermal activity have revealed significant right-left differences in magnitude and latency of response. However, little agreement exists regarding the meaning or even the direction of these differences. Given the evidence indicating contralateral control of electrodermal responses at the cortical level, the hypothesis is put forth that these responses may be augmented by stimulus input to the opposite hemisphere. Furthermore, it is suggested that such an augmentation of the GSR of the opposite body side may be stimulus specific, reflecting hemispheric engagement in the processing of the type of information for which it has been shown to be specialized.

The present study proposes to use two types of stimuli designated as Verbal and Nonverbal and three loci of stimulus presentation, Right, Left, and Center visual field. The independent variables are thus Stimulus Type, Right vs. Left Hand Recording Site, and Visual Field of Presentation. The dependent variables are the GSR magnitude of response quantified in resistance, conductance, and change in log conductance.

The method used is one of visual tachistoscopic presentation of a verbal or nonverbal stimulus in the right, left or center visual field. Each subject will receive twenty trials with the stimulus type and locus of presentation remaining constant. The recording of the GSR will be simultaneous and independent from right and left palmar sites.

CHAPTER II

EXPERIMENTAL DESIGN

This chapter presents the methodology of the present experiment. First, a description is given of the subjects who participated in the study, and the procedure used to determine hand preference. Next, the preparation of the experimental stimuli and the apparatus used for stimulus presentation are detailed. In the third section, the GSR instrumentation is presented followed by a description of the procedure followed in conducting the experiment. The chapter concludes with a presentation of the experimental design and statistical analysis and a statement of the specific null hypotheses to be tested.

1. The Subjects

Seventy-one right-handed females between the ages of eighteen and thirty-four (mean age: 22.9; median age: 25.8; standard deviation: 2.87) were selected as subjects for this study. All were enrolled as summer students at the University of Ottawa and were personally approached by the experimenter.

In order to assure the handedness of all subjects, hand preference was assessed by offering each subject a cardboard tube and observing the hand used to receive it. Subjects were also questioned as to which hand they normally used to write and throw a ball. This procedure was considered an adequate indication of normal lateralization of speech in the left hemisphere since experimental findings using sodium amytal techniques indicate this pattern in ninety per cent of all right-handers and sixty per cent of left-handed persons.[1] Hence the chances of including a subject with speech functions represented in the right hemisphere in this experiment were considered small.

All subjects completed the Eysenck Personality Inventory Form A, in view of the continuing interest in this measure in our laboratories, and to assess the possible contaminating effects of the personality dimensions of extraversion and neuroticism on the dependent variables. A sample of the inventory is found in Appendix 1.

Eleven subjects were eliminated from analysis in this study, eight through equipment failure and/or experimenter error, two when they became claustrophobic during the course of the experiment, and one who was discovered to be ambidextrous.

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1 C. Branch, B. Milner, and T. Rasmussen, "Intracarotid Sodium Amytal for the Lateralization of Cerebral Speech Dominance," Journal of Neurology, Vol. 21, 1964, p. 399-405.

2. Preparation of Test Stimuli and Apparatus for Stimulus Presentation

Two pools of stimuli were constructed for use in this experiment: Verbal stimuli in the form of a single letter of the alphabet (A,E,H,I, and T) and Nonverbal stimuli consisting of a random pattern of dots similar to those employed by Kimura.[2] Examples of each type of stimulus are reproduced in Appendix 3. Both verbal and nonverbal stimuli were printed on white five-inch by seven-inch cards using black dots from Letraset sheet No. 556. Each stimulus measured 1.6 centimeter by 1.1 centimeter and was printed on three separate cards: once in the center, another offset by four centimeters to the left of the fixation point, and a third offset an equal distance to the right of center. Thus each stimulus could be presented in one of three positions: center visual field (<u>CVF</u>), left visual field (<u>LVF</u>), and right visual field (<u>RVF</u>). The horizontal angle of the offset stimuli measured from the center fixation point to the inner edge of the figure was $2^{\circ}10'$.

A separate card contained a single dot which served as a fixation point for all subjects. For each experimental

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2 D. Kimura, "Dual Functional Asymmetry of the Brain in Visual Perception," <u>Neuropsychologia</u>, Vol. 4, 1966, p. 275-285.

session the chosen stimulus card and the fixation point card were mounted into two five-inch by seven-inch stainless steel card holders and inserted into separate channels of the tachistoscope.

Two channels of a Scientific Prototype 3-channel tachistoscope, Model GB were used to present the test stimuli. The optical system is a 3-channel Dodge Type with three partially front-silvered mirrors designed to bring the individual fields into a common plane and give similar visual brightness for identical illumination. Each channel contains two gas lamps for illuminating stimulus material. The level of illumination in the two channels used in this study was equated at one foot candle as measured by the Spectra Pritchard Photometer, Model 1970-PR. For all subjects, the blank channel held the card containing the fixation point card, and channel one held the verbal or nonverbal stimulus. The viewing distance from the subject to the stimulus was 119.4 centimeters.

The electronic control unit of the tachistoscope is equipped with an automatic time interval generator. Using the short stimulus duration period required in this study, however, it was noted that the timing condensers were not given adequate time to recharge after an interval had been generated. Hence the intervals generated were not those indicated on the timer dial. It was thus necessary to construct a table of recalibrated interstimulus intervals which corresponded to the settings on the timer dial. The list of dial settings and their recalibrated equivalents is given in Appendix 2.

3. Instrumentation for GSR Recording

Four Beckman silver silver-chloride electrodes were used for the active sites in the electrodermal recording. Two of the four active electrodes were used on each hand on the volar middle phalanges of the first and third fingers. Each electrode was applied using a Beckman adhesive collar to insure a standard contact area of .81 $cm.^2$. Electrode paste consisted of Unibase (Parke-Davis) thinned with one part-by volume of physiological saline as prescribed by Lykken and Venables.[3] Each electrode site was first cleansed with methyl alcohol and allowed to dry before electrodes were applied. Between experimental sessions, electrodes were suspended in a mild saline solution of 1% salt in distilled water.

A 10 microampheres D.C. constant current was impressed across the electrodes by means of two independent

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3 D.T. Lykken and P.H. Venables, "Direct Measurement of Skin Conductance: A Proposal for Standardization," Psychophysiology, Vol. 8, 1971, p. 656-672.

GSR transducer boxes equipped with isolated electrical systems and operational amplifier techniques. Measures of baseline resistance and changes in baseline (GSR) for right and left hand were recorded separately on 4 channels of a Watnabee 10" Multichannel polygraph, Type MC611. A fifth channel served as an event marker, activated by relay from the tachistoscope.

Electrodes as well as baseline and response channels were systematically alternated for each subject in order to randomize undetected differences. All equipment was calibrated before and after each subject for reliability and accuracy of recording.

Side-by-side records of skin resistance levels and GSR were obtained for right and left hand sites for each subject.. A change in resistance of at least 200 ohms occurring within one to five seconds after stimulus onset was considered a measureable response. Resistance measures were quantified according to the formula:

$$R_a - R_b = R_r$$

where R_a represents the basal resistance level just prior to stimulus onset, R_b is equal to the basal resistance at the point of maximum response, and R_r represents the change in resistance.

All electrodermal measures obtained in resistance were subjected to two transformations, conductance change, and change in log conductance. These are expressed as follows:

$$\text{Conductance change} = \left({}^{1000}/R_a - {}^{1000}/R_b\right)$$

$$\text{Change in log conductance} = \left(\log_{10} {}^{1000}/R_a - \log_{10} {}^{1000}/R_b\right)$$

These additional transformations were undertaken in view of the current state of controversy regarding the desireability of using resistance, conductance or change in log conductance measures. This was considered appropriate since all three measures have been shown to yield different results, and since the logarithmic transformation meets more closely the assumptions of the analysis of variance model.[4]

4. The Experiment

Prior to the experimental session, each subject was randomly assigned to one of six experimental treatments designated according to the nature of the stimulus (*Verbal* or *Nonverbal*) and the visual field of presentation (*RVF*, *LVF*, or *CVF*). Each was also assigned randomly to receive one of the five stimuli from the appropriate stimulus pool.

Subjects were greeted upon their arrival at the laboratory and were presented with Form A of the Eysenck

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4 E. Haggard, "On the Application of Analysis of Variance to GSR Data: II. Some Effects of the Use of Inappropriate Measures," *Journal of Experimental Psychology*, Vol. 39, 1949, p. 861-867.

Personality Inventory. Upon completing the inventory, each subject was tested for hand preference. She was then instructed to wash and dry her hands and be seated at the tachistoscope. Any necessary adjustments of chair height. were made at this time to ensure comfortable viewing. The electrodes were applied and a brief explanation given as follows:

> In this experiment you will be asked to fixate on a small black dot which you can now see in the center of the screen. After about five minutes a stimulus will appear briefly, then the black dot will return. Your job, at all times, is to fixate on the black dot. It is essential to this experiment that your eyes be focused on the center of the screen. You will not be asked to remember what you have seen. The experiment will last approximately twenty minutes. During that time it is important that you sit as quietly as possible and do not speak. There are no hidden purposes in this experiment. Make yourself comfortable, place your face against the viewing hood and we will begin.

A five minute resting period preceded the presentation of stimuli. At the end of the interval the test stimulus replaced the fixation dot for a period of 50 milliseconds. Each subject received twenty such presentations separated by an interstimulus interval of twenty to thirty-five seconds, during which time the fixation dot reappeared. The test stimulus and its location in the right, left, or center visual field remained constant for any one subject.

The choice of a stimulus exposure period of 50 milliseconds is consistent with other studies using a visual tachistoscopic technique. The control of eye movements by the use of sublatency exposure times was considered imperative in the present study since a warning signal telling subjects to fixate would represent an interference with the GSR recording. Fifty milliseconds is well below the reported latency for eye movements[5] and from a pilot project using ten subjects, proved to be above the recognition threshold for the experimental stimuli.

5. Experimental Design and Statistical Analysis

The experimental design used in this study was of the split-plot type discussed by Kirk[6] and consisting of two between-block treatments (Stimulus Type and Visual Field of Presentation) and one within-block treatment (Right vs. Left Hand Recording Site). The statistical treatment of the GSR data employed a 2x2x3 ANOVA of the initial response as well as of the subjects' mean response over all twenty trials. The use of a mean response measure was adopted in view of the difficulty of meeting the assumption of equality and symmetry

5 R.E. Kirk, Experimental Design: Procedures for the Behavioral Sciences, Brooks/Cole Publishing, Belmont, Calif., p. 283.

6 M.J. White, "Laterality Differences in Perception: A Review," Psychological Bulletin, Vol. 72, 1969, p. 387-405.

of covariance matrices in a repeated measures design involving a trial block analysis.[7] This approach resembles that used in other recent studies by Lykken[8] and Hare.[9]

Thus the independent variables in this study were Verbal vs. Nonverbal stimulus, Right vs. Left Hand recording site, and Right, Left and Center Visual Field of Presentation, corresponding to stimulus delivery to left, right and both hemispheres respectively.

As mentioned previously, the GSR dependent variable for left and right hand was quantified in resistance, conductance, and change in log conductance, and statistical analyses were undertaken separately for each of these transformations. Other reported data on subject EPI scores and basal resistance levels also used ANOVAS. Significant simple main effects were tested using the Tukey *post hoc* procedure with the level of probability set at 0.05 for the rejection of the null hypotheses.

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7 *Ibid.*, p. 256.

8 D.T. Lykken, I. Macindoe and A. Tellegen, "Perception: Autonomic Response to Shock as a Function of Predictability in Time and Locus," *Psychophysiology*, Vol. 9, 1972, p. 318-333.

9 R.D. Hare, "Orienting and Defensive Responses to Visual Stimuli," *Psychophysiology*, Vol. 10, 1973, p. 453-464.

5. Statement of the Null Hypotheses

The null hypotheses to be tested using the physiological data for initial and average response are the following:

1. There is no significant differences between GSR amplitude for right and left hand.

2. There is no significant interaction between Stimulus Type and Right and Left Hand GSR. (AXB).

3. There is no significant interaction between Right and Left Hand GSR and Visual Field of Presentation. (BXC).

4. There is no significant interaction between Stimulus Type and Visual Field of Presentation (AXC).

5. There is no significant Stimulus Type by Hand by Visual Field of Presentation interaction. (AXBXC).

CHAPTER III

PRESENTATION AND DISCUSSION OF RESULTS

This chapter presents the results of the analysis of the subject data and the response measures used in testing the null hypotheses presented in Chapter one. The first section details the results of the ANOVAS of the EPI scores and resting basal skin resistance levels. The second section contains the results of the ANOVAS of the physiological data. A summary of the experimental results is given in section three. Section four contains a discussion of the results of the analyses as well as a consideration of their implications for future research.

1. Relevant Subject Data: Measures on the Eysenck Personality Inventory (EPI) and Observations of Right and Left Hand Basal Resistance Levels

The means and standard deviations for extraversion and neuroticism for the six treatment groups on Form A of the EPI are presented in Table I. One-way ANOVAS of the two dimensions revealed no significant differences on extraversion ($F=1.99$) or neuroticism ($F=0.38$). Thus the experimental groups were matched on these two personality variables. Results of the ANOVAS are found in Tables II and III.

An inspection of initial basal resistance levels for left and right hands indicate higher resting levels for the

Table I.-

Means and Standard Deviations for EPI Dimensions of Extraversion and Neuroticism

Treatment		Extraversion	Neuroticism
Verbal/RFV	$\bar{x}$	9.10	10.10
	sd	3.65	3.78
Verbal/LVF	$\bar{x}$	13.80	10.30
	sd	3.94	4.17
Verbal/CVF	$\bar{x}$	11.90	8.80
	sd	3.39	4.60
Nonverbal/RVF	$\bar{x}$	13.60	11.80
	sd	2.94	3.22
Nonverbal/LVF	$\bar{x}$	14.00	10.60
	sd	4.34	6.10
Nonverbal/CVF	$\bar{x}$	11.30	10.20
	sd	5.55	5.55

Table II.-

Analysis of Variance for EPI Measure of Extraversion

Source of Variance	SS	df	MS	F Ratio
Between Groups	182.28	5	36.46	1.99
Within Groups	985.90	54	18.26	
Total	1168.18	59		

$F_{.95}\ (5,54) = 2.39$

Table III.-

Analysis of Variance for EPI Measure of Neuroticism

Source of Variance	SS	df	MS	F Ratio
Between Groups	46.40	5	9.28	0.38
Within Groups	1312.20	54	24.30	
Total	1358.60	59		

$F_{.95}(5,54) = 2.39$

right hand in twenty-two subjects and higher resting levels for the left hand in thirty-eight subjects. In nine subjects the side of higher basal skin resistance was variable during the course of the experiment. While intrasubject basal differences were apparent, an ANOVA of over-all basal resistance levels was not significant, $F=2.21$, $p<0.15$.

2. Physiological Response Results on Right vs. Left Hand GSR Measures

As related in Chapter two, all GSR measures were quantified in three ways: change in resistance, change in conductance, and change in log conductance. Both initial response amplitudes and response amplitudes averaged across the twenty experimental trials were analyzed using a 2x2x3 ANOVA.

Since considerable heterogeneity of variance was apparent from inspection of the data, variances were tested using the F_{max} procedure.[1] Results of the F_{max} tests are contained in Table IV. As some of the F_{max} tests proved to be significant, a square root (SQ RT)transformation was applied to the data.[2] Although one test was still beyond

1 R.E. Kirk, Experimental Design: Procedures for the Behavioral Sciences, Belmont, California, Brooks/Cole, 1968, p. 62.

2 Ibid., p. 65.

Table IV.-

GSR and Square Rooted GSR Measures for Initial and Average Response: F_{max} Test for Homogeneity of Variance

	TRIAL 1			TRIALS 1-20		
	RH/LH	Verbal/NonV RVF/LVF/CVF	RH/LH RVF/LVF/CVF	RH/LH	Verval/NonV RVF/LVF/CVF	RH/LH RVF/LVF/CVF
Resistance	1.22	32.18*	9.11*	1.13	7.33*	5.72*
√Resistance	1.13	7.13*	3.07	1.02	2.71	1.83
Conductance	1.46	2.51	4.28	1.00	1.95	2.29
√Conductance	1.24	2.30	4.67	1.00	1.81	1.59
▲Log. Cond.	1.03	9.25*	3.86	1.17	4.36	3.27
√▲Log Cond.	1.09	3.86	2.13	1.10	1.93	1.58
	$F_{max}(2,59)$ =1.96	$F_{max}(6,19)$ =4.90	$F_{max}(6,19)$ =4.90	$F_{max}(2,59)$ =1.96	$F_{max}(6,19)$ =4.90	$F_{max}(6,19)$ =4.90

*$p < .01$

the level for significance, given the robust nature of the F statistic, the violations of the assumption of equality of variance is within acceptable limits.[3] Means, standard deviations and ANOVAS for untransformed initial response data are contained in Appendix 4, and for averaged response data in Appendix 5.

The first hypothesis to be tested using the SQ RT data is that of no significant difference between right and left hand GSR response. Means and standard deviations for right and left hand initial response are given in Table V and for right and left hand average response in Table VI. ANOVAS for SQ RT resistance, conductance, and change in log conductance are found in Tables VII, VIII, and IX, and for the average response data in Tables X,XI, and XII.

ANOVAS for SQ RT resistance and SQ RT change in log conductance revealed a significant Hand main effect (B Factor) with $p < .02$. Left hand GSR response on the initial trial was, then, significantly greater than right hand GSR response for these two methods of quantification. Therefore the first null hypothesis:

1. There is no significant difference between GSR amplitude for right and left hand.

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3 H. Scheffé, The Analysis of Variance, New York, John Wiley and Sons Inc., 1959, p. 340-341.

Table V.-

Right and Left Hand Means and Standard Deviations for Square Rooted GSR Measures on Trial 1

Square Root Resistance Measure			
	Right Hand	$\bar{x}$	3.05
		sd	2.06
	Left Hand	$\bar{x}$	3.34
		sd	1.95
	Average Total	$\bar{x}$	3.20
		sd	2.00
Square Root Conductance Measure			
	Right Hand	$\bar{x}$	0.53
		sd	0.39
	Left Hand	$\bar{x}$	0.55
		sd	0.38
	Average Total	$\bar{x}$	0.54
		sd	0.37
Square Root Change in Log Conductance Measure			
	Right Hand	$\bar{x}$	0.14
		sd	0.09
	Left Hand	$\bar{x}$	0.15
		sd	0.09
	Average	$\bar{x}$	0.15
		sd	0.09

Table VI.-

Average Response: Right and Left Hand Means and Standard Deviations for Square Rooted GSR Measures

Square Root Resistance Measure			
	Right Hand	$\bar{x}$	1.05
		sd	0.97
	Left Hand	$\bar{x}$	1.13
		sd	0.98
	Average Total	$\bar{x}$	1.09
		sd	0.98
Square Root Conductance Measure			
	Right Hand	$\bar{x}$	0.18
		sd	0.20
	Left Hand	$\bar{x}$	0.19
		sd	0.20
	Average Total	$\bar{x}$	0.19
		sd	0.20
Square Root Change in Log Conductance Measure			
	Right	$\bar{x}$	0.05
		sd	0.04
	Left	$\bar{x}$	0.05
		sd	0.05
	Average Total	$\bar{x}$	0.05
		sd	0.04

Table VII.-

First Response: Analysis of Variance Using Square Root of Resistance Measure

"A" Factor: Verbal vs. Nonverbal Stimulus
"B" Factor: Right vs. Left Hand
"C" Factor: Right, Left, Center Visual Field of Presentation

Source of Variance	SS	df	MS	F Ratio
A	23.93	1	23.93	2.82
C	12.91	2	6.45	0.76
AXC	69.08	2	34.54	4.07 *
D	458.49	54	8.49	
B	2.56	1	2.56	5.38 *
AXB	0.58	1	0.58	1.23
BXC	2.59	2	1.30	2.73
AXBXC	0.19	2	0.10	0.20
BXD	25.66	54	0.48	

$F_{.95}\ (1,54) = 4.02$

$F_{.95}\ (2,54) = 3.17$

* $p < .02$

Table VIII.-

First Response: Analysis of Variance Using Square Root Conductance Measure

"A" Factor: Verbal vs. Nonverbal Stimulus
"B" Factor: Right vs. Left Hand
"C" Factor: Right, Left, Center Visual Field of Presentation

Source of Variance	SS	df	MS	F Ratio
A	101.70	1	101.70	0.31
C	411.72	2	205.85	0.64
AXC	519.97	2	259.98	0.80
D	17484.79	54	323.79	
B	11.10	1	11.10	0.95
AXB	0.68	1	0.68	0.06
BXC	23.11	2	11.55	0.99
AXBXC	24.74	2	12.37	1.06
BXD	631.38	54	11.69	

$F_{.95}\ (1, 54) = 4.02$

$F_{.95}\ (2, 54) = 3.17$

Table IX.-

First Response: Analysis of Variance Using Square Root of Change in Log Conductance Measure

"A" Factor: Verbal vs. Nonverbal Stimulus
"B" Factor: Right vs. Left Hand
"C" Factor: Right, Left, Center Visual Field of Presentation

Source of Variance	SS	df	MS	F Ratio
A	0.024	1	0.024	1.39
C	0.027	2	0.014	0.78
AXC	0.086	2	0.043	2.49
D	0.939	54	0.017	
B	0.003	1	0.003	5.02 *
AXB	0.001	1	0.001	1.37
BXC	0.004	2	0.002	2.76
AXBXC	0.001	2	0.001	0.95
BXD	0.034	54	0.001	

$F_{.95}\ (1,54) = 4.02$

$F_{.95}\ (2,54) = 3.17$

* $p < .02$

Table X.-

Average Response: Analysis of Variance Using Square Root of Resistance Response

"A" Factor: Verbal vs. Nonverbal Stimulus
"B" Factor: Right vs. Left Hand
"C" Factor" Right, Left, Center Visual Field of Presentation

Source of Variance	SS	df	MS	F Ratio
A	1.15	1	1.15	1.25
C	0.11	2	0.05	0.06
AXC	4.44	2	2.22	2.41
D	49.81	54	0.92	
B	0.18	1	0.18	2.31
AXB	0.14	1	0.14	1.77
BXC	0.21	2	0.11	1.33
AXBXC	0.01	2	0.01	0.05
BXD	4.28	54	0.08	

$F_{.95}\ (1,54) = 4.02$

$F_{.95}\ (2,54) = 3.17$

Table XI.-

Average Response: Analysis of Variance Using Square Root Conductance Measure

"A" Factor: Verbal vs. Nonverbal Stimuli
"B" Factor: Right vs. Left Hand
"C" Factor: Right, Left, Center Visual Field of Presentation

Source of Variance	SS	df	MS	F Ratio
A	0.0302	1	0.0302	0.623
C	0.0088	2	0.0044	0.091
AXC	0.0113	2	0.0057	0.117
D	0.2617	54	0.0485	
B	0.0024	1	0.0024	0.885
AXB	0.0004	1	0.0004	0.135
BXC	0.0022	2	0.0011	0.418
AXBXC	0.0021	2	0.0011	0.386
BXD	0.1452	54	0.0027	

$F_{.95}$ (1,54) = 4.02

$F_{.95}$ (2,54) = 3.17

Table XIII.-

Average Response: Analysis of Variance Using Square Root of Change in Log Conductance Response

"A" Factor: Verbal vs. Nonverbal Stimuli
"B" Factor: Right vs. Left Hand
"C" Factor: Right, Left, Center Visual Field of Presentation

Source of Variance	SS	df	MS	F Ratio
A	0.00256	1	0.00256	1.008
C	0.00004	2	0.00002	0.009
AXC	0.00362	2	0.00178	0.702
D	0.13704	54	0.00254	
B	0.00032	1	0.00032	0.271
AXB	0.00078	1	0.00078	0.654
BXC	0.00034	2	0.00017	1.417
AXBXC	0.00003	2	0.00001	0.113
BXD	0.00646	54	0.000.2	

$F_{.95}\ (1,54) = 4.02$

$F_{.95}\ (2,54) = 3.17$

can be rejected for initial response SQ RT resistance and SQ RT change in log conductance values but not for SQ RT conductance of initial response and for all three transformations of average response measures.

The second hypothesis to be tested is that concerning the Stimulus Type by Hand interaction (AxB). No significant AxB interactions were revealed in any of the ANOVAS for either SQ RT or untransformed scores. Therefore the second null hypothesis:

2. There is no significant interaction between Stimulus Type and Hand.

cannot be rejected.

The third hypothesis to be tested is that concerning the interactions of Hand and Visual Field of Presentation, (BXC). The BXC interaction did not reach significance for any of the SQ RT GSR values. However, significant BXC interactions occurred in the untransformed resistance and change in log conductance of initial response ANOVAS ($p<.03$) and for the untransformed change in log conductance average response ANOVA ($p<.04$). The BXC means and standard deviations for untransformed initial and average response data are found in Appendices 4 and 5 respectively.

Simple effects analysis of the BXC interactions for resistance and change in log conductance of initial response and change in log conductance of average response indicated greater magnitude of GSR response for the left than for the right hand when stimuli were presented in the left visual fields. The p values associated with the simple effects analysis for B at C_2 for all three significant BXC interactions was $p < .01$. The simple effects analysis and illustrations of the BXC interactions for initial and average response are found in Appendices 4 and 5 respectively. Thus the third null hypothesis:

> 3. There is no significant Hand by Visual Field of Presentation interaction.

is rejected for untransformed resistance and change in log conductance of initial response, and for change in log conductance of average response, but not for all other SQ RT and other untransformed measures.

The fourth hypothesis for consideration is that concerning the interaction of Stimulus Type and Visual Field of Presentation. Significant AXC interactions occurred in the ANOVAS for SQ RT resistance of initial response and untransformed resistance of initial and average response. The AXC means and standard deviations for the SQ RT initial response measures are contained in Table XIII while those for the untransformed initial and average response measure may be found in Appendices 4 and 5.

Simple effects analysis for all three significant AXC interactions revealed A at C_3 significant with p values

Table XIII.-

Verbal and Nonverbal Means and Standard Deviations for Right, Left and Center Visual Field of Presentation for Square Rooted GSR Measures on Trial 1

			Verbal	Nonverbal
Square Root Resistance Measure				
	Right	$\bar{x}$	2.75	2.70
		sd	2.37	1.14
	Left	$\bar{x}$	3.23	3.62
		sd	1.54	1.84
	Center	$\bar{x}$	4.94	1.91
		sd	3.04	1.47
	Average	$\bar{x}$	3.64	2.75
	Total	sd	2.40	1.51
Square Root Conductance Measure				
	Right	$\bar{x}$	0.48	0.46
		sd	0.38	0.28
	Left	$\bar{x}$	0.57	0.65
		sd	0.41	0.40
	Center	$\bar{x}$	0.67	0.43
		sd	0.42	0.43
	Average	$\bar{x}$	0.57	0.52
	Total	sd	0.40	0.38
Square Root Change in Log Conductance Measure				
	Right	$\bar{x}$	0.13	0.13
		sd	0.10	0.06
	Left	$\bar{x}$	0.15	0.17
		sd	0.08	0.09
	Center	$\bar{x}$	0.21	0.10
		sd	0.12	0.09
	Average	$\bar{x}$	0.16	0.13
	Total	sd	0.10	0.08

as follows: initial response, SQ RT and untransformed measures, $p<.01$; and average response untransformed resistance measure, $p<.03$. Thus GSR response for verbal stimuli was, on the average, significantly greater than for nonverbal stimuli presented in the center visual field, in those ANOVAS revealing significant AXC interactions. The results of the simple effects analysis for SQ RT of initial response in resistance are given in Table XIV and an illustration of the interaction is found in Figure 2 on the following page. Simple effects analyses and illustrations of AXC interactions for initial and average untransformed responses are contained in Appendices 4 and 5.

Simple effects analysis of the AXC interaction for untransformed resistance of initial response also showed C at A1 significant. Tukey *post hoc* tests, however, were not significant for any of the comparisons of individual AC means.

The fourth null hypothesis:

4. There is no significant interaction between *Stimulus Type* and *Visual Field of Presentation*.

can therefore be rejected for initial response SQ RT and untransformed resistance and for average response resistance.

The fifth and final hypothesis to be tested using the GSR measures is that of interaction between *Stimulus Type*, *Hand*, and *Visual Field of Presentation*. No significant

Table XIV.-

First Response: Analysis of Variance Summary Table for Simple Effects on Stimulus Level by Visual Field of Presentation Interaction Using Square Root Resistance Measure

Source of Variability	SS	df	MS	F Ratio
A at c1	0.01	1	0.01	0.001
A at c2	1.52	1	1.52	0.180
A at c3	91.80	1	91.80	10.810 *
C at a1	53.00	2	26.50	3.120
C at a2	29.28	2	14.64	1.720
Error Term	458.49	54	8.49	

$F_{.95}\ (1,54) = 4.02$

$F_{.95}\ (2,54) = 3.17$

* $p < .02$

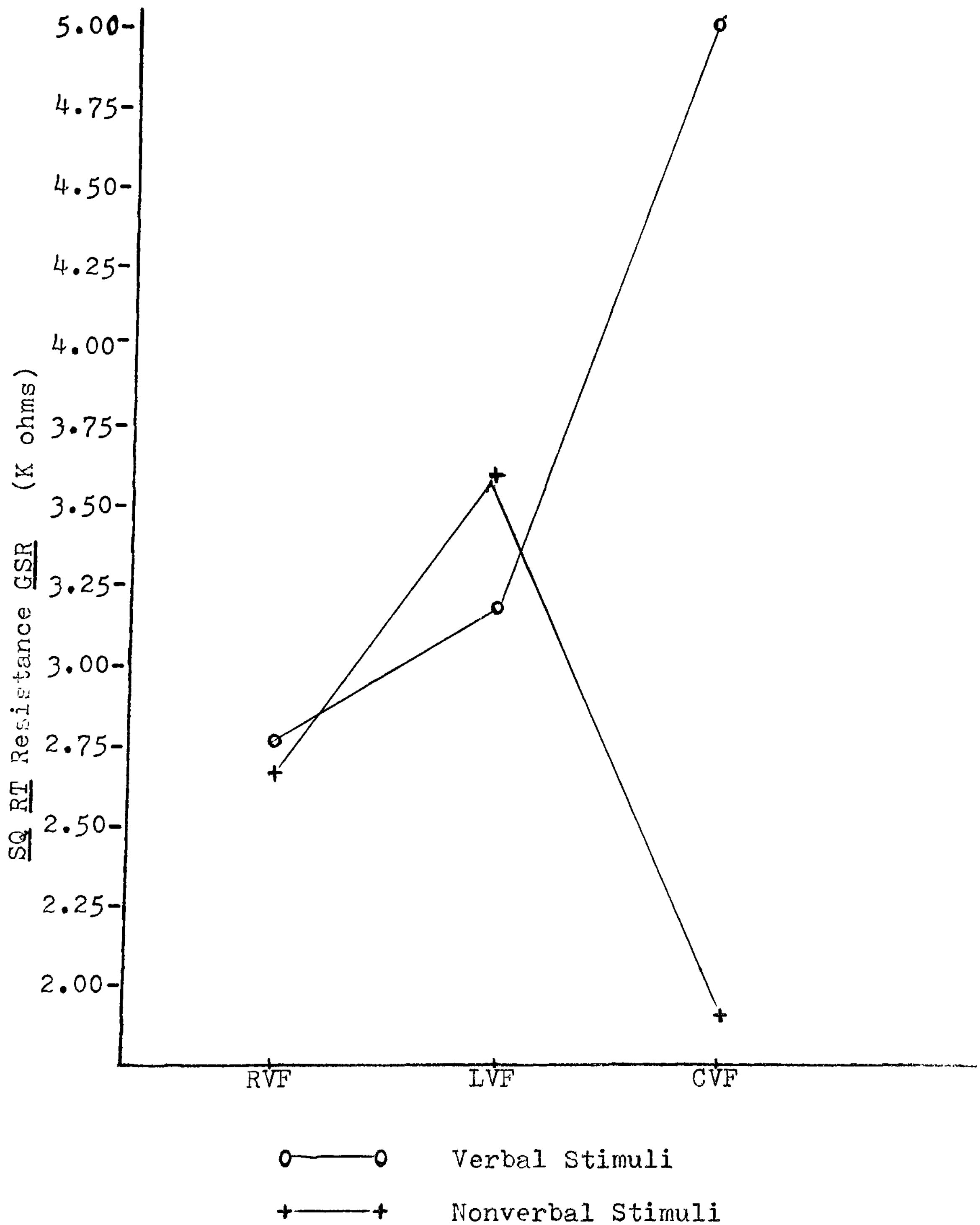

Figure 2.- SQ RT Resistance GSR Stimulus Level by Visual Field of Presentation Interaction.

AXBXC interaction occurred in any of the ANOVAS for SQ RT or untransformed data. Therefore the fifth null hypothesis:

> 5. There is no significant Stimulus Type by Hand by Visual Field of Presentation interaction.

cannot be rejected.

3. Summary of the Results

The results reported in the previous chapter indicated intrasubject differences in resting levels of basal skin resistance; however, no overall differences between right and left hand basal resistance levels emerged when the group was considered as a whole. A cross-over effect was also noted in which the side of higher basal skin resistance was variable throughout the experiment for nine subjects.

ANOVAS of the responses measures revealed no significant interaction between Stimulus Type and Hand or between these two factors and Visual Field of Presentation. The Hand main effect, however, proved to be significant at $p < .02$ for SQ RT resistance and change in log conductance of initial response with the left hand being the site of greater response. A Hand by Visual Field of Presentation interaction was also evident for the untransformed resistance and change in log conductance of initial response and for the untransformed change in log conductance average response measure. In all three of these interactions, the left hand exceeded the right hand response for stimuli presented in the LVF. Finally, a significant Stimulus Type by Visual Field of Presentation interaction occurred in the ANOVAS for SQ RT resistance of initial response and untransformed resistance of initial and average response. In all three interactions, GSR magnitude of response was greater for verbal than for nonverbal stimuli presented in the CVF.

4. Discussion of the Results

The observation of initial basal skin resistance levels revealed twenty-two subjects with higher right hand resting levels and thirty-eight with higher left hand levels. The lack of a consistent relationship between resting skin resistance level and body side is in agreement with findings from several other studies in which subjects were nearly equally divided on this measure.[4,5,6] Furthermore, the finding of variability in the body side of highest basal resistance during the course of the experiment has also been noted

4 J.G. Varni, H.O. Doerr, and J.R. Franklin, "Bilateral Differences in Skin Resistance and Vasomotor Activity," Psychophysiology, Vol. 8, 1971, p. 390-400.

5 D. Crocco, Bilingual Memory and the Orienting Reflex, unpublished Doctoral Thesis presented to the School of Graduate Studies of the University of Ottawa, Ontario, 1974.

6 C.R. Galbrecht, R.A. Dykman, W.G. Reese, and T. Suzuki, "Intrasession Adaptation and Intersession Extinction of the Components of the Orienting Response," Journal of Experimental Psychology, Vol. 70, 1965, p. 585-597.

by one author.[7] No interpretation of these results can be offered from the present study. However, the fact that the relationship of right and left basal resistance levels does not remain static within certain subjects indicates their possible relationship with other environmental or subject variables. Furthermore, it contradicts an explanation in terms of equipment differences or differences in scar tissue in right and left hands.

The first hypothesis tested in this study concerned the relative responsiveness of right and left hands. The results of the analyses indicating greater over-all magnitude of response in the left hand are in agreement with findings of Crocco[8] and Fisher[9] and are further supported by a similar left hand responsiveness under the LVF condition for untransformed resistance of initial response and change in log conductance of initial and average response. The augmentation of the left hand response when stimuli are presented in the LVF (right hemisphere) lends some support to the basic hypothesis of a contralateral relationship between GSR response and hemispheric involvement. While the over-all magnitude

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7 P.A. Obrist, "Skin Resistance Levels and Galvanic Skin Response: Unilateral Differences," Science, Vol. 139, 1963, p. 227-228.

8 Crocco, op cit., p.115.

9 S. Fisher, "Body Image and Asymmetry of Body Reactivity," Journal of Abnormal and Social Psychology, Vol. 57, 1958, p. 292-298.

of left hand response would appear to be greater under all experimental conditions, the possibility remains that this effect is enhanced when right hemisphere (LVF) stimulation is applied.

In this regard, current methods of electrodermal recording and scoring are of interest. Several authors, most notably Lykken[10,11] have advocated the use of a range correction procedure in which the individual's response measure is expressed in terms of estimates of his maximum and minimum levels of response amplitude. Such a technique effectively reduces the error variance and results in larger and more significant treatment effects. A range correction procedure may be particularly useful when using lateral GSR measures, since that portion of the response over and above the normal responsiveness of a given hand may contain important physiological information.

No significant interaction was found between Stimulus Type and Hand or between these two factors and Visual Field of Presentation. Part of the explanation for this may lie in the choice of experimental stimuli for use in this study.

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10 D.T. Lykken, "Range Correction Applied to Heart Rate and GSR Data," Psychophysiology, Vol. 9, 1972, p. 373-379.

11 D.T. Lykken, and P.H. Venables, "Direct Measurement of Skin Conductance: A Proposal for Standardization," Psychophysiology, Vol. 8, 1971, p. 656-672.

While their simplicity may have appropriately eliminated certain contaminating variables such as eye movements, reading habits, and the availability of verbal labels for nonverbal stimuli, it may also have reduced the level of the experimental task to the point where hemispheric differences were effectively eliminated. As indicated in the split-brain studies, both hemispheres retain the ability to perform elementary verbal and perceptual tasks. Moreover, the cerebral hemispheres are able to effect single trial learning with simple stimuli in many instances, making it impossible to differentiate between previously acquired knowledge and the surprisingly rapid ability of certain portions of the brain to take over new functions. Given the basic type of stimuli used in this experiment, both of these explanations are plausible.

Pertinent to the question of stimulus choice are the EEG and evoked potential studies mentioned previously in which more complex tasks comprised the stimulus situation. These included nonverbal tests such as the Kohs Block Design, the Modified Minnesota Paper Form Board Test[12] and the Seashore Tonal Memory Test[13] and verbal tasks such as mentally

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12 D. Galin and R. Ornstein, "Lateral Specialization of Cognitive Mode: An EEG Study," <u>Psychophysiology</u>, Vol. 9, 1972, p. 412-418.

13 J.C. Doyle, R. Ornstein, and D. Galin, "Lateral Specialization of Cognitive Mode II: EEG Frequency Analysis," <u>Psychophysiology</u>, Vol. 11, 1974, p. 567-578.

composing a letter. Another group of investigators manipulated subjects' attention levels through use of high and low significance stimuli.[14] Whereas some individuals were merely presented with the experimental stimuli, another group received instructions to discriminate between certain stimuli. The authors report greatest asymmetry of evoked response under the second condition. It is possible that a similar relationship between lateral GSR and hemispheric engagement would emerge with the use of tasks which are more complex as well as more inherently interesting.

An additional and unexpected finding in this study is that of greater GSR responsiveness for verbal than for nonverbal stimuli presented in the CVF. The results may be attributable to two factors. The first of these is the difference in the informational value of the two types of stimuli. Considered from the point of view of the OR theory, OR's to stimuli with potential informational value (signal stimuli) are reportedly stronger and more resistance to extinction than those to neutral or nonsignal stimuli.[15] Given the greater signal value of the alphabet letter as compared to a pattern of

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14 Y. Matsumiya, V. Tagliasco, C.T. Lambroso, and H. Goodglass, "Auditory Evoked Response: Meaningfulness of Stimuli and Interhemispheric Asymmetry," Science, Vol. 175, p. 790-792.

15 E.N. Sokolov, Perception and the Conditioned Reflex, New York, Pergamon Press, 1963, p. 163.

dots, it is not surprising that greater GSR responses were elicited for verbal stimuli. A second factor and a possible explanation for the occurrence of the verbal-nonverbal difference only under the CVF condition is the fact that the CVF represents the least ambiguous of the three visual field loci. While subjects in the LVF and RVF conditions may have required a number of trials to ascertain the nature of the nonverbal stimuli, and hence have maintained GSR responses in greater magnitude and for more trials, those receiving the stimulus in the CVF probably achieved immediate recognition of both types of stimuli.

While the results of the present study did not support the basic hypothesis of a relationship between lateral GSR and differential hemispheric engagement in the processing of verbal and nonverbal stimuli, several possible avenues of future research in this area are evident. A theory of GSR has recently come to the author's attention in which separate consideration is given to the tonic and phasic aspects of the response. While electrodermal responses to external stimulus agents are seen as reflecting both tonic and phasic activity, under nonspecific stimulus conditions these components may be separated. Thus Katkin[15] and Miller and

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15 E.D. Katkin, "Relationship Between Manifest Anxiety and Two Indices of Autonomic Response to Stress," Journal of Personality and Social Psychology, Vol. 2, 1965, p. 324-333.

Shmanovian[16] both found nonspecific phasic GSR related to differences in experimentally induced stress, while the tonic component was observed to reflect the cognitive activity stimulated by an interview session. Likewise Kilpatrick[17] found tonic skin conductance levels were related to cognitive and perceptual activity on the Halstead Category Test while phasic changes were not. Extending the multiple component theory to lateral electrodermal differences, it is possible that tonic rather than phasic measures are more appropriate indicators of hemispheric activity. Some support for this speculation was obtained in an additional analysis made of the tonic conductance levels in this experiment. Right hand levels were observed to be higher under the verbal as compared to the nonverbal stimulus condition, possibly reflecting left hemisphere engagement. The use of an appropriate range correction method with tonic measures may further clarify these results.

It is the opinion of the writer that the investigation of lateral electrodermal measures and their relationship to

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16 L.H. Miller and B.M. Shmanovian, "Replicability of Two GSR Indices as a Function of Stress and Cognitive Activity," Journal of Personality and Social Psychology, Vol. 2, 1965, p. 753-756.

17 D.G. Kilpatrick, "Differential Responsiveness of Two Electrodermal Indices to Psychological Stress and Performance of a Complex Cognitive Task," Psychophysiology, Vol. 9, 1972, p. 218-226.

hemispheric activity is a worthwhile area for future research. The use of other more complex verbal and nonverbal tasks, the incorporation of a range correction procedure, and attention to the tonic aspect of the GSR are suggested as important questions for consideration in the formulation of new studies.

CONCLUSIONS

The analyses of the experimental results of the present study indicated a significant Hand main effect for SQ RT resistance and change in log conductance of initial response. In both instances the left hand was the side of greater response. A Hand by Visual Field of Presentation interaction occurred in the untransformed resistance and change in log conductance of initial and average response, the left being more responsive than the right hand for stimuli presented in the LVF. These findings were interpretated as indicative of a generally greater reactivity of the left hand with the possibility that this responsiveness is augmented with LVF (right hemisphere) stimulation. The desireability of using a range correction procedure to further clarify lateral GSR differences was discussed.

The null hypotheses regarding a Stimulus Type by Hand interaction and the interaction of these two factors with Visual Field of Presentation were not rejected. Several possible explanations for this are offered including the simplicity of the experimental stimuli, the ability of both hemispheres to process both verbal and nonverbal stimuli of an elementary nature, and the need to engage subjects in more active and complex tasks which might better differentiate hemispheric functioning.

CONCLUSIONS

A significant _Stimulus Type_ by _Visual Field of Presentation_ interaction emerged for _SQ RT_ resistance of initial response and untransformed resistance of initial and average response. In all three instances, greater _GSR_'s occurred to verbal than to nonverbal stimuli presented in the _CVF_. This finding was interpreted as being the result of the greater informational value of the verbal stimuli. That this was evident only in the _CVF_ condition is attributed to the lesser ambiguity of this position allowing for easy discrimination of both stimulus types.

For future studies the use of basal resistance levels is recommended in light of recent findings of a relationship between tonic electrodermal measures and cognitive activity.

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Kimura, D., "Dual Functional Asymmetry of the Brain in Visual Perception," _Neuropsychologia_, Vol. 4, 1966, p. 275-285.
A series of investigations using hemifield presentation of verbal and nonverbal stimuli are summarized and the results related to an evolving theory of right hemisphere functions.

Lykken, D.T. and P. Venables, "Direct Measurement of Skin Conductance: A Proposal for Standardization," _Psychophysiology_, Vol. 8, 1971, p. 656-672.
The authors discuss the problem of standardized techniques for _GSR_ measurement and argue the merits of a constant voltage rather than constant current system.

Varni, J,G,, H.O. Doerr, and J.R. Franklin, "Bilateral Differences in Skin Resistance and Vasomotor Activity," _Psychophysiology_, Vol. 8, 1971, p. 390-400.
Conflicting evidence of lateral electrodermal differences is presented in the context of an attempt to relate lateral differences in skin resistance to other autonomic variables. Special consideration is given to the need to re-evaluate current theories of autonomic arousal.

White, M.J. "Laterality Differences in Perception: A Review," _Psychological Bulletin_, Vol. 72, 1969, p. 387-405.
An excellent review of the relevant findings, problems, and theoretical positions related to the use of visual hemifield presentation techniques.

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The author presents a review of psychometric findings related to hemispheric functional differences in patients with lateralized brain lesions.

APPENDIX 1

EYSENCK PERSONALITY INVENTORY

APPENDIX 1

EYSENCK PERSONALITY INVENTORY

FORM A

By H. J. Eysenck
and Sybil B. G. Eysenck

Name________________________ Age__________ Sex__________

Grade or Occupation________________________ Date__________

School or Firm________________________ Marital Status__________

INSTRUCTIONS

Here are some questions regarding the way you behave, feel and act. After each question is a space for answering "Yes," or "No."

Try and decide whether "Yes," or "No" represents your usual way of acting or feeling. Then blacken in the space under the column headed "Yes" or "No."

Section of Answer Column Correctly Marked

Yes No

Yes No

Work quickly, and don't spend too much time over any question; we want your first reaction, not a long drawn-out thought process. The whole questionnaire shouldn't take more than a few minutes. Be sure not to omit any questions. Now turn the page over and go ahead. Work quickly, and remember to answer every question. There are no right or wrong answers, and this isn't a test of intelligence or ability, but simply a measure of the way you behave.

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BOX 7234, SAN DIEGO, CALIFORNIA 92107

1. Do you often long for excitement? . . . . Yes No

2. Do you often need understanding friends to cheer you up? . . . . Yes No

3. Are you usually carefree? . . . . Yes No

4. Do you find it very hard to take no for an answer? . . . Yes No

5. Do you stop and think things over before doing anything? . . . . Yes No

6. If you say you will do something do you always keep your promise, no matter how inconvenient it might be to do so? . . . . Yes No

7. Does your mood often go up and down? . . . . Yes No

8. Do you generally do and say things quickly without stopping to think? . . . . Yes No

9. Do you ever feel "just miserable" for no good reason? Yes No

10. Would you do almost anything for a dare? . . . . Yes No

11. Do you suddenly feel shy when you want to talk to an attractive stranger? . . . . Yes No

12. Once in a while do you lose your temper and get angry? . . . . Yes No

13. Do you often do things on the spur of the moment? . . Yes No

14. Do you often worry about things you should not have done or said? . . . . Yes No

15. Generally do you prefer reading to meeting people? . . Yes No

16. Are your feelings rather easily hurt? . . . . Yes No

17. Do you like going out a lot? . . . . Yes No

18. Do you occasionally have thoughts and ideas that you would not like other people to know about? . . . . . . Yes No

19. Are you sometimes bubbling over with energy and sometimes very sluggish? . . . . Yes No

20. Do you prefer to have few but special friends? . . . . . Yes No

21. Do you daydream a lot? . . . . Yes No

22. When people shout at you, do you shout back? . . . . . . Yes No

23. Are you often troubled about feelings of guilt? . . . . . . Yes No

24. Are all your habits good and desirable ones? . . . . . Yes No

25. Can you usually let yourself go and enjoy yourself a lot at a gay party? . . . . Yes No

26. Would you call yourself tense or "highly-strung"? . . . Yes No

27. Do other people think of you as being very lively? . . Yes No

28. After you have done something important, do you often come away feeling you could have done better? . . . . Yes No

29. Are you mostly quiet when you are with other people? Yes No

30. Do you sometimes gossip? . Yes No

31. Do ideas run through your head so that you cannot sleep? . . . . Yes No

32. If there is something you want to know about, would you rather look it up in a book than talk to someone about it? . . . . Yes No

33. Do you get palpitations or thumping in your heart? . . . Yes No

34. Do you like the kind of work that you need to pay close attention to? . . . . Yes No

35. Do you get attacks of shaking or trembling? . . . . Yes No

36. Would you always declare everything at the customs, even if you knew that you could never be found out? . . Yes No

37. Do you hate being with a crowd who play jokes on one another? . . . . Yes No

38. Are you an irritable person? . . . . Yes No

39. Do you like doing things in which you have to act quickly? . . . . Yes No

40. Do you worry about awful things that might happen? . . Yes No

41. Are you slow and unhurried in the way you move? . . . Yes No

42. Have you ever been late for an appointment or work? . Yes No

43. Do you have many nightmares? . . . . Yes No

44. Do you like talking to people so much that you would never miss a chance of talking to a stranger? . . . . . . Yes No

45. Are you troubled by aches and pains? . . . . Yes No

46. Would you be very unhappy if you could not see lots of people most of the time? . . . . Yes No

47. Would you call yourself a nervous person? . . . . Yes No

48. Of all the people you know are there some whom you definitely do not like? . . . . Yes No

49. Would you say you were fairly self-confident? . . . . . . Yes No

50. Are you easily hurt when people find fault with you or your work? . . . . Yes No

51. Do you find it hard to really enjoy yourself at a lively party? . . . . Yes No

52. Are you troubled with feelings of inferiority? . . . . . . Yes No

53. Can you easily get some life into a rather dull party?. Yes No

54. Do you sometimes talk about things you know nothing about? . . . . Yes No

55. Do you worry about your health? . . . . Yes No

56. Do you like playing pranks on others? . . . . Yes No

57. Do you suffer from sleeplessness? . . . . Yes No

PLEASE CHECK TO SEE THAT YOU HAVE ANSWERED A

APPENDIX 2

RECALIBRATED VALUES FOR TIMER DIAL OF SCIENTIFIC PROTOTYPE MODEL GB TACHISTOSCOPE

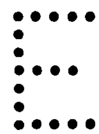
APPENDIX 2

RECALIBRATED VALUES FOR TIMER DIAL OF SCIENTIFIC PROTOTYPE MODEL GB TACHISTOSCOPE

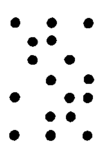
Values Indicated on Timer Dial of Blank Channel of Model GB		Interval Generated When Channel One Set for Stimulus Exposure of 50 milliseconds
Range Dial	Multiplier Dial	
2	10	15.0 seconds
2	20	16.0
2	30	16.5
2	40	17.5
2	50	18.0
2	60	18.5
2	70	19.0
2	80	20.0
2	90	20.5
3	00	21.0
3	10	22.0
3	20	22.5
3	30	23.0
3	40	24.0
3	50	24.5
3	60	25.0
3	70	26.0
3	80	26.5
3	90	27.0
4	00	28.0
4	10	28.5
4	20	29.0
4	30	30.0
4	40	30.5
4	50	31.0
4	60	32.0
4	70	33.0
4	80	33.5
4	90	34.0
5	00	35.0

APPENDIX 3

SAMPLES OF VERBAL AND NONVERBAL TEST STIMULI



VERBAL STIMULUS: CENTER VISUAL FIELD



NONVERBAL STIMULUS : LEFT VISUAL FIELD

APPENDIX 4

(1) MEANS AND STANDARD DEVIATIONS FOR UNTRANSFORMED INITIAL RESPONSE DATA

(2) ANOVAS AND SIMPLE EFFECTS ANALYSES FOR UNTRANSFORMED INITIAL RESPONSE DATA

APPENDIX 4

<u>Verbal</u> and <u>Nonverbal</u> Means and Standard Deviations for <u>Right</u>, <u>Left</u>, and <u>Center</u> Visual Field of Presentation for untransformed <u>GSR</u> Measures on Trial 1

			Verbal	Nonverbal
Resistance Measure				
	Right	$\bar{x}$	13.23	8.64
		sd	16.28	6.44
	Left	$\bar{x}$	13.07	16.55
		sd	8.81	15.48
	Center	$\bar{x}$	33.63	5.81
		sd	36.52	6.63
	Average	$\bar{x}$	19.98	10.33
	Total	sd	23.64	10.41
Conductance Measure				
	Right	$\bar{x}$	0.38	0.29
		sd	0.43	0.67
	Left	$\bar{x}$	0.49	0.59
		sd	0.49	0.61
	Center	$\bar{x}$	0.62	0.37
		sd	0.62	0.55
	Average	$\bar{x}$	0.50	0.42
	Total	sd	0.52	0.61
Change in Log Conductance				
Measure	Right	$\bar{x}$	0.027	0.020
		sd	0.034	0.016
	Left	$\bar{x}$	0.031	0.038
		sd	0.024	0.034
	Center	$\bar{x}$	0.056	0.018
		sd	0.050	0.022
	Average	$\bar{x}$	0.038	0.025
	Total	sd	0.038	0.025

APPENDIX 4

Right and Left Hand Means and Standard Deviationa for Right Left, and Center Visual Field of Presentation for untransformed GSR Measures on Trial 1

			Right Hand	Left Hand
Resistance Measure				
	Right	x̄	10.70	11.16
		sd	17.02	16.40
	Left	x̄	11.74	17.89
		sd	9.69	14.94
	Center	x̄	20.65	18.80
		sd	29.25	22.84
	Average Total	x̄	14.36	15.95
		sd	20.33	18.39
Conductance Measure		x̄	0.31	0.36
	Right	sd	0.35	0.72
	Left	x̄	0.51	0.58
		sd	0.56	0.55
	Center	x̄	0.51	0.47
		sd	0.60	0.58
	Average Total	x̄	0.45	0.47
		sd	0.51	0.62
Change in Log Conductance Measure				
	Right	x̄	0.021	0.025
		sd	0.022	0.031
	Left	x̄	0.029	0.040
		sd	0.025	0.032
	Center	x̄	0.038	0.035
		sd	0.043	0.033
	Average Total	x̄	0.030	0.033
		sd	0.032	0.032

APPENDIX 4

Initial Response: Analysis of Variance Using Resistance Measure

"A" Factor: Verbal vs. Nonverbal Stimuli
"B" Factor: Right vs. Left Hand
"C" Factor: Right, Left, Center Visual Field of Presentation

Source of Variance	SS	df	MS	F Ratio
A	2789.81	1	2789.81	3.54
C	1552.36	2	776.17	0.98
AXC	5281.49	2	2640.75	3.35*
D	42607.66	54	789.03	
B	75.52	1	75.52	1.66
AXB	1.59	1	1.59	0.03
BXC	339.04	2	169.52	3.72**
AXBXC	63.90	2	31.95	0.70
BXD	2460.09	54	45.56	

$F_{.95}$ (1,54) = 4.02

$F_{.95}$ (2,54) = 3.17

* $p < .04$

** $p < .03$

APPENDIX 4

Initial Response Analysis of Variance Summary Table for Simple Effects on Resistance GSR Measure Stimulus Type by Visual Field of Presentation Interaction

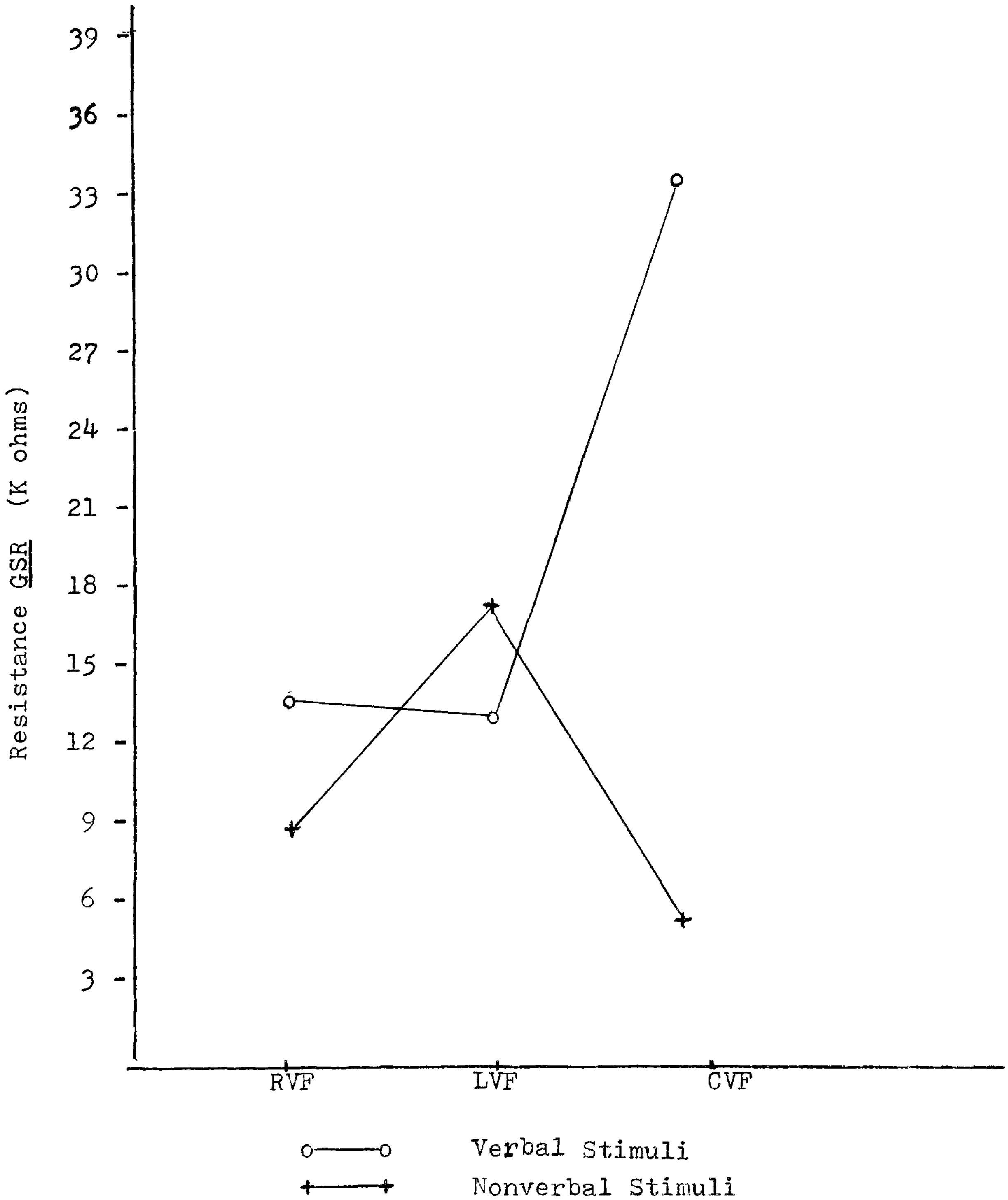
Source of Variance	SS	df	MS	F Ratio
A at c1	210.68	1	210.68	0.27
A at c2	121.11	1	121.10	0.15
A at c3	7739.52	1	7739.52	9.80**
C at a1	5594.01	2	2797.01	3.55*
C at a2	1239.84	2	619.92	0.79
Error Term	42607.66	54	789.03	

$F_{.95}$ (1,54) = 4.02

$F_{.95}$ (2,54) = 3.17

** $p < .01$

* $p < .05$



Resistance GSR Stimulus Type by Visual Field of Presentation Interaction - Initial Response

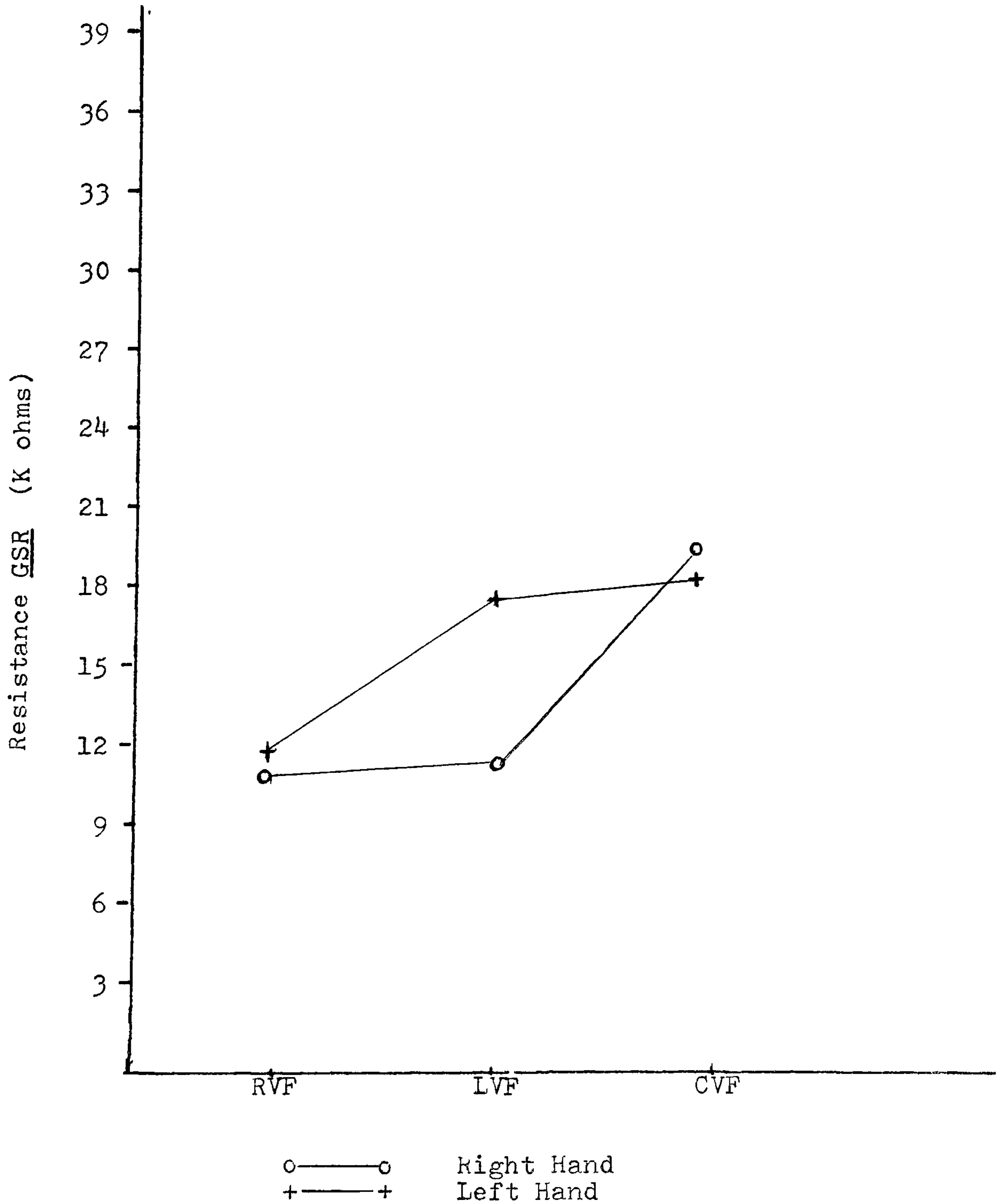
Initial Response Analysis of Variance Summary Table for Simple Effects on Resistance GSR Measure Hand by Visual Field of Presentation Interaction

Source of Variance	SS	df	MS	F Ratio
B at c1	1.12	1	1.12	0.02
B at c2	378.20	1	378.20	11.04*
B at c3	34.23	1	34.23	0.08
Error Term	2460.09	54	45.55	
C at b1	1196.58	2	598.29	1.43
C at b2	696.60	2	348.30	0.83
Error Term (pooled)	45067.32	108	417.29	

$F_{.95}$ (1,54) = 4.02

$F_{.95}$ (2,108) = 3.17

* $p < .01$



Resistance GSR Hand by Visual Field of Presentation Interaction - Initial Response

Initial Response: Analysis of Variance Using Change in Conductance Measure

"A" Factor: Verbal vs. Nonverbal Stimuli
"B" Factor: Right vs. Left Hand
"C" Factor: Right, Left, Center Visual Field of Presentation

Source of Variance	SS	df	MS	F Ratio
A	0.18431	1	0.18431	0.33
C	0.95453	2	0.47727	0.86
AXC	0.61005	2	0.30503	0.55
D	29.94463	54	0.55453	
B	0.01368	1	0.01368	0.52
AXB	0.00040	1	0.00040	0.02
BXC	0.06832	2	0.03416	1.30
AXBXC	0.08034	2	0.04172	1.53
BXD	1.41330	54	0.02617	

$F_{.95}\ (1,54) = 4.02$

$F_{.95}\ (2,54) = 3.17$

APPENDIX 4

Initial Response: Analysis of Variance Using Change in Log Conductance Measure

"A" Factor: Verbal vs. Nonverbal Stimuli
"B" Factor: Right vs. Left Hand
"C" Factor: Right, Left, Center Visual Field of Presentation

Source of Variance	SS	df	MS	F Ratio
A	0.00464	1	0.00464	2.17
C	0.00427	2	0.00214	0.99
AXC	0.01053	2	0.00526	2.46
D	0.11560	54	0.00214	
B	0.00037	1	0.00037	3.03
AXB	0.00002	1	0.00002	0.16
BXC	0.00093	2	0.00047	3.84*
AXBXC	0.00038	2	0.00019	1.55
BXD	0.00656	54	0.00012	

$F_{.95}\ (1,54) = 4.02$

$F_{.95}\ (2,54) = 3.17$

* $p < .03$

APPENDIX 4

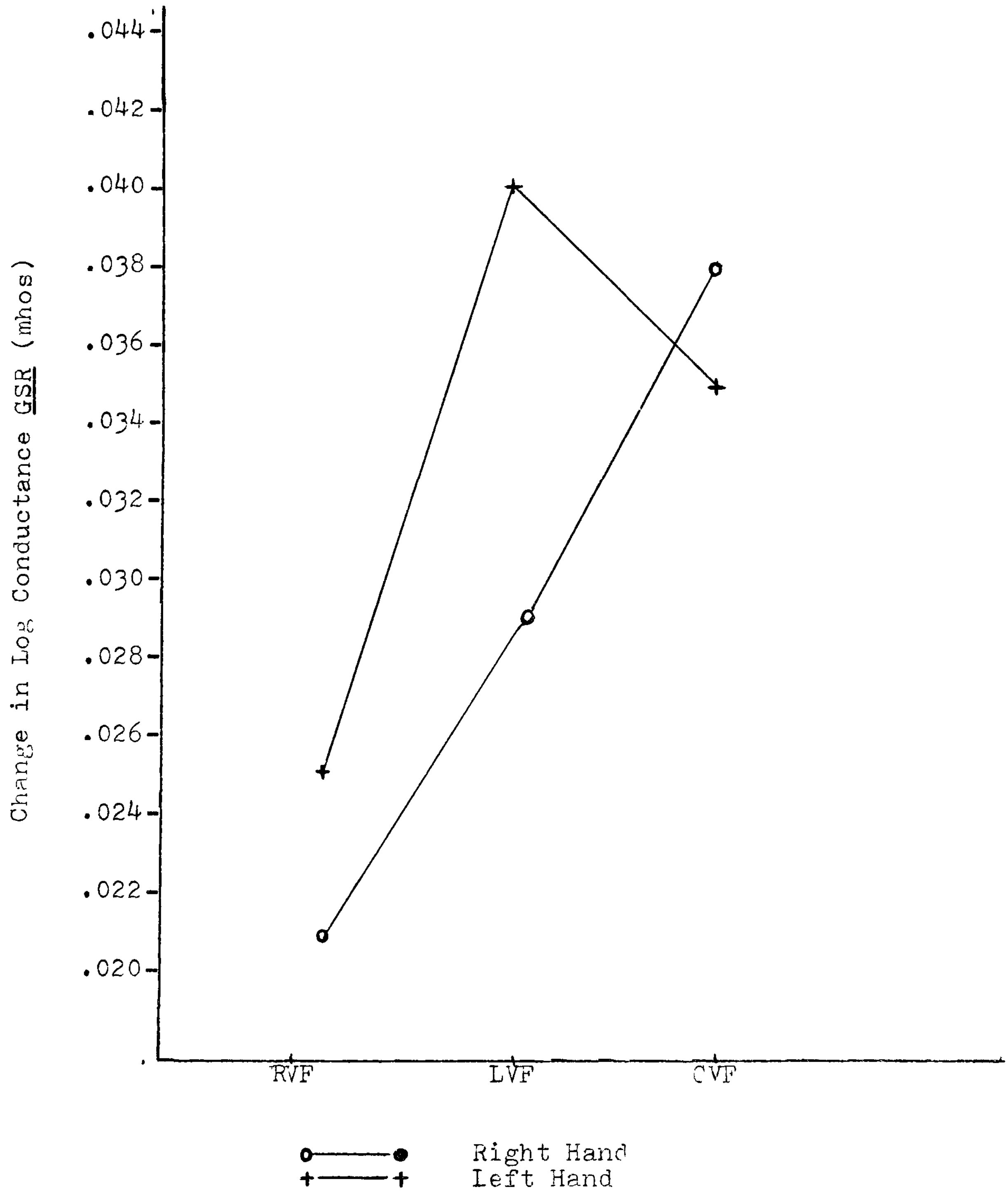
Initial Response Analysis of Variance Summary Table for Simple Effects on Change in Log Conductance GSR Measure Hand by Visual Field of Presentation Interaction

Source of Variance	SS	df	MS	F Ratio
B at c1	0.00015	1	0.00015	1.24
B at c2	0.00112	1	0.00112	9.26*
B at c3	0.00010	1	0.00010	0.83
Error Term	0.00655	54	0.00012	
C at b1	0.00290	2	0.00145	1.28
C at b2	0.00240	2	0.00120	1.06
Error Term (pooled)	0.12215	108	0.00113	

$F_{.95}\ (1,54) = 4.02$

$F_{.95}\ (2,108) = 3.17$

* $p < .01$



Change in Log Conductance GSR Hand by Visual Field of Presentation Interaction - Initial Response

APPENDIX 5

(1) MEANS AND STANDARD DEVIATIONS FOR UNTRANSFORMED AVERAGE RESPONSE DATA

(2) ANOVAS AND SIMPLE EFFECTS ANALYSES FOR UNTRANSFORMED AVERAGE RESPONSE DATA

APPENDIX 5

Verbal and Nonverbal Means and Standard Deviations for Right Left and Center Visual Field of Presentation for Untransformed Average GSR Measures

			Verbal	Nonverbal
Resistance Measure				
	Right	$\bar{x}$	1.86	3.02
		sd	3.24	4.86
	Left	$\bar{x}$	2.44	4.03
		sd	3.53	4.09
	Center	$\bar{x}$	5.37	2.41
		sd	8.77	3.66
	Average	$\bar{x}$	3.22	3.15
	Total	sd	5.77	4.23
Conductance Measure				
	Right	$\bar{x}$	0.09	0.11
		sd	0.14	0.14
	Left	$\bar{x}$	0.12	0.11
		sd	0.19	0.19
	Center	$\bar{x}$	0.11	0.11
		sd	0.19	0.18
	Average	$\bar{x}$	0.11	0.11
	Total	sd	0.18	0.17
Change in Log Conductance				
Measure	Right	$\bar{x}$	0.005	0.008
		sd	0.007	0.010
	Left	$\bar{x}$	0.007	0.007
		sd	0.010	0.010
	Center	$\bar{x}$	0.009	0.006
		sd	0.016	0.010
	Average	$\bar{x}$	0.007	0.007
	Total	sd	0.012	0.010

Right and Left Hand Means and Standard Deviations for Right Left and Center Visual Field of Presentation for Untransformed Average GSR Measures

			Right Hand	Left Hand
Resistance Measure				
	Right	$\bar{x}$	2.90	2.99
		sd	3.89	4.36
	Left	$\bar{x}$	2.27	3.19
		sd	3.14	4.40
	Center	$\bar{x}$	4.15	3.63
		sd	7.15	5.83
	Average Total	$\bar{x}$	3.11	3.27
		sd	5.21	4.91
Conductance Measure				
	Right	$\bar{x}$	0.09	0.10
		sd	0.13	0.15
	Left	$\bar{x}$	0.11	0.13
		sd	0.18	0.20
	Center	$\bar{x}$	0.11	0.11
		sd	0.20	0.17
	Average Total	$\bar{x}$	0.11	0.11
		sd	0.17	0.18
Change in Log Conductance Measure				
	Right	$\bar{x}$	0.006	0.007
		sd	0.007	0.009
	Left	$\bar{x}$	0.006	0.009
		sd	0.008	0.011
	Center	$\bar{x}$	0.008	0.008
		sd	0.013	0.012
	Average Total	$\bar{x}$	0.007	0.007
		sd	0.010	0.011

Average Response: Analysis of Variance Using Resistance Measure

"A" Factor: Verbal vs. Nonverbal Stimuli
"B" Factor: Right vs. Left Hand
"C" Factor: Right, Left, Center Visual Field of Presentation

Source of Variance	SS	df	MS	F Ratio
A	0.15	1	0.15	0.01
C	30.50	2	15.25	0.79
AXC	138.12	2	69.06	3.58*
D	1041.15	54	19.29	
B	0.76	1	0.76	0.36
AXB	1.06	1	1.06	0.51
BXC	10.55	2	5.28	2.52
AXBXC	0.71	2	0.35	0.17
BXD	112.89	54	2.09	

$F_{.95}(1,54) = 4.02$

$F_{.95}(2,54) = 3.17$

* $p < .02$

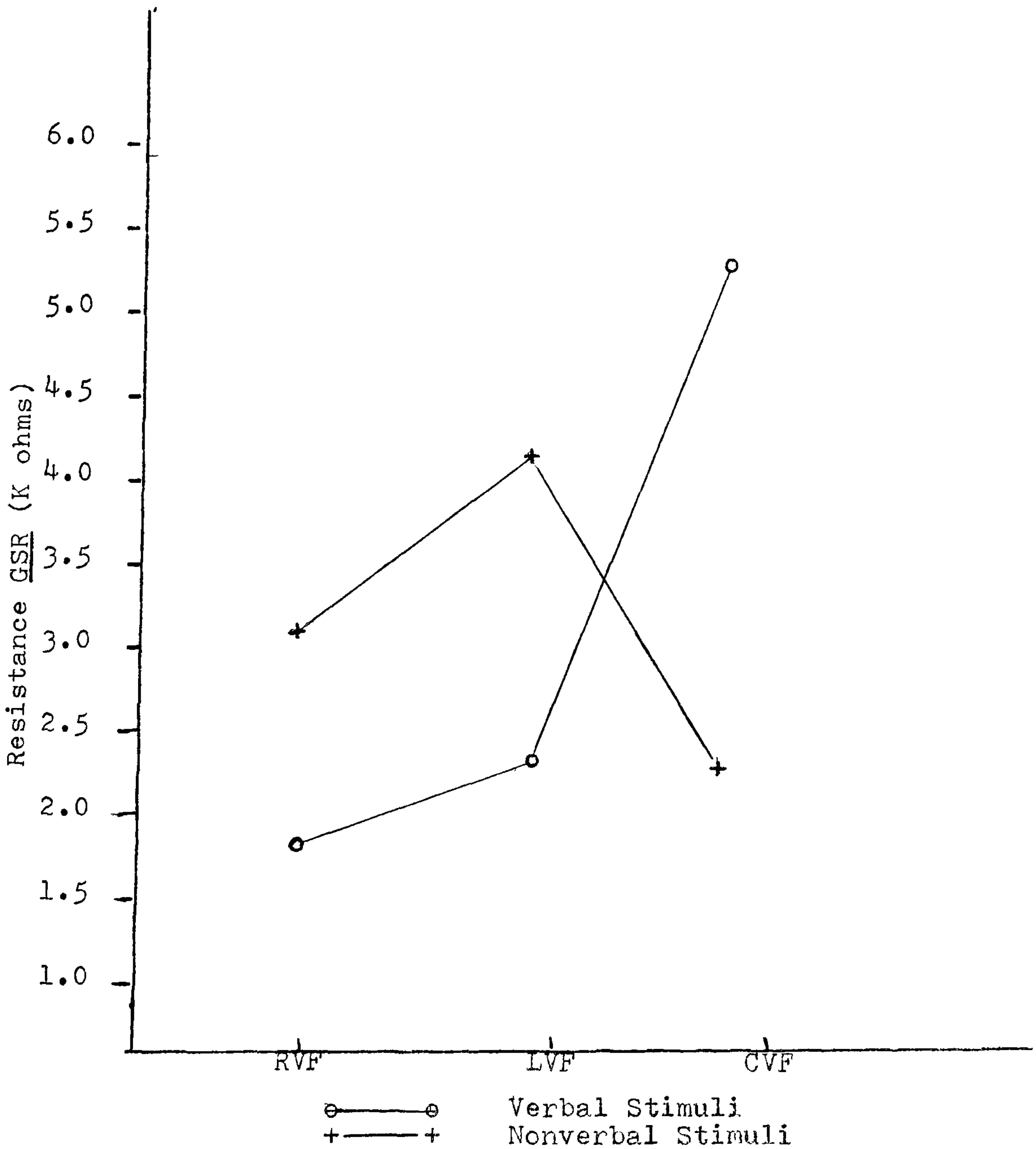
Mean Response Analysis of Variance Summary Table for Simple Effects on Resistance GSR Measure Stimulus Type by Visual Field of Presentation Interaction

Source of Variance	SS	df	MS	F Ratio
A at c1	47.09	1	47.09	2.44
A at c2	3.25	1	3.25	0.17
A at c3	87.62	1	87.62	4.54*
C at a1	282.60	2	141.30	7.33*
C at a2	53.56	2	26.78	1.39
Error Term	1041.51	54	19.29	

$F_{.95}(1,54) = 4.02$

$F_{.95}(2,54) = 3.17$

* $p < .03$



Resistance GSR Stimulus Level by Visual Field of Presentation Interaction - Average Response

Average Response: Analysis of Variance Using Conductance Measure

"A" Factor: Verbal vs. Nonverbal Stimuli
"B" Factor: Right vs. Left Hand
"C" Factor: Right, Left, Center Visual Field of Presentation

Source of Variance	SS	df	MS	F Ratio
A	0.0001	1	0.0001	0.004
C	0.0093	2	0.0047	0.164
AXC	0.0057	2	0.0028	0.099
D	1.5400	54	0.0285	
B	0.0013	1	0.0013	0.679
AXB	0.0018	1	0.0018	0.989
BXC	0.0032	2	0.0016	0.857
AXBXC	0.0019	2	0.0010	0.513
BXD	0.1001	54	0.0019	

$F_{.95}\ (1,54) = 4.02$

$F_{.95}\ (2,54) = 3.17$

Average Response: Analysis of Variance Using Change in Log Conductance Measure

"A" Factor: Verbal vs. Nonverbal Stimuli
"B" Factor: Right vs. Left Hand
"C" Factor: Right, Left, Center Visual Field of Presentation

Source of Variance	SS	df	MS	F Ratio
A	0.000006	1	0.000006	0.006
C	0.000044	2	0.000022	0.228
AXC	0.000195	2	0.000097	1.001
D	0.005226	54	0.000097	
B	0.000011	1	0.000011	2.182
AXB	0.000007	1	0.000007	0.147
BXC	0.000034	2	0.000017	3.356*
AXBXC	0.000001	2	0.000001	0.096
AXD	0.000272	54	0.000005	

$F_{.95}$ (1,54) = 4.02

$F_{.95}$ (2,54) = 3.17

* $p < .04$

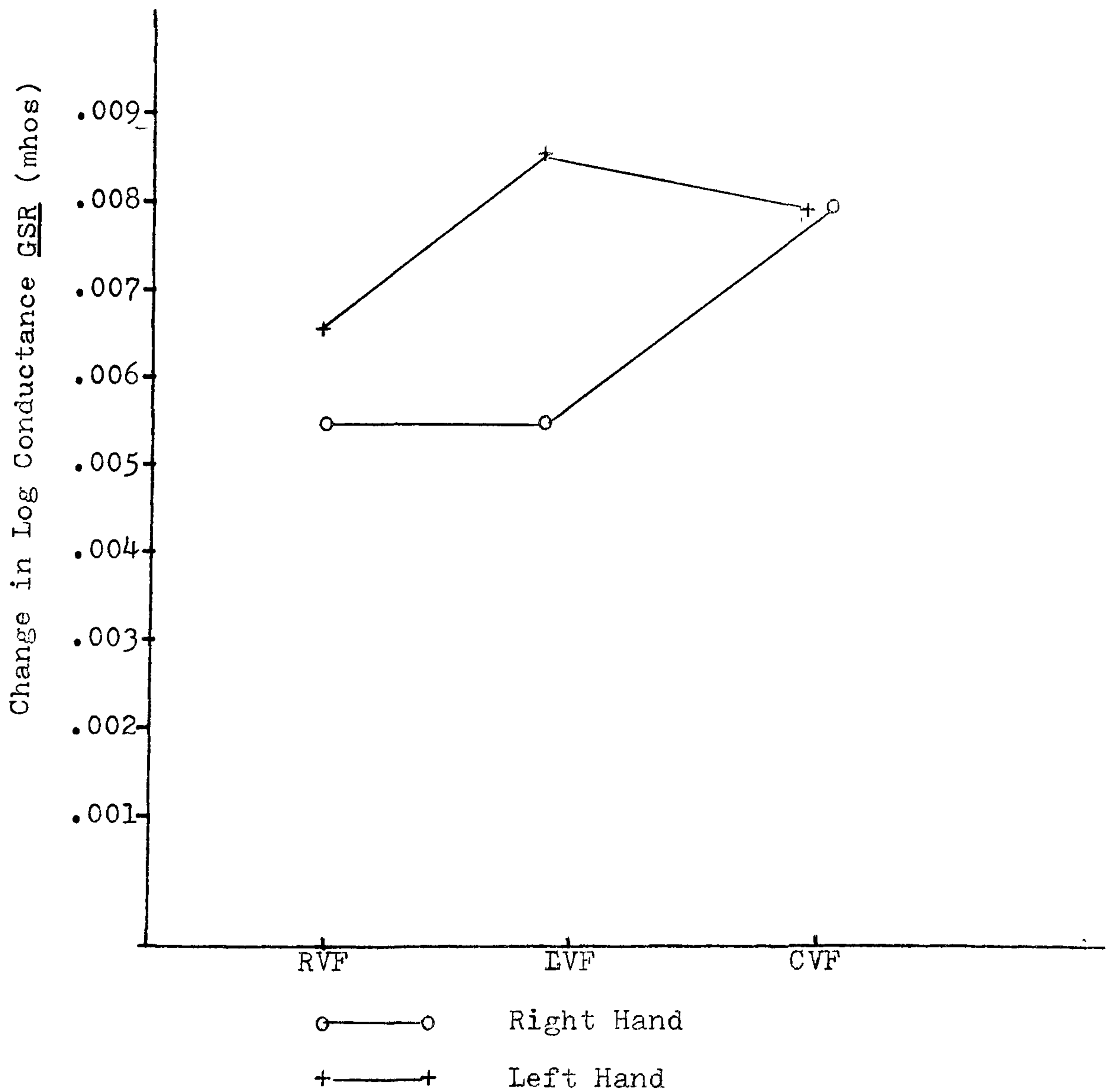
Average Response Analysis of Variance Summary Table for Simple Effects on Change in Log Conductance GSR Measure Hand by Visual Field of Presentation Interaction

Source of Variance	SS	df	MS	F Ratio
B at c1	0.000001	1	0.000001	0.20
B at c2	0.000040	1	0.000040	8.00*
B at c3	0.000004	1	0.000004	0.80
Error Term	0.000272	54	0.000005	
C at b1	0.000059	2	0.000030	0.59
C at b2	0.000020	2	0.000010	0.20
Error Term (pooled)	0.005498	108	0.000051	

$F_{.95}\ (1,54) = 4.02$

$F_{.95}\ (2,108) = 3.17$

* $p < .01$



Change in Log Conductance GSR Hand by Visual Field of Presentation Interaction - Average Response

APPENDIX 6

ABSTRACT OF

Hemispheric Functional Asymmetry
and
Lateral Differences in Galvanic Skin Response

APPENDIX 6

ABSTRACT OF

Hemispheric Functional Asymmetry and Lateral Differences in Galvanic Skin Response[1]

This study investigated the relationship of lateral differences in galvanic skin response to hemispheric stimulation and the processing of verbal and nonverbal stimuli. Two types of stimuli (Verbal and Nonverbal) were tachistoscopically presented at three different positions in the visual field, Right, Left and Center, corresponding to stimulus delivery to left, right, and both hemispheres respectively. Changes in resistance (GSR) were recorded simultaneously from right and left hands.

Previous research focusing on lateral electrodermal measures has revealed significant differences in reactivity which have been related to differences in body image, handedness, individual autonomic patterns, and site of stimulation. Several studies using lateralized shocks and muscular activity have found the GSR to be augmented on the

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1 Kathleen A. Simas, Masters thesis presented to the School of Graduate Studies of the University of Ottawa, Ontario, 1975, viii-105 p.

side ipsalateral to stimulation. The probability of confounding movement artifacts in such studies, however, makes these results questionable. Moreover, in none of the studies have stimuli been lateralized in terms of hemispheric stimulation or type of stimuli for which the hemisphere is specialized. The present study sought to investigate the relationship of these two variables to lateral GSR measures. More specifically, given the contralateral control of the GSR at the cortical level, it was predicted that hemispheric stimulation via stimulus presentation in the opposite visual hemifield would result in an augmented response in the hand site contralateral to the hemisphere stimulated.

The null hypothesis concerning Hand differences was rejected for SQ RT resistance and change in log conductance of initial response with the left side being more responsive than the right regardless of stimulus or visual field of presentation. A significant Hand by Visual Field of Presentation interaction for untransformed resistance and change in log conductance of initial and average response showed left hand to be more responsive than the right hand for stimuli presented in the left visual field. A significant Stimulus Type by Visual Field of Presentation for SQ RT resistance of initial response and untransformed resistance of initial and average response revealed GSR's greater for verbal than nonverbal stimuli presented in the center visual field.

The general lack of support for the hypothesis regarding lateral GSR measures and visual field of presentation (hemispheric stimulation) and for the relationship of these two variables to stimulus type is attributed to the failure of the experimental stimuli to discriminantly engage the hemispheres in specialized activity, to the difficulties in the methodology for scoring the GSR record, and to the insensitivity of the phasic GSR to cognitive activity. The use of more complex cognitive tasks, the adoption of a range correction procedure, and the analyses of tonic electrodermal measures are suggested as modifications for future studies of this kind.