

INFORMATION TO USERS

The most advanced technology has been used to photograph and reproduce this manuscript from the microfilm master. UMI films the original text directly from the copy submitted. Thus, some dissertation copies are in typewriter face, while others may be from a computer printer.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyrighted material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each oversize page is available as one exposure on a standard 35 mm slide or as a 17" × 23" black and white photographic print for an additional charge.

Photographs included in the original manuscript have been reproduced xerographically in this copy. 35 mm slides or 6" × 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.



300 North Zeeb Road, Ann Arbor, MI 48106-1346 USA

Order Number 8820901

**Hemispheric specialization and individual differences in visual
information processing**

Sherman, Rochelle Schwartz, Ph.D.

City University of New York, 1988

Copyright ©1987 by Sherman, Rochelle Schwartz. All rights reserved.

U·M·I
300 N. Zeeb Rd.
Ann Arbor, MI 48106

PLEASE NOTE:

In all cases this material has been filmed in the best possible way from the available copy. Problems encountered with this document have been identified here with a check mark ✓.

1. Glossy photographs or pages _____
2. Colored illustrations, paper or print _____
3. Photographs with dark background _____
4. Illustrations are poor copy _____
5. Pages with black marks, not original copy ✓
6. Print shows through as there is text on both sides of page _____
7. Indistinct, broken or small print on several pages ✓
8. Print exceeds margin requirements _____
9. Tightly bound copy with print lost in spine _____
10. Computer printout pages with indistinct print _____
11. Page(s) _____ lacking when material received, and not available from school or author.
12. Page(s) _____ seem to be missing in numbering only as text follows.
13. Two pages numbered _____. Text follows.
14. Curling and wrinkled pages _____
15. Dissertation contains pages with print at a slant, filmed as received _____
16. Other _____



HEMISPHERIC SPECIALIZATION AND INDIVIDUAL
DIFFERENCES IN VISUAL INFORMATION
PROCESSING

by

ROCHELLE SCHWARTZ SHERMAN

A dissertation submitted to the Graduate Faculty
in Psychology in partial fulfillment of the
requirements for the degree of Doctor of Philosophy,
The City University of New York.

1988

© 1987

ROCHELLE SCHWARTZ SHERMAN

All Rights Reserved

This manuscript has been read and accepted for the Graduate Faculty in Psychology in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

12/20/87
Date

Jose M. Koley, Ph.D.
Chair of Examining Committee

January 5, 1988
Date

Herbert J. Sobelstein
Executive Officer

Leslie Burton, Ph.D.

Susan Egelko, Ph.D.

Donald Heller, Ph.D.

The City University of New York

Abstract

HEMISPHERE SPECIALIZATION AND
INDIVIDUAL DIFFERENCES IN VISUAL
INFORMATION PROCESSING

by

Rochelle Schwartz Sherman

Adviser: Dr. Jane Healey

Sergent (1982d,e) developed a theory of hemispheric specialization in which superiorities for processing verbal/spatial and verbal/analytic information is related to hemispheric specialization for processing spatial frequencies. She theorized that the right hemisphere (RH) is better at processing low spatial frequencies and the left hemisphere (LH) is specialized at processing high spatial frequencies. The present study sought to replicate and extend Sergent's theory by examining patterns of hemispheric superiority as a function of spatial frequency, gender and cognitive strategies. Eighteen right handed males and 18 right handed females were tested in a variation of Sergent's original experimental procedure. Spatial frequency was manipulated by rapidly presenting large letters (i.e. low spatial frequency components) constructed of small letters (i.e. high spatial frequency components) on a computer screen in the left and right visual fields. A response consisted of the depression of the keyboard

space bar. Subjects were asked to depress the bar if a defined target letter appeared as either the large or small letter (or both). Response times were measured in milliseconds. In a counterbalanced design procedure, half of the subjects were instructed to process the stimuli in a large-to-small processing order while the other half were instructed to process the stimuli in a small-to-large order.

Sergent's findings were partially replicated in that RH superiorities occurred when the large letters were target letters. Conversely, LH superiorities occurred when the small letters were target letters. However, these predicted patterns were found in only half on the subjects.

Instructional strategy did influence the direction of hemispheric superiority but not as dramatically as expected and not consistently. There were no sex differences in response times, laterality patterns or performance on cognitive tests. However, females showed much stronger laterality patterns. Overall, the findings tended to support Sergent's basic premise, although the present findings suggest that individual differences can differ from group effects and that important individual differences, such as sex differences in the degree and patterning of laterality, can be masked by group effects.

ACKNOWLEDGMENTS

Many family members, faculty members, friends, neighbors and fellow graduate students contributed to this dissertation; I am indebted to them all. This project would not have been brought to fruition without the keen and steady mentorship of my Committee Chairman, Dr. Jane Healey. Jane's friendship and support was critical and I am proud that Dr. Healey's name is on this dissertation. Drs. Louis Gerstman, Donald Heller, Leslie Burton and Susan Egelko were wonderful and I cannot imagine a Committee as helpful and supportive as mine.

This dissertation would not have been completed without the support of Drs. Steven Kaye and Sherry Pally. Steve's technical expertise and statistical savvy guided me through many critical moments. Sherry's advise and emotional support was enduring and much appreciated.

My parents and grandparents were there when I needed financial aid and babysitting assistance after the birth of my daughter, Sari Helena. Sari was born in the midst of all the confusion and I hope I can make it up to her one day by helping her with her own career development. This dissertation provided my father with many opportunities to stay with Sari and their relationship has a bitter sweet irony, as my father's affliction with Parkinson's disease was the catalyst in my becoming a neuropsychologist.

My apologies to my husband Ken, as well as to Sari, for our missed weekends and nights together. I hope we have many years together in which to make up for all the lost time.

TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT	iv
ACKNOWLEDGMENTS	vi
LIST OF TABLES	ix
LIST OF FIGURES	xi
CHAPTER ONE: INTRODUCTION	1
CHAPTER TWO: METHODS	51
CHAPTER THREE: RESULTS	58
CHAPTER FOUR: DISCUSSION	74
CHAPTER FIVE:	
APPENDIX A. Directions	122
APPENDIX B. Gestalt Completion Test	125
APPENDIX C. Hidden Figures Test	129
APPENDIX D. Rey-Osterreith Test	132
APPENDIX E. Handedness Questionnaire	133
CHAPTER SIX: REFERENCES	134

LIST OF TABLES

<u>Table No.</u>		<u>Page</u>
1	Stimulus Condition	98
2	Sergent's Data	99
3	Mean Response Times and S.D.s For Each Stimulus Condition	100
4	Mean Response Times and S.D.s For Each Instructional Set	101
5	Mean Response Times and S.D. for Each Visual Field	102
6	Mean Response Times and S.D.s for Each Sex Across Stimulus Condition, Instructional Set and Visual Field ...	103
7	Stimulus Condition x Visual Field	104
8	Mean Response Times and S.D.s For Each Instructional Set by Sex by VF	105
9	Mean Response Times for Instructional Sets by Sex by Visual Field	106
10	Mean Response Times and S.D. as Function of Instructional Set, Stimulus Condition and Visual Field	107
11	Instructional Set x Stimulus Condition x Visual Field	108
12	Mean Response Times and S.D.s as Function of Instructional Set and Stimulus Condition	109
13	Mean Response Times and S.D.s as Function of Sex, Instructional Set, Stimulus Condition and Visual Field	110
14	Patterns of Perceptual Asymmetries Across Instructional Set	111
15	Perceptual Asymmetry Patterns with Magnitudes Above or Below One S.D. for Conditions 3 and 4	112
16	Intercorrelations of Cognitive Means with Perceptual Asymmetry Scores	113
17	Means and S.D. for Cognitive Tests	114

18	Intercorrelations Between Cognitive Means and Conformity Index	115
19	Intercorrelations Between Cognitive Means and Instructional Set	116

LIST OF FIGURES

<u>Figure No.</u>		<u>Page</u>
1	Visual Pathways and Lateralization	117
2	Sample of Sergeant's Stimuli	118
3	Instructional Set x Stimulus Condition All Subjects	119
4	Instructional Set x Stimulus Condition Females Subjects	120
5	Instructional Set x Stimulus Condition Male Subjects	121

CHAPTER ONEINTRODUCTION

Neuropsychological research has increased dramatically over the last fifty years. Evidence has accumulated which demonstrates that a wide variety of cognitive functions can be localized to either the left or right hemisphere. Most of this evidence has been derived from clinical observations and behavioral studies of individuals who have suffered unilateral cerebral damage as a result of vascular disease, tumor or injury (Geschwind, 1970; Luria, 1966); surgical intervention for severe epilepsy or tumor (e.g. temporal lobectomy, Milner, 1970; commissurotomy, Levy-Agresti and Sperry, 1968; Gazzaniga, 1970; and hemispherectomy. Smith, 1974). Corroborating evidence has also been obtained from studies involving direct cortical stimulation (Penfield and Roberts, 1959) and pharmacological agents (Wada and Rasmussen, 1960). Extensive clinical studies of brain damaged individuals have attributed verbal functions to the left hemisphere (Hecaen, 1962, 1976, 1978, 1980) and nonverbal visuospatial functions to the right hemisphere (Benton, 1969, 1977, 1979; Benton and Van Allen, 1968; Hecaen, 1962). Morphological differences between the hemispheres have been found as well (Geschwind and Levitsky, 1968).

Due to ethical and practical limitations in studying clinical populations, as well as technological advances, there has been a tremendous increase in the body of literature demonstrating differences in hemispheric specialization in normal subjects using a wide variety of experimental techniques. One of the most common experimental techniques involves tachistoscopic presentation of visual information exclusively to either the right or left visual field. Since this dissertation also involves tachistoscopic or visual half field presentation, a brief review of the technique will be presented below.

Tachistoscopes utilize the natural decussation or splitting of information along the visual pathways to the left and right side of the brain. In tachistoscopic experiments, visual stimuli are presented briefly to either the left or right of a centrally located fixation point and accuracy and/or reaction time of verbal or manual responses are measured. The neurophysiology of the human visual system contains four hemiretinal visual fields. The nasal hemiretinas cross so that information is transmitted to the contralateral hemisphere (see Fig. 1). Information projected onto the left hemiretina and coming from the left visual field (LVF) is transmitted to the visual cortex of the right hemisphere (RH), while information projected to the right hemiretina and coming from the right visual field (RVF) is directed to the visual cortex of the left hemisphere (LH). Visual

information is shared between the two visual fields through saccadic movements of the eyes as well as through the transmission of information through the splenium or posterior end of the corpus callosum. Tachistoscopes, which can present visual information at rates which are fast enough to elude saccadic eye movements, are able to present stimuli exclusively to one visual half field. Thus, the relative supremacy of each hemisphere for particular types of stimulus material or type of information processing can be examined, since faster reaction times and/or increased accuracy are expected for information presented to the visual field contralateral to the hemisphere best suited to process that specific type of stimulus material.

Theories of Hemispheric Specialization

Material Specific Theories

Broca (1861), Dax (1865) and Jackson (1879), were among the first investigators to describe selective language disturbances in individuals with damage to the left cerebral hemisphere. By 1900 there was a consensus among investigators that language functions were located in the left hemisphere, although there was still virtually no understanding of what cognitive functions, if any, were controlled by the right hemisphere. It was not until the 1930s, and the systematic investigation of brain damaged and normal individuals on a variety of cognitive measures, that the right hemisphere lost its

"non-dominant" or ancillary status. Contemporary investigators credit the right hemisphere with the specialized processing of nonverbal information such as visual-spatial and emotional material (Brain, 1941; Patterson and Zangwill, 1944; Benton and VanAllen, 1968; Benton, Hannay and Varney, 1975; Landis, 1979).

Later studies involving normal and/or brain damaged individuals continued to support a dichotomization of functions in the left and right hemispheres. The majority of this research focused on the type of stimuli each hemisphere is specialized for and support "material specific theories" which maintain that the left hemisphere (LH) is specialized for processing linguistic information while the right hemisphere is specialized for processing visuospatial information. For example, it is generally found that verbal stimuli such as letters or words are processed faster and more accurately by the left hemisphere (LH) as compared to the right hemisphere (Hellige, 1978; Hines, 1976). The success of rigid material specific theories began to fade when the some language abilities were found in the right hemisphere (Gazzaniga, 1976). A general lack of empirical consistency has led to alternative ways of conceptualizing hemispheric specialization such as "information processing" theories which attribute hemispheric differences to the ways in which information is processed rather than the nature of the stimulus

material.

Information Processing Theories of Hemispheric Specialization

The general consensus among investigators is that the cerebral hemispheres have different functions, although disagreements remain as to the nature of these differences. Bradshaw and Nettleton (1981), in a review of normal subjects, concluded that the LH is specialized for processing temporal, sequential and segmental data. Examining research on audiological, visual and tactile modalities, they maintained that the superiority of the LH for analytic processing, as well as its capacity to process speech, is secondary to its capacity to process information which is time dependent and sequential. The authors further concluded that any superiorities in visual-spatial processing by the RH existed by default, or because the LH does not have room to accommodate this type of processing. To support their theory, Bradshaw and Nettleton (1981) cited research which demonstrate that 1) the LH is superior at processing non-verbal, temporally ordered stimuli e.g. non speech sounds and 2) the RH is capable of processing some types of visually presented verbal stimuli which are processed as a gestalt or visual template over time. Although their review provides a thoughtful interpretation of some inconsistencies, it still does not account for some data generated from studies of RH functioning.

Moscovitch (1979) reviewed findings from experimental studies employing individuals without cerebral damage and formulated his theory of hemispheric specialization from a "levels of processing" point of view. Moscovitch disagreed with a material specific "verbal-nonverbal" dichotomy and suggested that hemispheric asymmetries are determined by the cognitive demands of a particular task. Accordingly, relatively simple tasks could be performed equally well by either hemisphere, whereas more complex tasks elicit higher level hemispheric-specific types of processing. To support his theory, Moscovitch referred to data which showed a lack of hemispheric asymmetry on tasks requiring peripheral or sensory processing and contrasted these citations with those showing hemispheric asymmetry when integrative tasks are used which involve cortical or central processing. However, Moscovitch's theory still contains vestiges of a material specific hypothesis, since he does not explain or refute a verbal-nonverbal dichotomy once higher levels of processing are reached.

Luria (1966) proposed that the brain operates in two fundamental ways: one is to process discrete information into simultaneous groups, while the second is to organize discrete units of information into a meaningful sequence or category. Luria's theory, which was an outgrowth of his research on individuals with circumscribed brain damage, was not developed in terms

of lateralization of function in normals.

Goldberg and Costa (1980) reviewed clinical and experimental research, as well as neuroanatomical studies, and proposed that the right hemisphere is superior at processing novel information which has not yet entered into a formal descriptive system, while the left hemisphere is superior at processing information which is familiar and/or is readily processed within an existing formal descriptive system. This theory combines data from several areas of research and provides some explanations for inconsistencies in other theories of hemispheric specialization. However, Goldberg and Costa's theory is difficult to test empirically; formal descriptive systems are supposedly independent of language, but it is virtually impossible to create a set of stimuli with which to test the theory which are independent of language.

In summary, theories which conceptualize hemispheric specialization exclusively from a "material specific" or "informational processing" point of view sometimes provide adequate explanations of some data sets, while at other times they appear to interact with information processing theories.

Sergent's Theory of Visual Information Processing

An example of an alternative theory which incorporates both material specificity and information processing is Sergent's (1982d,e) model of hemispheric

specialization of visual information processing. Sergent (1982d,e) reviewed existing research on cerebral laterality and the visual system and developed a novel explanation of visual hemifield superiorities. According to Sergent, each hemisphere is specialized for processing different spatial frequencies. Spatial frequency is defined as the number of pairs of alternating, evenly spaced dark and light patches per degree of visual angle. Theoretically, each visual stimulus, regardless of its complexity, can be decomposed into its component spatial frequencies by Fourier analysis. It is believed that a similar analysis of spatial frequencies occurs in the human visual system during the perception of a visual stimulus. Sergent's (1982d,e) own research demonstrated that the left hemisphere is better at processing relatively high spatial frequencies, while the right hemisphere is more adept at processing relatively low spatial frequencies. Stated more simply, her theory operationalizes the concepts of analytic and holistic processing in ways which allow systematic comparisons of high and low spatial frequencies. For example, Sergent's definition of low spatial frequencies corresponds to the overall gestalt and boundary conditions of a stimulus, while higher spatial frequencies correspond to internal stimulus details.

Spatial Frequency and Hemispheric Specialization

Sergent's theory (1982d,e) developed out of her earlier review (Sergent and Bindra, 1981) of tachistoscopic research in which formally irreconcilable differences among experimental findings were related to differences in task demands and experimental parameters which were previously thought to be of no consequence. For example, many investigators of hemispheric functioning have concluded that the RH is better than the LH at facial recognition and that, therefore, the RH is better at visual-spatial processing. After thoroughly examining the similarities and differences of these studies, Sergent and Bindra (1981) argued that the RH superiorities were found in many of these studies not because of the nonverbal nature of the stimuli per se, but because of a secondary artifact involving task parameters which biased processing towards features which are perceived more easily. Sergent's (Sergent, 1982e; Sergent and Bindra, 1981) extensive comparison of experimental paradigms led her to conclude that several characteristics seemed to account for RH superiorities more consistently than did the "non-verbal" nature of the stimulus: 1) brief stimulus durations; 2) highly discriminable stimuli and 3) small and familiar sets of stimuli. Conversely, LH superiorities on tasks involving verbal material were attributed to the tendency of these studies to employ longer exposure times and more complex tasks such as lexical decisions.

(Sergent's third characteristic is an example of the contradictory nature of theories of hemispheric specialization: she posits that the RH is specialized for processing familiar stimuli, while Goldberg and Costa (1980) contend that the RH is specialized for processing novel stimuli).

Sergent further proposed that traditional "analytic - holistic" dichotomies are actually the result of differential abilities of each hemisphere for processing different levels of spatial frequencies. RH superiorities were found on tasks with short stimulus durations. Therefore, such tasks are assumed to require rapid integration of small amounts of briefly presented information. Furthermore, this type of processing is considered consistent with processing of low spatial frequencies, provided that the exposure times are long enough to invoke the participation of sustained frequency channels in the visual system.

Neurophysiological Evidence for Sergent's Theory

There is evidence at the peripheral and central levels of the nervous system which bears on Sergent's theory concerning low and high spatial frequencies. For example, on the peripheral processing level, Brietmeyer and his colleagues (Breitmeyer and Ganz, 1976; 1977) have found evidence of two types of neurons in the visual system. Transient neurons, which have rapid response and decay times for low spatial frequencies and

sustained neurons, which respond and decay at a slower rate. Accordingly, stimuli with short durations will allow for the processing of only low spatial frequencies or overall gestalts, whereas stimuli with longer durations will allow for the analysis of both high and low spatial frequencies, or the extraction of overall gestalts and internal details. There is also research which suggests that there are differences at central or cortical levels of visual information processing which appear to correspond to the "parallel" and "serial" processing distinctions in the cerebral laterality literature.

The classic experiments by Hubel and Wiesel (1959, 1962) examined the peristriate cortex of cats and found hyper complex cells which respond to particular patterns of light. Hubel and Wiesel (1962) found further distinctions among the hyper complex cells, which receive convergent information from other cells and, thus, act as relay stations in perception with each category of hypercomplex cell containing many subtypes of complex cells. However, the question of how far this hierarchy goes in perception remains unresolved, as it appears implausible to attribute progressively more complex processing to a relatively small and decreasing population of cells, i.e. is there a cell for bright red sports cars? Instead, a theory of parallel processing was developed in which activity in cells of secondary

cortical areas act in concert to detect certain features. Accordingly, the interconnections between different areas would be responsible for particular types of stimuli being analyzed in particular ways or by particular areas.

Sagi and Julesz (1985) found that detection of feature gradients are performed in a parallel manner while identification of specific features in these gradients requires focal or serial inspection. These distinctions were derived from studies of basic visual dimensions and simple features such as line segments, yet they are consistent with theories which propose that parallel-serial processing distinctions are operative at higher neurophysiological levels.

Finally, differences between the left and right hemispheres have been found at the neuroanatomical level, particularly in areas dedicated to visual-spatial functioning. This evidence supports the idea that there are different types of processing in the left and right hemispheres. After studying the somesthetic system Semmes (1960) reported clinical evidence to support the notion that the left hemisphere has a more discrete neuronal organization, whereas the right hemisphere has more interconnections between the different lobes. Although Semmes was working in a different modality, this finding is consistent with Sergent's theory of visual information processing, as well as with models of hemispheric processing which describe the right

hemisphere as a simultaneous or holistic processor and the left hemisphere as a linear or sequential processor.

Sergent derived support for her theory from several areas of research, including neurophysiology and experimental psychology and concluded that hemispheric superiorities are affected by experimental parameters such as stimulus exposure time, stimulus discriminability and the cognitive requirements of the task. A review of this evidence, as well as Sergent's (1982a,e) own research, will be discussed below.

The Development of Visual Perception Over Time

The perception of a visual image has been compared to the development of a photographic image in that the overall form becomes visible before detailed information, until perceptual acuity reaches a maximum level (Ericksen and Schultz, 1978). The end product of the process is a function of several stimulus characteristics such as intensity, illumination, contrast and the length of time for which it presented. Ericksen and Schultz (1978), following a comprehensive review, concluded that it takes at least 100 msec. for a stimulus to reach the maximum acuity level. Coltheart (1980) conducted a similar review and concluded that an analysis of high spatial frequencies require more time than an analysis of low spatial frequency. Additionally, tasks which involve high spatial frequencies require more processing and exposure time

and are more difficult than tasks involving low spatial frequencies.

Sergent (1982a,d,e; Sergent and Bindra, 1981), after an extensive review of visual laterality experiments, concluded that studies (Bryden and Allard, 1976; Bradshaw, Hicks and Rose, 1979; Hellige and Webster, 1981; Hannay, Dee, Burns and Maskek, 1981) using brief exposure durations (below 100 msec), which would only have permitted the analysis of low spatial frequencies (Ericksen and Schultz, 1980), yield RH superiorities regardless of whether the stimulus were "verbal, i.e. letters, words, etc., or "nonverbal", i.e. faces or shapes. With respect to LH processing, there are several studies which support Sergent's hypothesis that longer exposure durations will result in LH superiorities. However, exposure duration alone does not provide a complete explanation of hemispheric superiority. For example, Bryden and Allard (1976) and Bradshaw, et,al, 1979) discovered LVF-RH superiorities for exposure durations of less than 30 msec; however, both studies also reported RVF-LH superiorities for comparable durations with different exposure conditions. Two other studies using different conditions and exposure durations of 30 msec or below (Hellige, 1976; Hannay, et al, 1981) also reported RVF-LH supriorities. Mapou and Friedes (1985) replicated Sergent's experiment on a microcomputer and found no significant differences

between two exposure durations (86.67 and 217.67 msec). Sergent (1982d,e; Sergent and Bindra, 1981) suggested that stimulus quality must also be considered.

Stimulus Quality and Hemispheric Superiorities

Sergent (1982d,e) found that hemispheric asymmetries in visual processing are influenced by the quality of the stimulus. Perceptual degradation of a stimulus reduces the proportion of high spatial frequency components and can be produced through several techniques including extreme lateralization, brief exposure durations (as previously discussed), masking or the addition of simultaneous cognitive demands such as a memory component.

Hellige (1976, exp. 2) examined both accuracy and RT to letter pairs as a factor of VF of presentation in a same-different recognition paradigm. Stimuli were presented alone or with a simultaneous pattern mask (a grid) which degraded the visibility of the stimulus. Stimuli presented with the pattern mask were recognized most accurately when they were presented to the RH, whereas those stimuli presented without the mask were recognized most efficiently by the LH.

Hellige and Webster (1979) used several types of masking procedures in a letter identification task with a brief exposure duration (7 msec.). Despite the different masks and temporal parameters, accuracy was better for stimuli presented to the LVF-RH. The authors

concluded that the RH was superior to the LH in processing degraded stimuli.

Greenblatt (1980) examined response accuracy on a two letter identification task as a function of increasing time delays between the target and a random pattern mask for both VFs. The results agreed with those of Hellige and Webster's (1979) and supported Sergent's general theory that the RH is superior at processing degraded stimuli.

Hellige (1980) used a combination of masking and memory load to examine hemispheric asymmetries. In a go/no-go RT paradigm, he asked subjects to report whether a probe letter was contained in a two-to-five letter memory set. The probes were presented to one VF at a time and were presented either alone or with a pattern mask. Presentations without masks resulted in RVF-LH superiorities, whereas degraded presentations resulted in LVF-RH superiorities.

Hannay, et al. (1981), in a shape recognition task, also asked subjects to maintain particular shapes in memory. The authors found LVF-RH superiorities in the early parts of the tasks, which Sergent interpreted as evidence of RH superiority in processing degraded percepts.

Jonsson and Hellige (1986) investigated the processing of different spatial frequencies in the cerebral hemispheres by systematically reducing the clarity of the stimulus. They began with a clearly

presented physical letter identification task and gradually eliminated high spatial frequencies by blurring the stimuli. As the amount of blurring increased, the range of spatial frequencies was restricted to the lower frequency range. The authors predicted and found evidence demonstrating that the blurring produced more interference with processing in the RVF-LH than in the LVF-RH, as would be expected according to Sergent's theory.

Sergent and Bindra (1981) reviewed the facial recognition literature and found that many studies employed matching paradigms, which require subjects to hold a set of target stimuli in memory. On the other hand, studies using verbal material rarely included a memory component. Sergent and Bindra (1981) concluded that LVF-RH superiorities for facial stimuli were the result of the memory components of the task and their effects on stimulus quality, rather than the nature of the stimuli, i.e. the use of faces.

In summary, there are many studies which suggest that perceptual degradation of lateralized stimuli result in LVF-RH superiorities, regardless of the type of material used. Sergent interpreted the results of these studies as supporting her theory of differential hemispheric superiority for high and low spatial frequencies. However, certain conditions of perceptual degradation and exposure duration did not account for

the RH superiorities. For example, Sergent noted that Hellige (1980) reported that hemisphere superiority shifted from the RH to the LH as task difficulty increased, even with degraded stimuli. Sergent (1982d,e; Sergent and Bindra, 1981) has suggested that task difficulty also determines hemispheric superiority.

Task Difficulty and Hemispheric Asymmetry

Difficulty level is determined by several factors such as the degree of familiarity an individual has with a particular stimulus or task instruction; the amount of practice an individual has with the task; the nature of the stimuli used; and the type of processing required. Tasks which are difficult and are presented for long enough intervals to allow for processing of more stimulus details generally yield LH superiorities (Sergent, 1982a; Sergent and Bindra, 1981). Repeated exposure to a task which initially yields RH superiorities seems to increase the level of analysis possible and often leads to shifts in hemispheric superiority over to the LH, even with brief exposure durations.

For example, Patterson and Bradshaw (1975) measured RTs on a facial recognition task in which faces could differ on one, two or three features. When faces differed on all three features and the face to be matched was retained in memory, RTs were fastest for stimuli presented to the LVF-RH. However, when faces

differed on only one feature, presentations to the RVF-LH produced the quickest RTs.

In a same-different response task with comparable stimuli (four features could vary), Sergent found that hemisphere superiorities were related to the number of different features per stimulus: faces which differed in three or four features were processed by the RH, whereas faces differing on only one or two features were processed by the LH.

Hellige (1976) found LVF-RH superiorities on a same-different lexical decision task early in the testing sessions; however, repetition of the task on later days resulted in shifts in processing with superiorities occurring in the RVF-LH. Similar results were found by Hannay, et al. (1981) on two shape recognition tasks. The authors attributed the shifts in hemispheric superiority to the use of verbal labeling, although it is difficult to dissociate these effects from practice effects alone. In a later study, Hellige (1980) found that degraded probes from a small memory set were processed best when presented to the LVF-RH. Increases in the size of the memory set resulted in a shift in hemispheric superiority to the RVF-LH, despite the stimulus degradation. Thus, the LH became more adept at processing the material as the task difficulty increased.

Sergent (1982a,d) reviewed the above citations and concluded that hemispheric superiorities in visual

information processing are dependent upon two factors: 1) the quality of the stimulus representation needed to perform a particular task and 2) the quality of stimulus representation actually reached, as different aspects or levels of the visual stimuli are processed at different rates. Global or holistic levels of processing, which are associated with low spatial frequency components, are processed earlier than more detailed information or high spatial frequency components. If the stimuli and task conditions favor the processing of relatively low spatial frequencies, the RH will perform more efficiently, thus resulting in LVF-RH superiorities. Conversely, a RVF-LH advantage will be obtained when stimuli and/or conditions favor the processing of high spatial frequencies. Further, Sergent's (1982d) theory portrays information processing as a continuum, with both hemispheres sharing the work according to the demands of the task and stimuli, rather than according to a strict material specific dichotomy.

Sergent's Paradigm

Theories of hemispheric specialization which focus on the verbal - nonverbal dichotomy may not account for all of the empirical findings all of the time, although they do account for some empirical findings, particularly when combined with information processing theories (Hardyck, 1983). This is particularly true in the clinical literature; however, the study of normal

hemispheric processing is very different from the study of the brain injured. To begin with, the cerebral injuries or diseases which bring these individuals to clinical attention in the first place may produce subtle changes in areas of the brain other than the site of lesion, thus preventing direct comparisons with normal populations. On the other hand, the extensive behavioral testing and neuroradiological measurements taken on clinical populations can provide more information about particular areas or types of cognitive functioning as compared to normal populations. The major advantages to a conceptual model like Sergent's is that it allows for the incorporation of normal human neurophysiology into an experimental framework, thus providing a basis for describing normal hemispheric functioning. Additionally, this model can be easily tested.

In order to test her theory, Sergent chose a set of stimuli which had been used previously in lateralized studies of visual information processing and which allowed measures of relative spatial frequencies to be taken. Large letters constructed out of small letters were used (see Fig. 2). Small letters were approximately one ninth the size of large letters. Four different letters were used (H, L, T and F) which resulted in a total of 16 stimuli. The letters H and L were used as targets, and T and F were distractor stimuli. Six

conditions were created on the basis of whether the two letters (that is the large letters and their component small letters) were the same or different; whether a target was presented as a large letter, small letter, neither or both; and whether the large and small letters were identical. The conditions were as follows (see Table 1.) Condition 1, large and small letters are identical targets (L+S+Id); Condition 2, large and small letters are different and both targets (L+S+NonId); Condition 3, large and small letters are different with only the large letter as target (L+S-); Condition 4, large and small letters are different with only the small letters as targets (L-S+); Condition 5, large and small letters are identical and distractors (L-S-Id); Condition 6, large and small letters are different, both are distractors (L-S-NonId).

Subjects were asked to respond "yes" if targets appeared as either large letters, small letters or both; whereas "no" responses were expected when neither the large or small letter was a target. Thus, conditions 1 through 4 required "yes" responses, while conditions 5 and 6 required "no" responses. Stimuli were presented for 150 msec. to either visual field, as well as to the central visual field. Errors and RTs were recorded from the stimulus onset times.

Sergent hypothesized that low spatial frequencies would be processed more efficiently by the RH and higher spatial frequency components would be processed more

efficiently by the LH. Thus, her specific predictions for the experiment detailed above were that RTs would be fastest for LVF-RH presentations when decisions could be made on the basis of the large letters alone (L+S+ID, L+S+NonID, L+S-). Conversely, faster RTs were predicted for the LH in conditions 4 through 6, which required the analysis of high spatial frequency elements, e.g. small letters. The results of this experiment confirmed Sergeant's predictions for the LVF and RVF. Also, the nonconflict conditions with identical letters (L+S+Id) yielded the fastest RTs, followed in order by the nonconflict nonidentical letters (L+S+NonID), and the two conflict conditions (L+S-, L-S+) (See Table 2).

A second experiment used only 4 conditions (1,2,5,and 6) in which either both large and small letters or neither were targets. Backward masking was used to examine the effects of perceptual degradation of the stimuli as a function of visual field of presentation. The mean presentation time was 62 msec., with presentation times determined individually for each subject and set at 10 msec. below chance recognition of small letters. A pattern mask was presented for 1 second immediately following the offset of the stimulus. The required responses were similar to those in the first experiment, i.e. "Yes-No", although this time the decision was assumed to be made on the basis of the large letter or low spatial frequency elements. Again,

Sergent's results confirmed her predictions, as she found LVF-RH advantages across all conditions of degraded stimuli.

Research by other investigators has provided both indirect and direct evidence in support of Sergent's theory. After an extensive review of all lateralized tachistoscopic studies using normal subjects published between 1978 and 1981, Hardyck (1983) concluded that there is a fair amount of support for Sergent's theory, particularly since because it operationalizes concepts which are often described subjectively. Hardyck noted the importance of individual differences and other variables which contribute to individual differences such as sex and handedness in determining patterns of hemispheric specialization as well as individual levels of compliance and competency. Additionally, Hardyck stressed the importance of empirical comparisons between results obtained via computers and those obtained with more traditional tachistoscopic methods of stimulus presentation.

Processing Order and Hemispheric Superiorities

In addition to evidence supporting differential processing with different stimulus material, there is evidence which suggests that task demands play an important role in determining how information is processed.

Stimulus characteristics such as size and density

have been shown to influence processing order. Kinchla and Wolfe (1979) presented subjects with nonlateralized versions of the type of stimuli used by Sergent (1982d) and found that RTs varied as a function of the visual angle subtended by the stimulus. They showed that responses were faster to large letters, which subtended the largest visual angles. The following studies also have used stimuli and paradigms which are comparable to those used by Sergent(1982d,e) to look at processing order.

Navon (1979), using similar stimuli, required subjects to identify either large or small letters. Large letters were processed at consistently faster rates than were small letters. The identity of the small letters did not significantly effect the time needed to identify the large letter, although the identity of the large letter did affect response times needed to identify the small letters. Navon concluded that global processing always preceeds local processing, regardless of the stimuli involved. However, he used very brief exposure times (40 msec.), which probably did not allow for full processing of the stimuli. Furthermore, Navon's task differed from Sergent's in that subjects were not required to detect a target and stimuli were not lateralized. If global precedence is a true phenomenon in visual information processing it is important to understand how such a phenomenon fits into a model of functional lateralization.

Miller (1980) replicated and extended Navon's findings by adding two conditions. In one, large letters were constructed out of different small letters. The second condition contained small letters which were all different, as well as inverted, in order to reduce familiarity. The results indicated that global processing is relatively independent of processing at the local level, and performed before processing at the local level as long as changes at the local level do not disturb the overall gestalt of the global form.

Martin (1979) lateralized Navon's paradigm with modified instructions to create an interference effect similar to the effect obtained by Stroop (1935). Subjects were directed to attend exclusively to either the large or small letters, which resulted in conditions in which the large and small letters were consistent with each other, conflicting, or neutral (large letters were made up of a letter like geometric form rather than letters). Global judgments were significantly faster than local judgments. Processing of local aspects of a stimulus was performed more efficiently in the left hemisphere, while processing of global aspects was not strongly lateralized. However, when attention was directed to global processing in the conflicting condition there was a LVF-RH advantage which Martin attributed to the Stroop-like interference from local processing. However, Martin's study contained several

biases, such as the use of verbal responses, which may have favored processing in the RVF-LH.

In summary, it is unclear how the use of different task instructions may influence processing of spatial frequencies. Sergent's (1982d) data with nonlateralized central visual field presentations suggests that global processing does not necessarily precede local processing as Navon (1978) and Miller (1980) suggest, although Sergent did not evaluate the effect of different task instructions. In Sergent's paradigm low spatial frequencies (or small letters) are processed more efficiently by the RVF-LH, while high spatial frequencies (or large letters) are processed more efficiently by the LVF-RH. The question remains as to whether these hemispheric superiorities can be altered or even reversed by different task instructions i.e. instructions which are consistent with the innate hemispheric bias of the task, or which are inconsistent with innate hemispheric biases.

Information Processing Strategies

There is evidence that some differences in hemispheric superiority may be related to a) the imposition of different task instructions by the experimenter or "extrinsic" strategies and b) a subject's preference or innate bias towards performing a task in a particular way, or "intrinsic" strategy. For example, Bever and Chiarello (1974) examined the effects

of environment and experience on the development of perceptual asymmetries. They examined musicians and nonmusicians on an auditory test of cerebral lateralization (dichotic listening) and found that musicians evidenced REA-LH advantages while listening to music, as compared to the usual LEA-RH advantages demonstrated by nonmusicians. Bever and Chiarello (1974) attributed their findings to the musical training and subsequent use of analytical strategies on the part of musicians as compared to the more "holistic" (or less analytical) strategies used by more naive listeners. Similar results have been found by Hirshkowitz, Earle and Paley (1979), although not by Zattore (1979). However, it is still unclear as to whether a bias towards a particular strategy yields changes in cerebral organization or vice versa.

There is evidence which suggests that hemispheric superiorities for particular tasks can be influenced by the use of different strategies. Egeth, Jonides and Wall (1972) employed a letter identification task with nonlateralized stimuli and found that increasing the number of elements in a stimulus array did not increase RTs in either the "same" or "different" conditions; however, when the task was changed to a search paradigm, the results changed. Although the results were difficult to interpret along the lines of a specific type of information processing, they did suggest that the variability within the same and different responses

might have been due to subjects employing different strategies.

Cohen (1973) measured RTs on a task which required subjects to decide whether a lateralized set of stimuli were all the same or whether the set contained one item which was different. When the task involved letters increasing the number of items in the set resulted in increased RTs for RVF-LH presentations, but not for LVF-RH presentations. However, when the task involved shapes, set size did not effect RT in either VF. Cohen concluded that verbal stimuli are processed serially by the left hemisphere and in parallel by the right hemisphere, whereas shapes are processed in parallel by both hemispheres. However, an examination of Cohen's (1973) stimuli indicate that the shapes were not geometric forms or unnameable items, but rather symbols on a typewriter which are commonly used in a verbal context, e.g. (, <, ^, *, etc. Thus, the stimuli probably did not represent true nonverbal stimuli at all.

Seamon (1974), in a series of experiments, demonstrated that instructional set can be more important than the type of stimuli used or the hemisphere of presentation in determining the type of cognitive processing which ensues. Seamon asked subjects to determine whether a probe word was included in a set of words held in memory. Three groups of

subjects received different sets of instructions. Group 1 was told to merely rehearse the words subvocally (non-imagery condition); Group 2 was told to generate separate images for each word (separate imagery condition); and Group 3 was told to generate visual images which were contextually related (relational imagery condition). When the probe words were not lateralized, RTs increased as a function of set size for all three groups, whereas RTs remained constant as set size increased for the group using relational imagery. Seamon then examined the effects of relational imagery with lateralized probes and found faster RTs for presentations to the LVF-RH, which he considered to be consistent with the right hemispheres advantage in processing visual spatial imagistic material. However, the visual spatial nature of the instructions is only one possible explanation of the LVF-RH advantage. Another possibility is that the relational imagery condition asked subjects to create an internal mental image by which to remember the material, as opposed to a sequential or serial chain.

Cooper (1976, 1981) examined the ways in which different individuals can implement different strategies to solve the same visuo-spatial task. In this paradigm subjects were required to hold a set of shapes in memory and were then shown both target and distractor shapes. Distractor shapes varied in the amount they differed from target items and RTs were measured as to how long the comparisons took. Overall group data indicated that

the time required to complete visual comparisons decreased monotonically as dissimilarity between the target and distractor items increased. Put more simply, RTs decreased as the discriminations between target and distractor items became easier. However, an analysis of individual performance patterns indicated that there were two reliably different patterns of performance. One subgroup's "different" RTs decreased sharply as dissimilarity between the target and distractor shapes increased, whereas "same" responses fell in between the fastest and slowest times for "different" responses. The other subgroup had a different response pattern altogether in that "different" responses were not affected by the degree of similarity between the target and distractor shapes, with "same" and "different" responses requiring similar amounts of time. Interestingly, this latter subgroup performed considerably faster than the other subgroup, although the magnitude and pattern of error rates for the two subgroups did not differ significantly.

Cooper (1981) interpreted these results as evidence for analytic and holistic styles of information processing. She then examined whether an individual can be induced to switch from their natural holistic mode of processing to an analytic mode and vice versa. Her results indicated there was a subgroup of subjects who could switch processing styles; however, it was more

difficult to induce subjects who showed natural biases towards analytic processing into using a holistic strategy. One procedure which was particularly successful in inducing such a processing change was the use of stimuli with particularly strong configurational properties, i.e. photographs of human faces.

One difficulty with interpreting the effects of cognitive processing given the studies just reviewed is that the stimuli differ in their cognitive demands and visuo-spatial complexity. It is difficult to compare physical aspects such as stimulus quality if the level of spatial frequency varies widely across stimuli. Given the ways in which stimulus parameters such as stimulus sparsity and exposure duration affect spatial frequency, as well as the ways in which task difficulty and innate biases towards particular processing styles affect hemispheric superiority, it is difficult to measure "holistic" or "analytic" processing, particularly since they are so difficult to operationalize.

The Effect of Gender on Hemispheric Specialization

There is clinical and experimental evidence which suggests that gender affects the degree and patterning of cerebral organization. Investigators comparing groups of males and females with unilateral brain damage (Lansdell, 1962; McGlone and Kertesz, 1973; McGlone, 1980; Hecaen, 1981) consistently report that

males are more vulnerable than women to disturbances in language abilities following unilateral damage to the LH and disturbances in visuo-spatial abilities following unilateral damage to the right hemisphere (Landsell and Urbach, 1965; McGlone and Keretz, 1973; McGlone, 1977, 1978; Hecaen, 1980). They concluded on the basis of these findings that males were more strongly lateralized than females, i.e. that, in males, language functions most often were located in the left hemisphere and spatial functions in the right hemisphere. These functional dissociations between the left and right hemispheres were not as strong in females. Interest in gender differences and their effects on the brain has also generated a large body of research using perceptual asymmetries and normal subjects. Even limiting the discussion to visual laterality paradigms still leaves a diverse data base on which to construct a theory of the effects of gender on cerebral lateralization.

Verbal Studies

Bradshaw, Gates and Nettleton (1977) reported gender related differences on a lexical decision task. Real words or nonwords were presented randomly to either the LVF or RVF and subjects indicated whether or not the stimulus was a real word. Males were slower than females and evidenced a RVF-LH advantage, whereas females did not show any clear hemispheric advantages. Bradshaw and Gates (1978) replicated and extended these

results and again found that males showed consistent RVF-LH superiorities, while females showed LVF-RH superiorities in the early trials and RVF-LH superiorities towards the end of the experiment and after considerable experience with the task. In a second lexical decision task with different types of nonwords (pronounceable nonwords or homophones of real words), three quarters of the males produced faster RTs to RVF presentations, whereas three quarters of the females produced faster RTs to LVF presentations, although none of the findings reached statistical significance. A third experiment found no LVF superiorities in women.

In general, Bradshaw and Gates (1978) found women to evidence slight LVF superiorities on some lexical decision tasks and RVF advantages when the task involved word naming. In contrast, males evidenced RVF superiorities on all three tasks. Bradshaw and Gates (1978) suggested that females have more bilateral representation of language processes.

Kail and Siegel (1978) presented four numbers which were embedded in a lateralized 3 x 3 matrix. Males showed significant RVF superiorities on recall tasks, whereas women did not.

McKeever and Jackson (1979) also reported reduced RVF superiorities in women on a lateralized object naming task, particularly in the first half of the experimental session. In contrast, a color naming task

yielded RVF superiorities for both males and females. The authors suggested that object identification has enough of a spatial component to invoke RH mechanisms in females, while color naming does not.

Different patterns of hemispheric superiorities emerge on tasks involving less complex language related tasks. Gender differences were not found on recognition tasks involving single letters (Bradshaw, Bradley and Patterson, 1976; Bryden and Allard, 1976). Bryden (1965) reported larger RVF-LH superiorities in women.

In summary, visual half field studies employing verbal stimuli generally yield RVF advantages for men, whereas a consistent VF advantage is generally not found in women and are often inconsistent and perhaps dependent on the nature of the task (Healey, et al, 1985).

Nonverbal Studies

Tachistoscopic studies examining gender related differences with nonverbal stimuli generally involve dot localization or line orientation tasks. Kimura (1969) presented single dots randomly to either the LVF or RVF and found that males were more accurate in locating the dot with respect to the fixation point. In the first experiment men were more accurate with LVF presentations, whereas females were more accurate with RVF presentations. Her second experiment examined RTs rather than response accuracy. Again, males showed LVF

advantages, whereas females showed no significant visual field effects.

Bryden (1976a,b) extended Kimura's research by incorporating a simultaneous detection component into the dot localization task. A dot appeared on only two thirds of the trials and subjects were instructed to localize the dot if it was detected or say "no" if no dot was present. The first series of experiments (Bryden 1976a) yielded no gender related differences, although when the data were combined with another data set (Bryden, 1976b), 65% of the males and 57% of the females evidenced a LVF advantage for dot localization. The difference is not statistically significant; however, it is consistent with Kimura's (1969) results.

Davidoff (1977) utilized a dot detection task, rather than dot localization and reported that men were more accurate at detecting dots presented to the LVF as compared to the RVF, whereas no VF superiorities were found for women.

Similar gender related differences have been found on line detection tasks. Walter, Bryden and Allard (1976) reported that on a lateralized task in which subjects were instructed to detect a line embedded in visual noise, men showed significant LVF superiorities, whereas women showed no VF superiorities. The interaction of sex with VF was highly significant; however, Piazza (1980) reported no VF differences on

gender related effects for a lateralized task involving discrimination of line orientation.

In summary, tachistoscopic studies examining gender related differences with nonverbal material generally report LVF superiorities for men and no VF superiorities for women. These findings have been interpreted as supporting the hypothesis that males are more lateralized, that is, they show stronger right and left hemispheric differences; however, there are other interpretations of these data. For example, in women 1) verbal and spatial functions may be bilaterally represented; 2) even spatial information may be processed more linguistically; 3) verbal information may be processed more automatically, which would reduce asymmetries; 4) different strategies may be used as compared to males and 5) there may be better interhemispheric communication for different types of stimuli or types of processing. At this point it is still difficult to arrive at a clear interpretation of these patterns. There are several factors behind this ambiguity including difficulty in obtaining stable LVF-RH effects (Hellige, 1982) and the high preponderance of methodological differences between studies. As Sergent (1982d,e) and Hellige (1982) noted in reviews of experimental designs and mentioned earlier in this paper, VF superiorities on tachistoscopic tasks are affected by several factors.

Gender related differences in processing visual

information were found in a study of aphasics (Friedland and Kershner, 1986). This study examined the ability of individuals with expressive aphasia to process hierarchically structured verbal and nonverbal material. Female aphasics demonstrated difficulty extracting the hierarchical arrangements of visual spatial stimuli, which the authors interpreted as evidence that males are more reliant on the LH for processing verbal material and the RH for processing nonverbal material, whereas females are more inclined to use the LH to process both verbal and spatial information.

The question still remains as to whether males and females evidence different VF asymmetries and, inferentially, different patterns of hemispheric organization, because of 1) gender related structural differences or 2) dynamic functional differences which are vulnerable to the effects of different strategies which are "intrinsically" applied by the individual or "extrinsically" applied by the demands of the experiment.

Cognitive Sex Differences

There are generally accepted differences between males and females with respect to several cognitive functions. Females outperform males on some tests involving language abilities, particularly measures of verbal fluency (McGlone, 1980). In contrast, males generally do better than women on measures of visuospatial skills, including constructive abilities

and mathematics (Witig & Petersen, 1979). Males are also more prone to a variety of cognitive anomalies such as developmental reading disability, stuttering and retarded speech development. While differences in proficiency may not necessarily be related to sex differences in the degree and patterning of cerebral lateralization, there is suggestive evidence derived from studies of brain damaged individuals which supports the notion that these functional differences in cognitive skills are related to differences in cerebral lateralization (Levy, 1972; 1974).

Lansdell and Urbach (1965) examined males and females who had undergone excisions of their temporal lobes. Males showed more verbal impairments after left temporal lobectomies and visuospatial impairments after right temporal lobectomies. Females with similar unilateral damage to either hemisphere did not show similar dichotomous patterns. Lansdell and Urbach (1965) concluded that men are more vulnerable than women to selective cognitive impairments after damage to either hemisphere. McGlone (1978) arrived at similar conclusions after studying patterns of cognitive impairments in males and females following unilateral brain damage, chiefly that men with unilateral brain damage tend to show deficits in functions associated with the left hemisphere than do women with comparable lesions and that women's deficits are often less

profound and more diffuse. Other variables such as handedness (Piazza, 1980), socialization (Sherman, 1978) and age of maturation (Herbst and Petersen, 1980) also have been associated with patterns of cerebral lateralization.

Studies of perceptual asymmetries in normal individuals have generally found that a greater proportion of males show an advantage for verbal stimuli presented in the RVF, whereas females did not evidence significant perceptual asymmetries. Lake and Bryden (1976) tested a select group of predominantly right and left handed males and females on a dichotic listening task, which utilizes the natural decussation along the auditory pathways to measure perceptual asymmetries in the auditory realm. Verbal consonant vowel syllables, e.g. da-ga-ba, were presented to each ear at a time and a perceptual asymmetry scores was calculated. Males showed evidence of larger mean REA-LH advantages as compared to women, with 30 out of 36 males showing a REA and only 22 out of 36 women showing a REA. Several other dichotic listening studies failed to obtain right ear advantages for verbal material (Briggs and Nebes, 1976; Bryden, 1979; McGlone and Davidson, 1973); however, it is important to note that there are no studies of normal individuals which show either larger REAs or a greater frequency of REA in females as compared to males.

Studies of visual half field asymmetries have been

more consistent in demonstrating RVF-LH advantages in males. Bradshaw, Gates and Nettleton (1977) presented males and females with a lateralized lexical decision task and found that males had shorter RTs to LVF-RH presentations, whereas females did not evidence significant differences between the visual fields. Almost all of the males (11 out of 12) showed a RVF advantage, while only a little more than half (7 out of 12) showed a weak LVF-RH advantage. In contrast, a later experiment involving slightly different lexical decision tasks and responses found that females exhibited as strong a RVF-LH advantage as did their male counterparts. Healey et al., (1985) have shown that different types of tasks, even if they are both linguistic in nature, can yield markedly different patterns of perceptual asymmetries.

Healey and colleagues (1985) compared males and females on two types of lexical tasks, discrimination and production, and directed subjects' attention to particular visual fields through the use of a central fixation arrow. The results indicated that males and females evidenced similar patterns of VF asymmetries on language discrimination tasks, whereas females showed greater lateral differences on language production tasks. Additionally, attempts to control attention resulted in greater perceptual asymmetries, particularly in females. The authors suggested, as had Sergent

(1982d), that there should be more consideration of task demands in laterality experiments.

Visual half field studies using visuospatial stimuli generally report more consistent LVF-RH advantages for males than for females. Sasanuma and Kohayoshi (1978) found significant LVF advantages in men for a line orientation task and no VF advantages in females. Perez, Mazzuchi and Rizzolati (1975) found faster RTs in men on a facial recognition task for LVF presentations as compared to RVF presentations and no VF advantages for females. Rizzolati and Buchtel (1977) contrasted the effect of stimulus presentation time for a similar facial recognition task and also found that males evidenced shorter RTs for LVF presentations, while females evidenced no VHF asymmetries. Decreasing presentation time increased the disparity between the VFs for men, whereas presentation time had little effect on women. On the other hand, other studies have shown that women, as well as men, have RVF advantages (Young and Willis, 1976). Rizzolatti and Buchtel (1977) noted that RVF advantages were found in women when longer presentation times (over 150 msec) were used with a multiple choice matching task. They point out that women did not show any field differences for an identification task which used shorter presentation times (less than 150 msec.).

In summary, there is evidence which suggests that, in general, males and females have different patterns of

cognitive strengths and weaknesses. It has been hypothesized that some of these differences are associated with, if not directly related to, differences in the degree and patterning of the cerebral organization of these functions. Many of these sex differences have been found by applying statistical methods to large samples of brain damaged individuals rather than through direct observation. Bradshaw (1980), citing more than twenty of his own tachistoscopic studies involving schematic patterns, claims that he has not found any significant interactions between hemisphere and sex. While the evidence is compelling enough to stimulate further research, the possibility also exists that observed sex differences on measure of perceptual asymmetries are due to differences in the choice of strategies or different sensitivities to experimental designs.

Neuroanatomical Studies

Evidence suggests that at least some of the functional hemispheric differences associated with gender, including perceptual asymmetries, have a neuroanatomical basis, although the results are inconsistent with respect to the question of which sex is more lateralized. Geschwind and Levitsky (1974) found that the planum temporale generally is larger in the left hemisphere than in the right; Wada (1976) extended these findings by reporting that these left

right hemispheric differences are reduced in females. Lacoste-Utaming and Holloway (1981) reported that the splenium or posterior part of the corpus callosum is larger in women than in men. It is been suggested that a larger splenium allows more interhemispheric communication, as the splenium connects the peristriate, parietal and superior temporal areas, which are most involved in visual-spatial processing. The combined results of these studies support the idea that women are less lateralized than men for both verbal and visual-spatial types of material which, in turn, may lead to a) linguistic processing of spatial information in women and/or b) the use of different "intrinsic strategies" or innate cognitive biases towards processing visual information in women as compared to men. Other evidence suggests that women are more lateralized than men (Healey, et al, 1985) or evidence different patterns of frontal-posterior functioning (Kimura, 1986).

Transfer of Sergent's Task to a Microcomputer

Sergent's research, as well as most of the reasearch cited in her reviews (1982d,e; Sergent and Bindra, 1981) was conducted on a tachistoscope, an electronically operated machine which is capable of presenting visual stimuli to one visual field at a time for millisecond time intervals. The recent ascendancy of microcomputers allows for comparable stimulus presentations, and has several advantages over

tachistoscopes. For example, one of the problems with reaction time data is the wide distribution of scores. Some investigators repeat "outliers", or scores well outside of the expected response range; however, this is a tedious process with a tachistoscope since cards which need to be repeated must be taken out by hand and presented again. The necessity for the investigator to constantly monitor the responses, and in most cases record all of the response times by hand, as well as repeat stimulus cards, can take a long time, which is fatiguing for a subject. A microcomputer can automatically recycle stimuli which yield responses above or below a predetermined level of acceptable responses, as well as calculate means, standard deviations and response ranges in a fraction of the amount of time needed to do comparable work on a tachistoscope.

Tachistoscopes generally present black stimuli on white backgrounds and allow for presentation of stimuli exclusively to one visual field. Levy, (1974) has presented white stimuli on black backgrounds and found comparable perceptual asymmetries as studies using black stimuli on white backgrounds.

Computers use cathode ray tubes or screens (CRTs) which generally contrast green or white stimuli on black backgrounds, which tends to accentuate iconic traces or after images. Backward masking the stimuli with a

visual noise mask can erase such iconic traces, although the use of CRTs with less visual contrast also minimizes these after images. Pilot work for this study with an amber colored screen, chosen especially for its reduced levels of visual contrast, indicated that the use of a mask did not yield significantly different hemispheric asymmetries and therefore was not used in the study, since these reaction times were generally longer and more subjects had to be disqualified because of difficulties identifying the stimuli. Other studies using PCs have generally reproduced the results of tachistoscopes without the use of backward masking procedures (Mapou, 1985; Mapou and Friedes, 1985).

Mapou and Freides (1985), using a personal computer, replicated and extended Sergent's research, as well as the effects of different levels of exposure duration and different task instructions on perceptual asymmetries. Their attempts at replicating Sergent's findings were partially successful: Condition 3 (L+S-) yielded the expected right hemispheric superiorities and Condition 4 (L-S+) yielded the expected left hemispheric superiorities. Sergent's findings for Conditions 1 (L+S+ID) and Condition 2 (L+S+ NonId) were not replicated. There was no significant differences between exposure durations of 87 msec and 217 msec, and task instructions were found to have a significant effect on performance; however, there were several problems with Mapou and Freides' (1985) design which

prevents a direct comparison of their work with Sergent's research. The computer program used by Mapou and Freides (1982) did not eliminate the natural scrolling phenomenon on a CRT which presents top parts of the stimuli slightly ahead of bottom parts. The authors cite this as a serious design flaw which might have biased the results in favor of RVF-LH processing, since some stimulus parts were presented before others. Another problem with Mapou and Friedes' (1985) study was the use of a between subjects design, which prevents direct comparisons of the effects of instructional set for each individual subjects. This was particularly problematic since Mapou (1985) notes that individual data did not always agree with group data. Finally, Mapou and Freides (1985) used only male subjects. While Sergent (1982d) found no evidence of a significant sex difference, Sergent (1982d) was not manipulating "extrinsic" instructional set. Males and females seem to evidence different patterns of functional lateralization as evidenced by their different patterns of perceptual asymmetries on tasks involving verbal and non verbal material. Males and females also evidence neuroanatomical differences, particularly in areas of the brain involved in visuo-spatial processing (Lacoste-Utaming & Holloway, 1981). Therefore, it seems reasonable to presume there may be differences in information processing abilities between males and

females, particularly with regards to a) the ability to apply an "extrinsic strategy" and b) the capacity to override an innate "intrinsic strategy" which may be inconsistent with the extrinsic strategy demanded by the task.

In summary, Mapou and Freides (1985) attempted to replicate Sergent's (1982d,e) findings via a personal computer and their efforts were partially successful, although it is unclear as to whether their efforts would have been more successful if a) certain problems in their computer program which may have influenced hemispheric superiorities were eliminated and b) they had used a within subjects design to measure the effect of task instructions. This study will examine Sergent's theory of differential hemispheric sensitivities taking the above problems into account. A counterbalanced within-subjects design will be used to compare the effects of different task instructions. Additionally, the effect of gender will be examined, particularly in relation to possible interactive effects between gender, instructional task, and hemispheric superiorities.

The Present Study

The major goals of the present study are as follows:

- 1) To replicate and extend Sergent's (1982d,e) theory which posits that the right and left cerebral hemispheres are differentially sensitive to high and low

PLEASE NOTE:

Page(s) not included with original material
and unavailable from author or university.
Filmed as received.

U·M·I

CHAPTER TWOMETHODSSubjects

Evidence suggests (Bryden, 1982; Herron, 1981, for a review) that left handers and right handers have different patterns of cerebral organization. To eliminate such complications, only right handers participated in this study. Furthermore, only right handers without left handed relatives were allowed to participate, as familial history of left handedness has been shown to influence cerebral organization as well (Healey, 1981; Bryden, 1982; Annett, 1975). Handedness and familial handedness was determined by subjects responses to a questionnaire (Healey, 1981). A further requirement of natural or corrected visual acuity of 20/20 was required, and determined by performance on a Snellen Eye Chart. A total of 36 subjects (18 males, 18 females) participated in the study. The age range of participants were 18 to 35 years of age.

An initial practice session was run prior to the actual test session to verify the capacity of a subject to perform the task well enough to be included in the actual procedure. This session required subjects to respond to the target letters "H" or "L", regardless of whether the targets are large or small letters. This session did not require subjects to process the stimuli in any given order, e.g. large-to-small or small-to-large. Ninety six practice trials were run, with three

breaks after each cluster of 32. During these breaks the subjects were allowed to question the examiner. Each of the stimuli to be included in the actual trials were presented to each visual field once and in a random order. At the conclusion of the practice session, any subject with an error rate of greater than ten percent was discontinued from the study (Fifteen individuals were discontinued).

Following this, another set of instructions was presented to the subject on another card, which the subject was required to read aloud before he or she asked the examiner questions (see Appendix). There were two experimental conditions, each containing a different set of instructions. In experimental condition "L-S" the subject was asked to process the large letters prior to processing the small letters. Experimental condition "S-L" required the subject to process the small letters before the large letters. The conditions were counterbalanced across subjects and sex, so that nine males performed the task in a "L-S/S-L" order and nine in a "S-L/L-S" order. Similarly, nine females performed the task in a "L-S/S-L" order and nine in the "S-L/L-S" order. The subjects were questioned by the examiner before each experimental session to ensure the examiner that the subject fully understood the task requirements. It should be noted that two of Sergent's (1982d) conditions were not used in the present experiment, i.e.

Condition 5 (L-S-Id) and Condition 6 (L-S-NonId). These conditions were eliminated because they had the longest and most variable RTs.

Apparatus

The experiment was conducted on a IBM compatible Leading Edge Personal computer Model M and a Leading Edge Amber monitor (cathode ray tube or CRT). The program was written in advanced Basic program language and the scrolling effect referred to previously was eliminated through the use of a program compiler. Both presentation and reaction times were measured to the millisecond and controlled by the computer's internal clock. A response was made by depressing the space bar of the PC keyboard with both index fingers.

In order to simulate a tachistoscope as closely as possible, subjects rested their heads on a steel frame chin rest which prevents head movements that can change the lateralization parameters. The distance of the subject's eyes to the CRT screen is approximately 120 cm. Virtually all light was eliminated from the room by heavy draping on the windows of the test room, so that illumination was kept constant (approximately 4.6 footcandles). A red light bulb with limited spectral frequencies (the bulbs used in photographic darkrooms) was left on during the experimental procedure so that the examiner could monitor the testing situation. Screen luminance levels were set by the examiner and

remained constant across all subjects. Decay time of the video screen was less than 200 msec.

Prior to each stimulus presentation, a central fixation cross (see Appendix) appeared in the middle of the screen. Subjects were instructed to refocus their attention on this cross after each stimulus presentation.

All subjects were asked to respond as rapidly and accurately as possible and to avoid anticipating the side of stimulus presentation. The subject's head rested on a chin rest to prevent head movements. A response consisted of the depression of a computer space bar by both index fingers. Subjects were warned that there is an acceptable time limit for responding. Responses which were too fast would be repeated as well as responses which are too slow or missed altogether. Subjects were told that the experiment would take approximately 20 minutes, depending upon the accuracy and speed of their responses and that they would be allowed a brief rest around the middle of the procedure (between instructional sets).

At the end of the experimental procedure all subjects were administered a cognitive battery consisting of the Rey-Osterreith Complex Figure Test (Lezak, 1983), the Gestalt Closure Completion Test (Education Testing Service (ETS) 1976), the Hidden Figures Test (ETS, 1976).

Stimuli

The stimuli used in the experiment were the same as those used by Sergent (1982d) and their physical characteristics are also comparable. Large letters constructed out of small letters were available through the computer's internally generated character set. The letters used were H, L, T and F. All letters were uppercase.

Large letters were approximately 49 mm high and 28 mm wide, making them approximately nine times the size of the smaller letters, which were 5.5 mm high and 3.5 mm wide. The centers of the large letters were displaced approximately 2.6 degrees to the right or left of center of the screen for lateralized presentations to either the RVF or LVF, respectively and also centered vertically on the CRT screen.

At a standardized viewing distance of 120 cm. from the CRT screen to the subject's eyes, large letters subtended visual angles of approximately 2.4 degrees in height and 1.3 degrees in width, while small letters subtended visual angles of approximately .30 degrees in height and .12 degrees in width. Lateral displacement of the centers of the large letters was 1.4 degrees for lateralized presentations to the RVF and LVF. These conditions were comparable to those used by Sergent (1982d) and Mapou and Friedes (1985).

Target letters were H and L. The twelve possible stimuli appearing in each condition are listed in Table

1 (see Introduction).

Procedure

Before administration of the tachistoscopic task, the handedness questionnaire was completed, followed by a visual acuity test (performance on a Snellen Chart). A practice session chart was administered next, with basic instructions (see Appendix B). Subjects were told to depress the space bar as quickly as possible whenever an H or L appeared on the screen, regardless of whether the targets appeared as small letters, large letters or both. Subjects were told not to respond to F and T, unless they occurred in the presence of a H or L. There were 96 practice trials, presented in three sets of 32 trials. Subjects were read aloud the instructions prior to the beginning of the task and were allowed to ask clarifying questions. Any subject who had an error rate above ten percent was discontinued from the study.

The two experimental sets of trials followed the practice trials (for specific instructions, see Appendix). The subjects were told that a missed stimulus would be repeated and were encouraged to respond as accurately and quickly as possible. All subjects included in the study were required to complete the 96 practice trials as well as the 192 experimental trials for a total of 288 trials.

A fixation stimulus (a cross, see Appendix) appeared in the middle of the screen prior to each

stimulus presentation. The computer began timing the subject's response (in milliseconds) from the moment the stimulus was presented. If a stimulus was missed or resulted in a reaction time above 800 msec. or below 150 msec. the stimulus was recycled into the stimulus pool and presented at the end of the stimulus trial.

Following the experimental session and a brief rest interval the cognitive battery was administered.

CHAPTER THREE

RESULTS

Design and Analysis

There were 4 stimulus conditions (L+S+ Id; L+S+NonID; L+S-; L-S+) and an equal number of trials in the left and right visual fields within each stimulus condition. Each subject performed the task twice, each time under a different set of instructions (large-to-small and small-to-large). The order of the two instructional sets was counterbalanced across subjects. Thus, Stimulus Condition (4), Visual Field (2) and Instructional Set (2) were within-subject variables which were crossed with one another. There were 36 subjects in total, 18 males and 18 females, with sex as a between subject variable. All subjects were between the ages of 18 and 35 years, with a mean age of 25.4 for males and 26.7 for females. These age differences were not statistically significant ($p. > .05$). For the reaction time (RT) data, means and standard deviations were computed for the LVF and RVF for the 4 stimulus conditions in both instructional sets.

Differences in RT between the LVF and RVF can be interpreted as measures of hemispheric differences and hence related to cerebral lateralization. The relationship between visual field effect and cerebral laterality is not necessarily isomorphic and is not being interpreted as such.

A 2 (Sex) x 2 (Visual Field) x 2 (Instruction Set)

x 4 (Condition) repeated measures analysis of variance (ANOVA) was performed on the mean reaction times for each subject. Statistically significant main effects and interactions were examined by the use of a Tukey a posteriori comparison test (Kirk, 1968).

Results with direct relevance to the previously stated hypotheses will be examined first. Other main effects and interactions will be discussed afterwards.

Predicted Main Effects

Hypothesis 1: The Effects of Conditions

A significant main effect for stimulus condition was found ($F(1,34) = 32.872, p. < .001$). There were consistent increases in RT across Condition 1 (L+S+Id) through Condition 4 (L-S+) for both instructional sets, with particularly large increases in RT in the conflict conditions (conditions 3 and 4). The large RT difference between the two conflict conditions can be attributed to several factors including difficulty level and complexity and will be discussed later. Mean RTs and standard deviations are shown in Table 3.

Hypothesis 2: Effects of Instructional Set

A significant main effect was found for instructional strategy ($F(1,34) = 35.287, p. < .001$). The mean RTs and standard deviations for the two conditions are listed in Table 4. The L-S (large-to-small) instructional set consistently yielded faster RTs

as compared to the S-L (small-to-large) instructional set. This is consistent with Navon's (1977) theory of global precedence, as well as with subject's reports of the L-S condition being more natural.

The Effects of Visual Field Alone

Visual field alone did not significantly effect RTs ($F(1,34) = 101.67, p. > .500$). Mean RTs and standard deviations for the two visual fields are listed in Table 5. This finding was expected since the hemisphere bias predicted for the L-S instructional strategy was consistent with the hemisphere bias predicted for stimulus Conditions 1 through 3, but inconsistent with the hemisphere bias predicted for Condition 4. Conversely, the hemisphere bias predicted for the S-L instructional strategy was consistent with the hemisphere bias expected for Condition 4, but inconsistent with the hemisphere bias expected for Conditions 1 through 3. Sergent defined Conditions 1 and 2 as "nonconflict" conditions because there was no conflict between the target identities of the large and small letters (L+S+ Identical and L+S+ NonIdentical). Conditions 3 (L+S-) and Condition 4 (L-S+) were defined as "conflict" conditions because of the conflict between the target and nontarget identities of the large and small letters. These definitions will be used throughout the remainder of this dissertation. The visual field advantages in Conditions 1 and 2 (the

nonconflict conditions) was not significant, but were significant for Conditions 3 and 4 (the conflict conditions). Hence, in the conflict conditions, half of the hemispheric biases for stimulus condition and instructional strategy were consistent with each other, while half were inconsistent. In essence then, the two biases neutralized each other.

The Effects of Sex

A main effect for sex was not found ($F(1,34) = 1.193, p. < .283$). The mean RTs and standard deviations for males and females are listed in Table 6.

Predicted Interactions

Hypothesis 1: Stimulus Condition x Visual Field

The prediction that stimulus condition alone would effect hemispheric superiority was supported. A significant interaction of stimulus condition and VF ($F(1, 34) = 11.538, p. < .002$) was found. The mean RTs and standard deviations can be found in Table 7. The data provide partial support for Sergent's theory. Fig. 3 demonstrates that, across instructional sets, LVF-RH reaction times were faster (but not significantly) in Conditions 1,2 and 3 (L+S-) and RVF-LH reaction times were faster in Condition 4 (L-S+).

The data from the conflict conditions (Conditions 3 and 4) provide partial support for Sergent's theory. LVF-RH superiorities occurred in Condition 3 while RVF-LH superiorities were found in Condition 4. There was no

hemispheric superiority in Condition 1 and 2. Tukey post hoc tests showed that visual field differences were significant only for the conflict conditions. In the nonconflict conditions, visual field differences were very small (< 10 ms) and were not statistically significant. Thus, hemispheric superiorities were salient only in the conflict conditions.

Hypothesis 2: The Effect of Instructional Set on Visual Field

The hypothesis that instructional set alone would effect hemispheric superiorities was not supported. The interaction between instructional set and visual field was found not to be significant ($F(1,34) = 1.104, p < .301$). The mean RTs and standard deviations are listed in Table 8 and Fig. 4.

Instructional Set X Visual Field X Sex

In addition to the above findings, males and females did not differ in their pattern of visual field asymmetries with respect to instructional set ($F(1,34) = 0.127, p < .500$). The means and standard deviations are listed in Table 9.

Hypothesis 3: Stimulus Condition x Visual Field x Sex

The hypothesis that males would show greater perceptual asymmetries than females for processing the different conditions, particularly the conflict conditions (L+S- and L-S+) was not supported. Females

were somewhat faster than males although this advantage was not statistically significant ($F(1,34) = 1.193$, $p < .283$). (see Table 10 and Fig. 6).

Effects of Stimulus Condition and Instructional Set on Hemispheric Superiority

The prediction that stimulus condition would interact with instructional set to significantly effect visual half field superiorities was supported ($F(1,34) = 3.368$, $p < .022$). Table 11 and Fig 7 show the mean reaction times and standard deviations. Under Sergent's theory, Condition 3 (L+S-), as well as Conditions 1 and 2 (L+S+Id and L+S+NonId), should yield faster RTs for stimuli presented to the LVF-RH, while condition 4 (L-S+) should yield faster RTs for stimuli presented to the RVF-LH. Thus, it was predicted that there would be an interaction between stimulus condition, instructional set and visual field such that when the predicted hemispheric advantage for stimulus condition was consistent with the predicted hemispheric advantage for instructional set, the predicted hemispheric advantage would appear, whereas when the expected hemispheric advantage for stimulus condition conflicted with the predicted hemispheric advantage for instructional set, the conflicting hemispheric biases would work against each other and result in no significant visual field asymmetries. This prediction was partially borne out in that the expected

dissociative effects were found for the conflict conditions. Under the Large-to-Small (L-S) instructional strategy, it was predicted and found that a LVF-RH advantage would occur for Condition 3 (L+S-) and a significant RVF-LH advantage would occur for Condition 4 (L-S+). The expected LVF-RH advantages were not found in the nonconflict conditions (Conditions 1 and 2). It was expected that the L-S instructional strategy would result in a LVF-RH advantage for Conditions 1 and 2, since both of the stimuli and the instructional strategy were expected to result in LVF-RH advantages. However, neither Condition 1 (L+S+Id) nor Condition 2 (L+S+NonID) resulted in a significant VF advantage. Conversely, it was expected that there would not be a significant VF advantage for either Condition 1 or Condition 2 under the S-L instructional strategy. This was the case for Condition 2; however, Condition 1 resulted in a significant LVF-RH advantage. The result was unexpected and will be discussed in further detail in the discussion chapter.

Hypothesis 4: The Effect of Instructional Strategy and Stimulus Condition on Response Time

In terms of speed of response time, the interaction between instructional strategy and stimulus condition was not significant ($F(3,102) = 2.32, p. > .05$). Mean RTs and standard deviations are shown in Table 12 and illustrated in Fig. 8. The large-to-small (L-S)

instructional strategy yielded faster RTs relative to the small-to-large (S-L) instructional strategy across all four stimulus conditions. This was expected for the nonconflict conditions (1 and 2), where a response could be made after attending to the large letter alone. It was also expected for Condition 3 (L+S-) of the conflict conditions, since the target was a large letter. It was expected that the S-L instructional strategy would yield faster RTs than the L-S instructional strategy for Condition 4 (L-S+) of the conflict conditions. This expectation was not fulfilled; however, it is important to note that the difference between the RTs for the two instructional strategies for Condition 4 is extremely small (10 milliseconds) and nonsignificant ($p. > .05$).

Hypothesis 5: The Effect of Instructional Strategy, Stimulus Condition, and Gender on Visual Field

The hypothesis that gender, instructional set and stimulus condition would effect hemispheric superiorities was not supported. The interaction of sex, stimulus conditions and visual field was not significant ($F(3,102) = 1.71, p. < .17$). Table 13 provides the mean reaction times, standard deviations and the number of individual VF differences as a function of the 3 variables.

Transformation of Data

In addition to the group analysis, data for individual subjects were examined following a transformation of the data into asymmetry scores. In order to compare visual field differences while controlling for performance levels, a "normalized" difference score was computed using the following formula (Shankweiler and Studdert-Kennedy, 1976):

$$\frac{\text{LVF} - \text{RVF}}{(\text{LVF} + \text{RVF})} \times 100$$

Under this transformation a positive score indicates a RVF-LH advantage and a negative score indicates a LVF-RH advantage in RT. These normalized difference scores were subjected to a two-way ANOVA in order to assess the main effects and interactions mentioned previously, as well as one way ANOVAs on cognitive scores in order to assess whether performances on these tests, which involve difference aspects of cognition are related to perceptual asymmetries on the experimental task.

Main Effect: Stimulus Condition

A significant main effect was obtained for stimulus conditions ($F(3,210) = 8.13, p. < .001$), which supports the notion that stimulus conditions alone did influence patterns of hemispheric superiority.

Main Effect: Instructional Set

There was no significant main effect for instructional set for the normalized asymmetry scores ($F(1,70) = 1.19, p. > .500$). This was expected since the significant main effect for instructional set with an ANOVA involving raw, untransformed RT data was obtained because the Large-to-Small instructional set yielded significantly faster RTs than the S-L instructional set.

Main Effect: Sex

The transformation of raw reaction time data into normalized asymmetry scores did not yield a significant main effect for sex ($p. > .500$). Males and females did not yield significantly different visual half field asymmetries.

Patterns of Perceptual Asymmetry

The normalized visual field asymmetry scores were examined in terms of asymmetry patterns over Condition 3 (L+S-) and Condition 4 (L-S+). Subjects were divided into subgroups based upon the patterns of perceptual asymmetries obtained for the conflict conditions (Condition 3, L+S-; Condition 4, L-S+). The subgroups were as follows: Group A - individuals with LVF-RH superiorities in Condition 3 and RVF-LH superiorities in Condition 4; Group B - individuals with LVF-RH superiorities in Conditions 3 and 4; Group C - individuals with RVF-LH superiorities in Conditions 3 and 4; and Group D - individuals with RVF-LH

superiorities for Condition 3 and LVF-RH superiorities for Condition 4. Under Sergent's (1982d,e) theory, the "A" pattern should have occurred in the majority of subjects. The above patterns are listed in Table 14, as well as the number of subjects (males and females combined) exhibiting each pattern.

Eighteen out of 36 subjects, or exactly one half of the total subjects exhibited the pattern of visual field asymmetries as predicted by Sergent's theory when the L-S and S-L instructional strategies are combined (since there was no main effect for instructional strategy). The other 18 subjects exhibited different patterns.

Strength of Perceptual Asymmetry

In order to further examine these findings, subjects were divided into groups according to magnitude of visual field asymmetry for the conflict conditions. The number of subjects who exhibited asymmetry scores greater than one standard deviation from the mean were examined according to group and according to sex. The results are listed in Table 15.

Sex Differences

Males and females were not significantly different in their patterning of perceptual asymmetries (t test, $p > .500$). The number of males and females exhibiting each pattern of perceptual asymmetry for Conditions 3 and 4 are listed in Table 14. However, males and

females differed in their magnitude of lateralization. Table 15 lists the number of males and females with perceptual asymmetries above or below one standard deviation for Conditions 3 and 4 for each perceptual asymmetry pattern. When all four patterns of perceptual asymmetries are considered together, only 3 out of 18 males or less than 17% of the males have laterality magnitudes greater than one standard deviation, as compared to 15 out of 18 or 83% of the females.

Conformity of Individuals to Instructions

In order to assess whether males and females differed in their capacity to apply the two instructional strategies a conformity index was created and a student's t-test was performed in order to compare the scores of males and females. Two conformity indexes were created for the conflict conditions, one for Condition 3 and one for Condition 4. For "Conformity Index 3", the scores for both visual fields were combined and the RTs for Instructional Set 1 (Large-to-Small) were subtracted from the RTs for Instructional Set 2 (Small-to-Large). The Large-to-Small (L-S) Instructional set was consistent with the type of processing needed for Condition 3 (L+S-) in which the large letter was the target. Therefore, it was reasoned that RTs should be faster under the L-S instructional set for Condition 3 (L+S-) if the subject was applying the L-S strategy. For "Conformity Index 4", was created

by subtracting the RTs for for Instructional Set (Small-to-Large or S-L) from Instructional Set 1 (L-S), since the the S-L instructional should yield faster RTs than the L-S instructional strategy if the subject was following the instructional strategy. The Indexes are illustrated below:

$$\begin{array}{rcc}
 \underline{\text{Conform 3}} & = & \begin{array}{c} \text{Condition 3} \\ \text{Instructional} \\ \text{Set L-S} \\ \text{RTs} \end{array} & \begin{array}{c} \text{Condition 3} \\ \text{Instructional} \\ \text{Set S-L} \\ \text{RTs} \end{array} \\
 \\
 \underline{\text{Conform 4}} & & \begin{array}{c} \text{Condition 4} \\ \text{Instructional} \\ \text{Set S-L} \\ \text{RTs} \end{array} & \begin{array}{c} \text{Condition 4} \\ \text{Instructional} \\ \text{Set L-S} \\ \text{RTs} \end{array}
 \end{array}$$

Student t-tests were performed on the scores for males and females. Males and females did not differ significantly on either Conform 3 ($p. > .05$) or Conform 4 ($p. > .05$). Thus, males and females did not differ in their capacity to apply the two instructional strategies.

Cognitive Data

A. Methods of Analysis

The second part of the present study involved the assessment of several ancillary performance measures for the purpose of further explaining the variability in the RT measures within and between subgroups of subjects (males and females). These measures were selected in order to survey performance on different aspects of analytic, visuospatial and organizational abilities and were not meant to be an exhaustive evaluation of all of

the cognitive abilities which might be related to the experimental task. The cognitive tasks which were used are described briefly and the means and standard deviations for each task for all subjects collectively and by sex are given in Table 17. An intercorrelation matrix of the ancillary measures with each other are presented in Table 16.

Relationship Between Asymmetry Scores and Cognitive Scores

In order to assess whether there was any relationship between individual performances on the cognitive tests and the degree of lateralization in the conflict condition of the tachistoscopic test, a Pearson correlation was performed. None of the correlation coefficients were significant, which suggests that there was no relationship between the absolute degree of lateralization on the tachistoscopically presented conflict conditions and performance on the cognitive measures, even though the cognitive measures were thought to be associated with some of the lateralization patterns on the tachistoscopic task. The results are listed in Table 18.

Relationship Between Ability to Apply Strategies and Performance on Cognitive Tests

In order to see whether there was a relationship between the capacity to apply the instructional

strategies (L-S and S-L), the Conform Indexes created earlier were correlated with the scores on cognitive tests via two Pearson correlation coefficients. The correlations did not reach significance at an alpha level of .05 for either Conform 3 or Conform 4. The results are listed in Table 18.

Speed of Processing and Cognitive Performance

In order to assess whether overall reaction time was related to performances on any of the cognitive measures, Pearson correlation coefficients were obtained for overall reaction time on all of the tachistoscopic measures (both visual fields for all four stimulus conditions) for the two instructional sets separately and together. None of the correlations were significant, indicating that there was no relationship between speed of processing and responding on the tachistoscopic task and performances on any of the cognitive measures. See Table 19 for the intercorrelation matrix.

Rey-Osterreith

A Chi Square test was performed on the Rey-Osterreith scores and the perceptual asymmetry scores. The nonsignificant results ($p. > .05$) suggest that an individual's capacity to organize a complex visual-spatial stimulus is not related to asymmetry scores for the conflict stimulus conditions. There were also no sex differences ($p. > .05$).

Hidden Figures Test and Gestalt Completion Test

Student t-tests revealed that there was no relationship between gender and performance on either the Hidden Figures Test or the Gestalt Completion Test ($P. > .05$). This was surprising in view of the expected sex differences, e.g. a male advantage on the Hidden Figures Test.

CHAPTER FOURDISCUSSION

After surveying the literature on hemispheric superiorities in visual processing, Sergent (1982d) attempted to reconcile many of the experimental and theoretical inconsistencies with a novel theory in which visual perceptual asymmetries are related to differential hemispheric sensitivities for spatial frequencies. According to Sergent (1982d), the RH is better at processing low spatial frequencies which a) correspond to the gestalt of a figure; b) are available earlier in the sequence of information processing; c) are processed more readily under conditions of reduced stimulus energy or clarity. In contrast, the LH is better at processing high spatial frequencies which a) correspond to the internal details of a figure; b) are available later in the sequence of information processing; and c) are more vulnerable to reductions in stimulus energy or clarity.

The present study examined Sergent's (1982d) theory as well as the effects of instructional strategy on hemispheric superiorities in visual processing. The effect of gender was also examined, since males and females reportedly show different patterns of hemispheric specialization. The results of this study are mixed in regards to Sergent's theory: although the mean pattern of hemispheric superiorities inferred

through perceptual asymmetries for all subjects considered together partly agrees with Sergent's theory, fifty percent of individual subjects did not display the patterns of hemispheric superiority as seen in the group data. Males and females did not evidence different patterns of perceptual asymmetries for processing spatial frequencies, in fact their performances were remarkably similar. The relevance of these findings, as well as other predictions mentioned earlier in this paper will be discussed first. Subsequent to this, other results will be reviewed including the effect of individual differences and the relationship between laterality and cognition.

General Experimental Effects

Hypothesis 1: There will be a significant main effect for stimulus condition such that Condition 1 (L+S+Id) will yield the fastest RTs, followed by Condition 2 (L+S+NonId) and Condition 3 (L+S-), with Condition 4 (L-S+) yielding the slowest RTs. This hypothesis was supported across both instructional sets (IS) and sex. Reaction times consistently increased for Condition 1 (L+S+Id) through Condition 4 (L-S+). This was expected since the amount of information processing required to locate a target increases from Condition 1 through Condition 4. In the nonconflict conditions (L+S+Id and L+S+NonId), initial attention to either the large or small letters provides the subjects with enough

information with which to make a decision as to the presence or absence of a target. However, in the conflict conditions (L+S- and L-S+) subjects must often look at both letters before they can decide whether or not a stimulus contains a target letter. Sergent (1982d,e) reported similar increases in RTs across Conditions 1 through 4, as did Mapou (1985) in his extension of Sergent's (1982d) results. This results is important since it provides a replication of the overall experimental technique.

Hypothesis 2: There will be a significant main effect for instructional set such that the large-to-small (L-S) instructional set will yield faster reaction times than the small-to-large (S-L) instructional set. This hypothesis was borne out. These findings agree with subjects' self reports that the large-to-small (L-S) condition was easier or more natural than the small-to-large (S-L) instructional set. These findings are consistent with Navon's (1977) theory of global precedence in which information processing is described as proceeding from the large or overall features to the small or internal features in most individuals. Gestalt psychology (e.g. Kohler, 1947) has long emphasized that in most visual percepts, attention seems to be drawn first and most strongly to the highest level of structure. Palmer (1978) examined this effect more formally. He had subjects rate the similarity of

figures and found that ratings were much more strongly influenced by overall structural differences than by local structural differences, even though he controlled for the "size" of the difference in a template - matching paradigm. Similar results were found in studies of letter detection among background noise letters (Prizmetal & Banks, 1977; Banks & Prizmetal, 1976).

Predicted Interactions

Hypothesis 1: There will be a significant hemisphere by stimulus condition interaction such that the right hemisphere will be superior in the nonconflict conditions (Conditions 1 and 2), as well as for Condition 3 (L+S-), while the left hemisphere will be superior in Condition 4 (L-S+). This prediction was partially supported. Conditions 1 and 2 did yield RH advantage, but these asymmetries were not statistically significant. The right hemisphere advantage was statistically significant for Condition 3 (L+S-) as was the left hemisphere advantage for Condition 4, although these findings were true on a group level only. An analysis of individual performance patterns showed that while the composite group means for Conditions 3 and 4 agreed with Sergent's theory, individual patterns of perceptual asymmetries did not wholly support the above hypothesis.

Using a similar paradigm as Sergent (1982d,e),

Mapou (1985) failed to find significant LVF-RH superiorities in Conditions 1 and 2, although he successfully replicated Sergent's findings for Conditions 3 and 4. Mapou conducted his study on a CRT and accounted for the discrepancies between his findings and Sergent's via procedural differences. As was mentioned previously, Mapou's (1985) computer program did not eliminate the scrolling phenomenon inherent to CRT presentation. Consequently, small letters were available for processing before large letters, which may have heightened the availability of high spatial frequency components and reversed the natural order of processing. Mapou (1985) supported this notion of reversed or altered visual processing with evidence of RVF-LH superiorities for Condition 1 (L+S+Id). Since small letters, which comprised the top segments of the large letters, were available to the subject before the entire large letter, Mapou reasoned that the task was biased towards local or "left hemisphere" processing. Under Sergent's theory, Condition 1 should yield the strongest LVF-RH superiority, since the large and small letters are identical and therefore contain the least amount of conflict or the maximum "gestalt" like effect.

The present study eliminated the scrolling problem, and the LVF-RH superiorities were obtained for Conditions 1 through 3, although the LVF-RH visual field advantage was only significant for condition 3, (the RVF-LH advantage was significant in Condition 4). These

results do not agree with Sergent's, as she found significant LVF-RH superiorities for Condition 1 through Condition 3; however, there were procedural differences between this study and Sergent's, e.g. the methods of stimulus presentation, e.g. tachistoscope versus a CRT screen. These differences will be discussed later. Moscovitch (1979) suggested that hemispheric superiorities emerge only as processing complexity increases. Accordingly, tasks which are relatively simple can be performed equally well by either hemisphere. The results of this study agree with Moscovitch's theory, that is Conditions 1 and 2 may not have been complex enough to induce reliable hemispheric superiorities. This theory will be discussed in further detail later; however, it should be noted that an examination of Sergent's findings indicates that although visual half field asymmetries were present in all conditions, the conflict conditions (Conditions 3 and 4) yielded the most robust visual field asymmetries.

Hypothesis 2: There will be a significant instructional set by condition by hemisphere interaction such that the fastest reaction times under the large-to-small strategy will be obtained for LVF-RH presentations in condition 3 (L+S-) while the fastest reaction times for the small-to-large strategy will be obtained for RVF-LH presentations in condition 4 (L-S+).

It was predicted that the instructional set would

either facilitate or impede the expected effects for conditions based upon Sergent's theory. Specifically, the large-to-small (L-S) instructional strategy was expected to yield the fastest reaction times for Condition 1 (L+S+Id) in which subjects could rely upon the large letters alone in making their decisions as to whether or not a target was present. Condition 1 under L-S was also expected to yield the LVF-RH superiorities. Condition 2 (L+S+NonId) was expected to yield LVF-RH superiorities and to contain reaction times which were only slightly longer than Condition 1 under the L-S instructional strategy. These predictions were partially confirmed in that Conditions 1 resulted in the fastest reaction times over all of the conditions and instructional strategy combinations, followed by Condition 2; however, the right hemisphere superiorities were not significant. In the conflict conditions (3 and 4, L+S- and L-S+) the present results do show an interference effect between Condition 3 and the small-to-large (S-L) instructional strategy in that the expected LVF-RH advantage is not found in Condition 3 (L+S-) under the S-L instructional strategy (in fact, a small, nonsignificant RVF-LH advantage is seen), while the expected LVF-RH advantage is seen for Condition 3 (L+S-) under the large-to-small (L-S) instructional strategy. A similar dissociation occurs in Condition 4 (L-S+). According to Sergent's theory of differential

hemispheric sensitivities for spatial-frequencies, Condition 4 (L-S+) should result in a RVF-LH advantage. The small-to-large (S-L) instructional strategy is expected to enhance or create a left hemisphere advantage, while the large-to-small instructional strategy is expected to create a right hemisphere bias. These effects are indeed observed in the present results in which Condition 4 (L-S+) results in a RVF-LH advantage under the S-L instructional strategy and a small, nonsignificant LVF-RH advantage under the L-S instructional strategy.

Hypothesis 3: It was predicted that males and females would evidence different patterns of perceptual asymmetries, particularly in the conflict conditions (3 and 4), with females showing reduced patterns of laterality in both instructional sets. However, the present findings did not support that prediction at all, since males and females showed similar patterns of perceptual asymmetries in both instructional sets. Additionally, when the magnitude of perceptual asymmetries are examined, females were actually more lateralized than men. The results were surprising in view of neuroanatomical studies which show that there are gender related differences in areas of the brain which have a direct bearing on visuo-spatial processing, i.e. the peristriate, parietal and superior temporal regions. Lacoste-Utaming and Holloway (1981)

discovered that the splenium or posterior part of the corpus callosum is larger in women than in men. Thus, it was hypothesized that these increased connections might lead to reduced laterality patterns in women with linguistic processing of visual-spatial information and/or the use of different intrinsic strategies in cognitive processing in women as compared to men. The present findings suggest that women and men may have similar laterality patterns with respect to processing visual-spatial frequencies, but that women are more strongly lateralized than men.

The findings that women and men showed similar response patterns across the two different instructional sets was surprising in view of recent evidence which suggests that females are more reliant upon hierarchical or local aspects of stimulus processing (Friedland and Kershner, 1986). This study, which compared male and female aphasics with left hemisphere damage, found females to have more difficulty with overall gestalts. Consequently, under the present instructional sets, it was expected that women would perform better under the large-to-small instructional set, whereas men would perform better on the small-to-large instructional set. However, this was not the case; women did evidence faster overall reactions times as compared to males, but this speed advantage was not statistically significant and did not occur in one instructional set more than another. Hence, although the present set of findings

suggest that women and men process visual-spatial information via similar hemispheric laterality patterns, the increased magnitude of hemispheric asymmetries in women suggest that men and women may still process visual-spatial information differently.

The Effects of Gender: The Relationship of Perceptual Asymmetries to Cognitive Variables

In addition to expecting but not finding sex differences in perceptual asymmetries, it was predicted that males and females would evidence different performance patterns on cognitive tests involving visual spatial analytic versus holistic abilities. These predictions were not supported by the present set of data.

Several tests of cognitive abilities were administered in the hope that they might account for some of the variability in the RT data. The tests chosen were by no means exhaustive in terms of measuring different cognitive abilities. Rather, these tests were selected because they a) involved abilities related to those required by the experimental task and b) usually yield reliable sex differences. The results of the cognitive battery were disappointing in that they did little in the way of explaining variability in reaction times on the experimental task or patterns of perceptual asymmetries, even in the conflict conditions, nor did they yield the expected sex differences. These

findings, or the lack thereof, were surprising since other investigators have found relationships between performance on cognitive tests and patterns of perceptual asymmetries. For example, Healey (1981), in an investigation into the contribution of subject variables such as sex, handedness and familial history of handedness, found a relationship between performance on spatial tests and the degree and patterning of visual half field asymmetries.

Hidden Figures Test

This task, which measures the capacity to extract visual percepts from a more complex visual background, has been associated with left hemisphere processing (Teuber, 1966). Consequently, it was expected that individuals who exhibit strong RVF-LH superiorities on Conditions 3 and/or strong RVF-LH superiorities on both Conditions 3 and 4, would have high performances on the Hidden Figures Test. Also, since this task has been associated with gender differences (Ekstrom, et al, 1976), with males outperforming females, it was expected that such a male advantage would also emerge. The results of the present study suggest that there is some relationship between performance on the HFT and patterning of perceptual asymmetries on conflict conditions of this task; however, these results were not statistically significant. Females evidenced higher scores than males, although this difference was not

statistically significant. This may have been due to several factors including small sample size, since studies which report sex differences generally have large sample sizes, the educational backgrounds of the subjects, particularly female subjects may have also influenced the findings. While many studies involve graduate students and other individuals with high levels of education, the present study contained a high proportion of women with scientific or quantitative careers as well as graduate degrees. Hence, it is conceivable that although all of the subjects were volunteers selected at random, that the population from which these volunteers came was not representative of the general population. There is some indirect support for this hypothesis, since the subjects in the present study had somewhat higher scores than the general population.

Gestalt Completion Test

This task, which involves synthesis of disparate visual information into meaningful percepts or gestalts and has been associated with right hemisphere functioning, was thought to invoke similar processing components as the Conditions 1, 2 and 3 of the experimental task for which right hemisphere advantages were also expected. This hypothesis was not supported. Males and females yielded similar performances.

Rey Osterreith Complex Figure

It was hypothesized that the Rey-Osterreith drawing test, which involves visual-spatial organizational skills, might in some way be related to the capacity to implement different instructional strategies. This prediction received no support. In addition, there was no relationship between performance on this task, pattern of perceptual asymmetries, or sex.

In summary, there was no relationship between the perceptual asymmetry scores in the conflict or nonconflict conditions and performance on cognitive tests. Individuals who showed strong left hemisphere biases on the experimental task did not perform better on tests traditionally associated with left hemisphere functioning, i.e. verbal fluency or the Hidden Figures Test. Likewise, individuals who showed strong right hemisphere biases on the experimental task did not excel on the Gestalt Completion Test, which is generally associated with right hemisphere functioning.

The Influence of Procedural Variables

Before a comparison is made between the results of the present study and Sergent's (1982d,e) findings, procedural differences between the two studies must be addressed. Although the designs were similar, there are differences between the studies which may not be unimportant. Sergent's (1982d,e) study was conducted on a tachistoscope, which used a white visual field and

a black dot as a central fixation point. The stimuli were traditional black letters on a white background. The present study involved a black background and amber colored stimuli. It is unlikely the color differences alone led to significant changes in information processing and hemispheric involvement as Levy (1921, 1972) has shown that tachistoscopic presentations involving black backgrounds with white visual stimuli yield comparable patterns of hemispheric asymmetries as do more traditional presentations with white backgrounds and black visual stimuli. Another difference between the present study and Sergent's (1982d,e) concerns methods of controlling attention. Both Sergent's (1982d,e) study and the present study used "indirect" methods of controlling fixation in that although the subjects were provided with a central fixation point immediately prior to stimulus presentation, there is no direct way of verifying whether the subject actually attended to the fixation stimulus. Despite the fact that individuals in both studies a) received ample practice; b) were given periodic rests; and c) were provided with fixation stimuli, it is possible that a certain amount of responses contain "noise" or random responses in which visual field asymmetries are not the result of true processing differences between the cerebral hemispheres but the result of random responding due to attentional lapses. An alternative method of controlling fixation is to have an identifiable stimulus such as a

letter or number within the center of the fixation stimulus. There should be several different fixation stimuli which randomly vary over the experimental task and the subject should be required to identify this stimulus. This "direct" method of controlling fixation has been used by several investigators (McKeever, et al, 1972; Kershner, et al, 1977; Carter and Kinsbourne, 1979), but is also problematic since identification of central stimuli has been shown to affect patterns of visual half field asymmetries. Additionally, a subject might still attend to the fixation stimulus without attending to the target stimulus.

Another main procedural difference between this study and Sergent's (1982d) study is the use of a computer display rather than a tachistoscope. In general, the two methods seem comparable in that they yield comparable results, at least on a group level.

Mapou (1985) also used a computer display in order to replicate Sergent's (1982d) findings; however, the computer program which he used was unable to override the scrolling mechanism in the presentation of stimuli. Thus, small letters were presented slightly ahead of large letters, which resulted in RVF-LH superiorities in Condition 1 and 2 (L+S+ID and L+S+NonId), rather than the LVF-RH superiorities as predicted by Sergent (1982d, Exp. 1). The computer program utilized in this experiment was able to eliminate the scrolling problem,

yet Sergent's (1982d) findings were only partially replicated.

Another major difference between this study and Sergent's is that this study manipulated instructional strategy or the way a subject approached a task, whereas Sergent's study gave the subject's no task instructions. These different instructional sets alone were not successful in altering perceptual asymmetries, since they effected reaction time rather than perceptual asymmetry patterns. Nevertheless, when the results for the instructional sets are considered separately, as well as together, they are in agreement with Sergent's general group findings.

Sergent (1982d,e) did not look at individual performance patterns and so even though individual data did not agree with the group data, there is no way of knowing whether Sergent's findings are also statistical artifacts of group averaging or whether the individuals who participated in her study showed similar patterns of visual half field asymmetries as the group as a whole. This is an important point in terms of future research and suggests that individual performance patterns should be given as much consideration as overall group patterns.

General Discussion

The major findings of the present study will now be summarized. The present experiment was designed to

examine how different spatial frequencies of a stimulus affect the emergence of hemisphere asymmetries. The study is an attempt to understand cerebral lateralization in terms of characteristics which are basic to visual stimuli, or peripheral processing, as well as in terms which are relevant to processing taking place in the primary and secondary visual processing areas of the brain, or in terms of more central processing.

Research has shown (Navon, 1977; Miller, 1980; Sergent, 1982d,e) that different levels of a visual form are extracted at different rates. Low frequencies are extracted faster than high frequencies and, when all low frequencies have been extracted, further increases in exposure duration allow for the integration of higher frequencies (Breitmeyer & Ganz, 1977).

The present findings demonstrate this effect in that stimuli which can be responded to on the basis of large letters alone yield faster responses than stimuli which require processing of small letters. Furthermore, the results suggest that the right hemisphere has a greater capacity to perform cognitive operations on the basis of low frequencies. However, even the emergence of right hemisphere superiorities for large letters are still dependent upon the particular task. When the complexity of the task is reduced the degree of visual field asymmetries are also reduced. Also, there is a tremendous amount of individual variation in the

performance of the task which cannot be accounted for by spatial frequencies or task instruction. Sergent's (1982d, 1983a) theory that the hemispheres are differentially sensitive to high and low spatial frequencies was supported only partially. Even this support is tenuous since the findings were replicated in only half of the individual subjects. Although recent research has demonstrated that the human visual system does contain channels which are selectively responsive to specific spatial frequencies (Royer, Rzeszotarski and Gilmore, 1983); that selective processing of spatial frequencies are observable in infants as young as six weeks (Forentini, Pirchio and Sinelli, 1983); and that the visual cortex of the cat does contain areas which are responsive to particular spatial frequencies (Tootell, Silverman and DeValois, 1981), there is no evidence that these specialized areas are lateralized in ways such that high spatial frequencies are best processed by the left cerebral hemisphere and low spatial frequencies are best processed by the right cerebral hemisphere. Physiological research on the visual system provided the foundation upon which Sergent developed her theory and, while it is true that the human visual system is differentially sensitive to spatial frequencies and that the right hemisphere more often than not plays a dominant role in processing visual-spatial information, the conclusion that the

right hemisphere is specialized for processing a particular range of spatial frequencies is premature. Sergent (1983a, Sergent and Lorber, 1983) herself has become less supportive of her theory in that she admits that a) her theory does not account for perceptual asymmetries on verbal identification tasks and b) her theory does not account for information involving complex tasks. Sergent (1983a) modified her theory by relating hemispheric superiorities to differential sensitivities to stimulus energy and clarity.

Sergent (1982d,e) did not consider the effects of strategy on perceptual asymmetries. According to Hardyck's (1983) review, few investigators, if any at all, have considered strategy when designing studies. The results of Mapou's (1985) study demonstrated that instructional strategy, in combination with different levels of exposure durations, influences direction of hemispheric superiorities. The results of the present study also indicate that strategy can significantly alter the direction of hemispheric superiorities to the extent that predicted patterns of perceptual asymmetries for particular stimuli can be increased or decreased, depending upon which instructional strategy is used. Instructional strategy did not always have the predicted effects. Expected hemispheric superiorities emerged only in the conflict conditions and not in the nonconflict conditions. These results are best explained by Moscovitch's (1979) theory in which

increased laterality is related to increases in stimulus and processing complexity, since the conflict conditions were the conditions in which the large and small letters interfered with each other. In these stimuli, the amount of critical information transmitted between the hemispheres is increased, whereas when the interference is reduced, as in the nonconflict conditions where interferences between the large and small letters is minimized, the amount of critical information is not as large, thus reducing hemispheric superiorities to nonsignificant levels.

Unfortunately, even this replication of Sergent's (1982d) findings is disappointing as only half of the subjects showed the laterality patterns expected under Sergent's theory. This discrepancy between individual and group data must be explored further. The present study found no relationship between gender and performance on cognitive tests and patterns of hemispheric superiority. Indeed, individual patterns of hemispheric superiorities might be explained better by individual differences in general intelligence (Harshman, Hampson and Berenbaum, 1983) and hemispheric arousal (Levy, et al, 1983).

Despite the inability of Sergent's (1982d) theory to account for all of the present results, a total rejection of Sergent's (1982d) theory seems premature at this time, and a more direct method of evaluating

hemispheric specialization for spatial frequencies can be suggested. For example, although Navon (1977), Miller (1981) and Martin (1978) have demonstrated that large letters made up of small letters can be treated as nonverbal, spatial stimuli, these findings are true on a group level only. Also, Martin (1976) was successful at finding RVF-LH effects for small letters, but was unable to find a LVF-RH effect for large letters. Martin (1978) concluded that the hemispheres are not specialized for processing global forms; however, Martin's (1979) study used a vocal response, which may have invoked the use of left hemisphere processing. Also, it is possible that the use of stimuli which are thought to bias one hemisphere or the other do not always have the expected effects. For example, with respect to the traditional verbal-visuospatial dissociations and hemisphere asymmetries, verbal and visuospatial stimuli can result in different effects depending upon the actual physical attributes of the stimuli. Verbal stimuli are often composed of high frequencies and require a high level of resolution for identification. Conversely, visuospatial stimuli, for the most part, are generally composed of mixtures of high and low spatial frequencies and are more readily identified by processing the low frequencies alone (Navon, 1977). Hence, the left hemisphere/verbal and right hemisphere/visuospatial specializations frequently cited in the literature may result from each hemisphere

having preferential sensitivity to particular frequencies of input, i.e. spatial frequencies, rather than the verbal or nonverbal nature of the stimuli. Indirect evidence for this comes from an analysis of laterality studies involving facial recognition or discrimination (Patterson & Bradshaw, 1975), where the hemispheric superiority depends upon the number of items to be identified or distinguished. The results of the present study suggest that most subjects had an inherent right hemisphere bias for these stimuli, if they had any at all.

Future Research

Sergent's (1982d,e) theory received partial support since the expected results were not fully replicated on an individual basis. The discrepancy between her results and those of the present study may be due, at least in part, to procedural differences. Therefore, it is recommended that before any future attempts to replicate her results are conducted on a CRT, there must exist a better understanding of the similarities and differences between tachistoscopes and computers programmed to perform like a tachistoscope.

Any future attempts should compare individual and group data on a different set of stimuli in which spatial frequencies can be controlled more precisely. Royer, et al, (1983) have suggested using grating in order to filter out different levels of spatial

frequencies, although Sergent and Lorber (1983) cited evidence that the brain may automatically fill in missing frequencies. However, the spatial frequency hypothesis will remain in doubt without definitive proof that perceptual asymmetries can be differentially affected by the manipulation of low and high spatial frequencies independently of one another.

Future research should utilize stimuli other than large letters made up of small letters. While left and, more importantly, right visual half field asymmetries were obtained despite the "verbal" nature of the stimuli, it would be important to examine whether or not a replication of the test with geometric designs yielded similar results and, of greater interest in view of the present findings, the same pattern of perceptual asymmetries with letters and geometric designs in the same individuals.

Also in terms of future research, the magnitude of the effects of instructional strategy might have been examined best by including a block of trials in which subjects are not assigned a strategy or a "no instructional strategy" condition. This approach is problematic since subjects would then receive an extra session or more practice on either the L-S or S-L strategy, depending upon which strategy they evidenced a natural bias towards. A compromise might be to use a between subjects design, although then the capacity to

examine individual performance differences over time is lost.

Finally, the results of the present study as well as the results of other studies (Harshman, Hampson and Berenbaum, 1982) suggest that subject variables such as education and occupation should be taken into account when designing studies of visual half field asymmetries.

Table 1 Stimulus ConditionsLetters

Large	Small	Target Letters	Condition
H L	H L	Both Large and Small	(1) L+S+Id
H L	L H	Both Large and Small	(2) L+S+NonId
H H L L	T F T F	Large Letter Only	(3) L+S-
T F T F	H H L L	Small Letter Only	(4) L-S+
T F	T F	Neither Letter	(5) L-S-Id
T F	F T	Neither Letter	(6) L-S-NonId

L = Large Letters

S = Small Letters

Id = Identical Letters

NonId = Non Identical Letters

Table 2Sergent's (1982d) Data

	<u>Stimulus Conditions</u>	<u>Mean RTs</u>	
		LVF	RVF
1)	L+S+ Identical	519	536
2)	L+S+ NonIdentical	547	579
3)	L+S-	547	610
4)	L-S+	625	594

Table 3

Mean Reaction Times (ms) and
Standard Deviations for Each
Stimulus Condition

	----- Stimulus Condition -----			
	1	2	3	4
	L+S+Id	L+S+NonID	L+S-	L-S+

Mean RT	402	424	436	505
S.D.	079	084	092	092

Table 4

Mean Reaction Times and
Standard Deviations for
Each Instructional Set

L-S (Large-to-Small)

Mean 413

S.D. 078

S-L (Small-to-Large)

Mean 471

S.D. 095

Table 5

Mean Reaction Times (ms) and
Standard Deviations for Each
Visual Field

	Visual Field	
	L	R
Mean RT	442	441
S.D.	061	047

Table 6

Means and Standard Deviations
for Each Sex Across
Stimulus Conditions
Instructional Set
and
Visual Field

	Males	Females
Mean	454	430
S.D.	040	044

Table 7Stimulus Condition by Visual Field

Stimulus Condition	1	2	3	4
Visual Field				
L	396	425	429	518
R	409	427	445	490

Table 8

Mean Reaction Times and Standard
Deviations for Each Instructional
Set for Each Visual Field

Instructional Set	Visual Field	
	L	R
L-S		

Mean	410	416
S.D.	077	080
S-L		

Mean	473	468
S.D.	097	093

Table 9

Means and Standard Deviations
for the Two Instructional
Sets by Sex and Visual
Field

Instructional Set				

	L-S		S-L	
Visual Field	L	R	L	R
Males				

Mean	419	425	489	480
S.D.	064	056	038	014
Females				

Mean	401	406	457	456
S.D.	064	059	050	014

Table 10

Mean Reaction Times (ms) as Function
of Sex, Stimulus Condition and
Visual Field

		Stimulus Condition							
		1		2		3		4	
		L+S+Id		L+S+NonId		L+S-		L-S+	
Visual Field		L	R	L	R	L	R	L	R
	<u>Males</u>								
Mean RT		409	418	442	436	440	462	526	499
S.D.		086	074	093	089	101	100	098	105
<u>Females</u>									
Mean RT		384	400	405	412	416	432	512	481
S.D.		077	076	074	079	079	084	092	090

Table 11

Mean Reaction Times (ms) and Standard
Deviations as Function of
Instructional Set, Stimulus Condition
and Visual Field

Stimulus Condition								

1 2 3 4								
L+S+Id L+S+NonId L+S- L-S+								

Visual Field	L		R		L		R	
	L	R	L	R	L	R	L	R

<u>L-S (large-to-small instruction)</u>								
Mean	361	364	384	385	390	420	504	493
S.D.	069	061	075	073	069	084	093	103
<u>S-L (small-to-large instruction)</u>								
Mean	431	451	463	463	465	470	534	487
S.D.	098	089	095	091	112	101	084	089

Table 12

Mean Reaction Times (ms) and
Standard Deviations as
a Function of Instructional
Set and Stimulus Condition

		Stimulus Condition							

		1		2		3		4	
		L+S+ID		L+S+NonID		L+S-		L-S+	

Instructional Strategy		L-S	S-L	L-S	S-L	L-S	S-L	L-S	S-L

Mean RT		363	441	385	463	405	468	499	511
S.D.		065	094	074	093	077	107	098	089

Table 13
Mean Reaction Times (ms) and Standard
Deviations as a Function of Sex,
Instructional Set, Stimulus
Condition and Visual Field

		----- Stimulus Condition -----							
		1		2		3		4	
		L+S+Id		L+S+NonId		L+S-		L-S+	
Visual		L	R	L	R	L	R	L	R
Field									

(a) <u>Males, L-S (large-to-small instruction)</u>									
Mean		370	367	391	400	401	436	512	497
S.D.		072	053	081	077	077	095	102	108
(b) <u>Males, S-L (small-to-large instruction)</u>									
Mean		447	469	492	471	479	481	539	500
S.D.		099	094	104	101	125	105	093	101
(c) <u>Females, L-S (large-to-small instruction)</u>									
Mean		353	361	376	369	380	405	496	489
S.D.		068	069	071	067	059	072	097	102
(d) <u>Females, S-L (small-to-large instruction)</u>									
Mean		414	438	434	455	451	459	528	473
S.D.		097	084	077	080	099	095	087	077

Table 14

Patterns of Perceptual Asymmetries
Across Instructional Sets

	<u>Group A</u>	<u>Group B</u>	<u>Group C</u>	<u>Group D</u>
	<u>LVF Cond 3</u> <u>RVF Cond 4</u>	<u>LVF Cond 3</u> <u>LVF Cond 4</u>	<u>RVF Cond 3</u> <u>RVF Cond 4</u>	<u>RVF Cond 3</u> <u>LVF Cond 4</u>
<u>Males</u>	<u>10</u>	<u>1</u>	<u>3</u>	<u>4</u>
<u>Females</u>	<u>8</u>	<u>2</u>	<u>6</u>	<u>2</u>
<u>Total</u>	<u>18</u>	<u>3</u>	<u>9</u>	<u>6</u>

Table 15

Patterns of Perceptual Asymmetries
Across Instructional Sets with
Magnitudes +/- 1 Standard Deviation
for Conditions 3 and 4

	A	B	C	D
Males	1	0	0	2
Females	5	3	5	2

Total	6	3	5	2

Table 16Intercorrelations of Cognitive
Measures with Perceptual
Asymmetry Scores

	Hidden Figures	Gestalt Completion
Condition 3 Asymmetry	.232	.040
Condition 4 Asymmetry	-.116	.032

Table 17Means and Standard Deviations for
Cognitive Tests

	Hidden Figures	Gestalt Completion	Constrained Fluency
Males			
mean	8.53	13.61	14.61
s.d.	4.54	2.93	4.90
Females			
mean	11.28	11.44	16.44
s.d.	5.35	4.18	3.10

Males and Females			
mean	10.00	12.53	15.53
s.d.	5.03	3.72	4.15

Table 18Intercorrelations Between Cognitive
Measures and Conformity Index

	Hidden Figures	Gestalt Completion
Conform 3	-.010	-.286
Conform 4	.200	-.056

Table 19

Intercorrelations Between
Cognitive Measures and
Instructional Strategies

	Hidden Figures	Gestalt Completion
Instruction Set I (Large-to- Small)	.486	.485
Instruction Set II (Small-to- Large)	.437	.563
Instruction Sets I and II Combined (L-S and S-L)	.469	.541

TACHISTOSCOPIC PRESENTATIONS

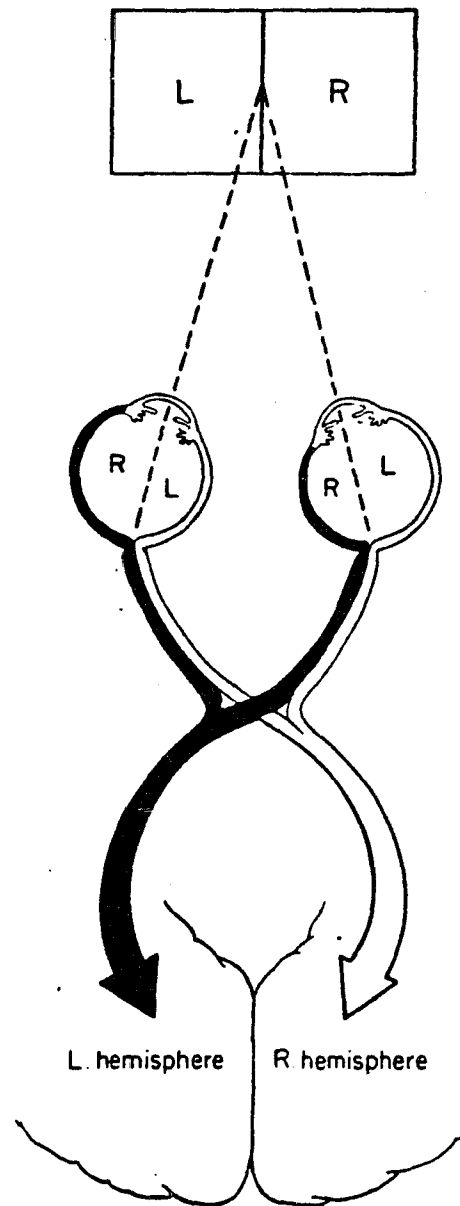


Figure 1. Schematic diagram of the classical visual system. On the top is a projection screen with a central point for gaze fixation. Images flashed on the left (L) project to the right hemisphere while images flashed on the right (R) project to the left hemisphere. The nasal part of the right eye and the temporal part of the left eye (black) transmit visual information to the left hemisphere; the nasal part of the left eye and the temporal part of the right eye (white) transmit visual information to the right hemisphere.

From Carlson, 1976

Fig. 2 Samples of Stimuli Used in Sergeant's (1982d) Procedure and in the Present Experiment.

```

H      H
H      H
H      H
H H H H H
H      H
H      H
H      H

```

(a)

```

L      L
L      L
L      L
L L L L L
L      L
L      L
L      L

```

(b)

```

F
F
F
F
F
F
F F F F F

```

(c)

```

T T T T T
T
T
T
T
T
T

```

(d)

```

H H H H H
H
H
H
H
H

```

(e)

```

T T T T T
T
T
T T T T T
T
T
T

```

(f)

- (a) Condition 1: L+S+Id
- (b) Condition 2: L+S+NonId
- (c) Condition 3: L+S-
- (d) Condition 4: L-S+
- (e) Condition 5: L-S-Id
- (f) Condition 6: L-S-NonId

Figure 3.

Instructional Set by Stimulus Condition
by Visual Fields for All Subjects

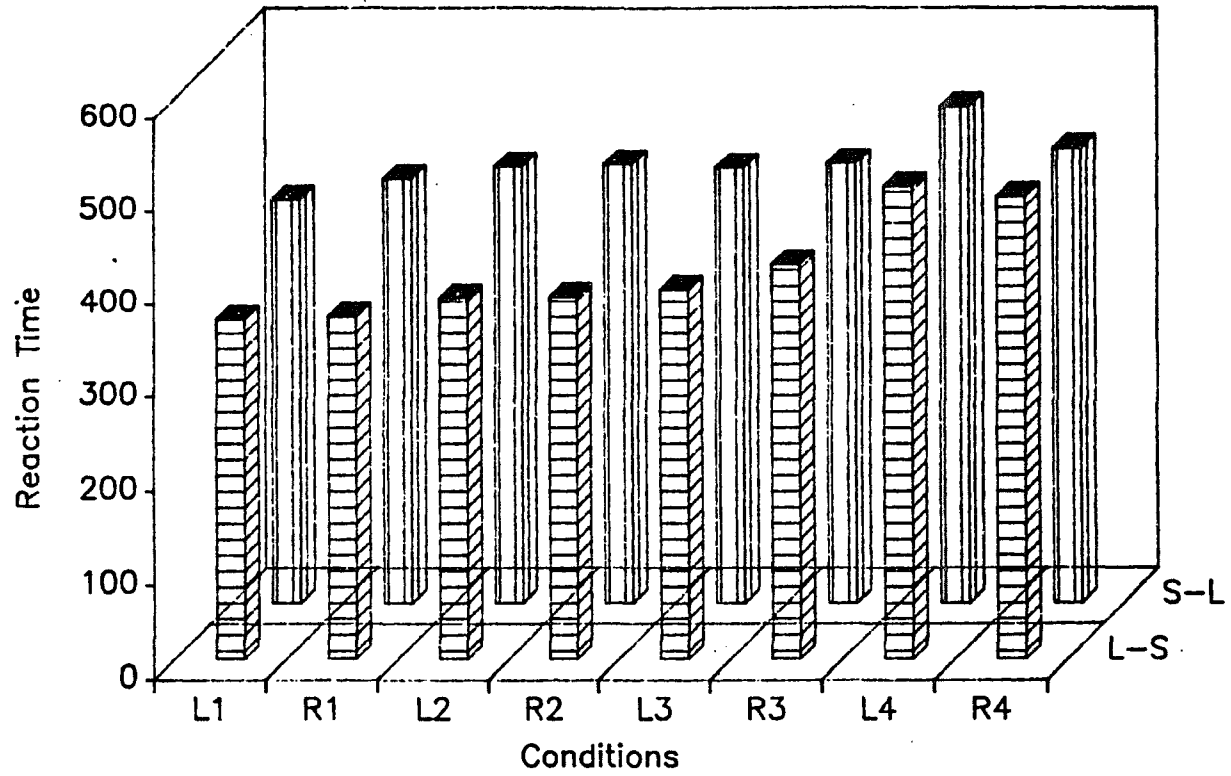


Figure 4.

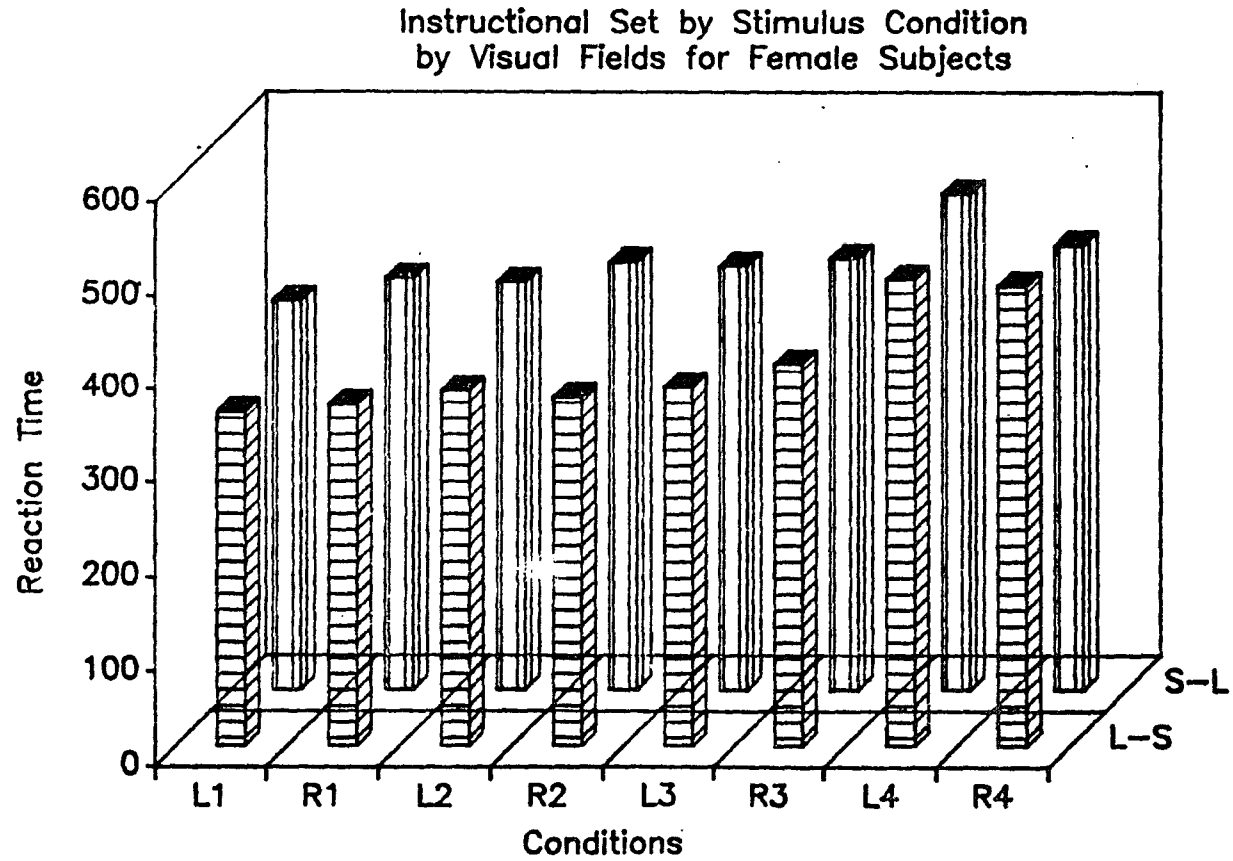
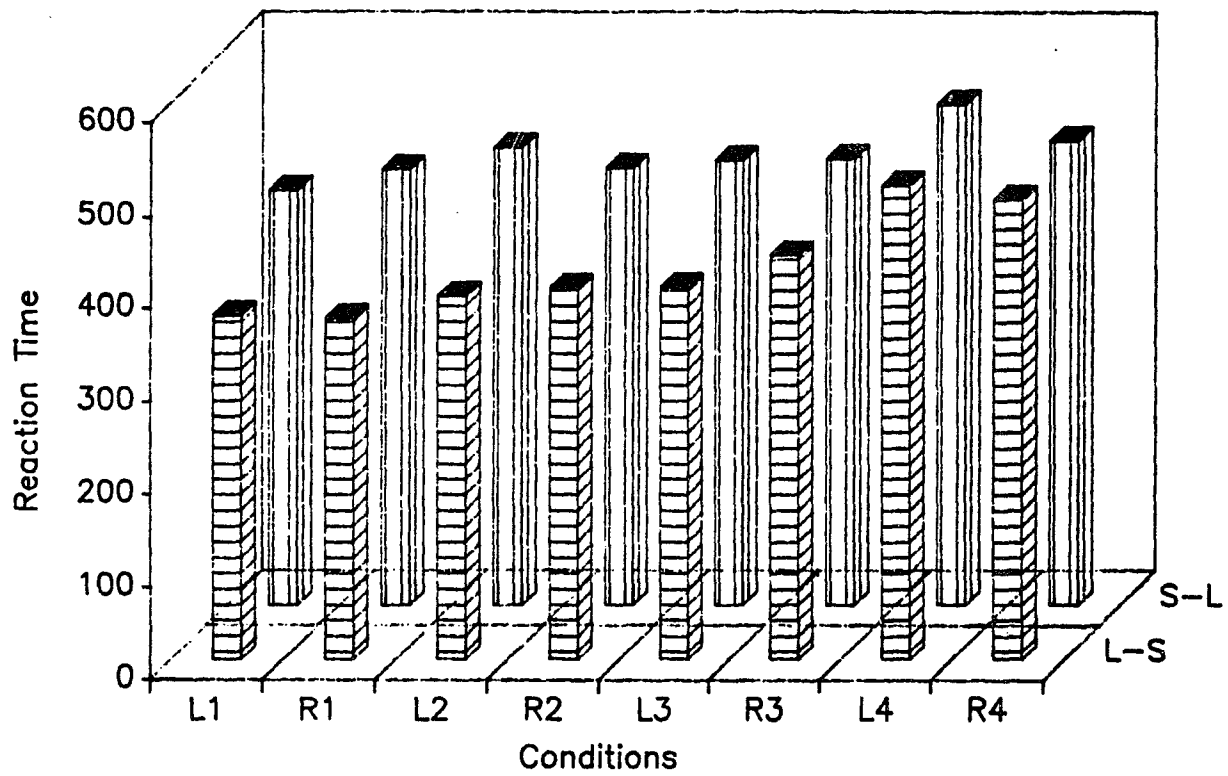


Figure 5.

Instructional Set by Stimulus Condition
by Visual Fields for Male Subjects



PLEASE NOTE:

Copyrighted materials in this document have not been filmed at the request of the author. They are available for consultation, however, in the author's university library.

These consist of pages:

Appendix A "Directions" p. 122-124

Appendix B "Gestalt Completion Test" P. 125-128

Appendix C "Hidden Figures Test" P. 129-131

Appendix D "Rey-Osterreith Test" p. 132

Appendix E "Handedness Questionnaire" P. 133

**University
Microfilms
International**

300 N Zeeb Rd., Ann Arbor, MI 48106 (313) 761-4700

APPENDIX E
HANDEDNESS QUESTIONNAIRE

Please respond to the following questions by circling the appropriate answer, e.g. "R" indicating "Right Hand"; an "L", indicating "Left Hand"; or "B", for both or either hand".

Which hand do you right with?	R	L	B
Which hand do you throw a ball with?	R	L	B
Which hand do hold a spoon or fork?	R	L	B
Which hand do you zip up a zipper with?	R	L	B
Which hand do you draw with?	R	L	B
Which hand do you use to deal cards?	R	L	B
Which hand dials or pushes buttons on a phone?	R	L	B

To the best of your knowlede:

Are either of your parents left handed?	Yes	___	No	___
Are any of your siblings left handed?	Yes	___	No	___
Are any of your first cousins left handed?	Yes	___	No	___
Are or were any of your grandparents left handed?	Yes	___	No	___
Are any of your children left handed?	Yes	___	No	___

CHAPTER SIXREFERENCES

Benton, A.L., Hannay, J., & Varney, N.R. (1973). Three-dimensional constructional disease: its relationship to side of lesion and aphasic disorder. Documenta Ophthalmologica, 34, 67-76.

Benton, A.L., & Van Allen, M.W. (1975). Geographic orientation in patients with unilateral disease. Neurology, 25 907-910.

Benton, A.L., Hannay, H.J., & Varney, N.R. (1975). Visual perception of line direction in patients with unilateral brain disease. Neurology, 25, 907-910.

Bever, T.G., & Chiarello, R.J. (1974). Cerebral dominance in musicians and nonmusicians. Science, 185, 537-539.

Bradshaw, J.L., & Bradley, D., & Patterson, K. (1976). Hemispheric differences in processing visual patterns. Quarterly Journal of Experimental Psychology, 26, 667-681.

Bradshaw, J.L., & Gates, E.A. (1978). Visual field differences in verbal tasks: Effects of task familiarity and sex of subject. Brain and Language, 5, 166-187.

Bradsaw, J.L., Gates, A., & Patterson, K. (1976). Hemispheric differences in processing visual patterns. Quarterly Journal of Experimental Psychology, 26, 667-681.

Bradshaw, G.J., Hicks, R.E., & Rose, B. (1979). Lexical discrimination and letter string identification in the two visual fields. Brain and Language, 8, 10-18.

Bradshaw, J.L., & Nettleton, N.C. (1981). The nature of hemispheric specialization in man. The Brain and Behavioral Sciences, 4, 51-92.

Breitmeyer, B.G., & Ganz, L. (1976). Implications of sustained and transient channels for theories of visual pattern masking, saccadic suppression, and information processing. Psychological Review, 83, 1-36.

Breitmeyer, B.G. & Ganz, L. (1977). Temporal studies with flashed gratings: Inferences about human transient and sustained channels. Vision Research, 17, 861-865.

- Briggs, G. G., & Nebes, R.D. (1975). Patterns of hand preference in a student population. Cortex, 11, 230-238.
- Broca, P. (1861). Nouvelle observation d'aphemie produite par une lesion de la moite posterieure des deuxieme et troisieme circonvolutions frontales. Bulletin de la Sociaty Anatomique de Paris, 36, 398-407.
- Bryden, M.P. (1965). Tachistoscopic recognition, handedness, and cerebral dominance. Neuropsychologia, 3, 1-8.
- Bryden, M.P. (1976). Response bias and hemispheric differences in dot localization. Perception and Psychophysics, 19, 23-28.(a)
- Bryden, M.P. (1976b). Sex differences in cerebral organization. Paper presented at the Fourth Annual Meeting of the International Neuropsychology Society, Toronto, Canada, February.
- Bryden, M.P. (1979a). Evidence for sex-related differences in cerebral organization. In M. Wittig & A.C. Petersen (Eds.), Sex Related Differences In Cognitive Functioning.: Developmental issues. New York: Academic Press.
- Bryden, M.P., & Allard, F. (1976). Visual hemifield differences depend on typeface. Brain and Language, 3, 191-200.
- Carlson, N.R., (1977). Physiology of Behavior, Allyn and Bacon, Inc., Boston.
- Cohen, G. (1973). Hemispheric differences in serial vs. parallel processing. Journal of Experimental Psychology, 97, 349-356.
- Cooper, L.A. (1976). Individual differences in visual comparison processes. Perception and Psychophysics, 19, 433-444.
- Coltheart, M. (1980). Iconic memory and visible persistence. Perception and Psychophysics, 27, 183-228.
- Davidoff, J.B. (1977). Hemispheric differences in dot detection. Cortex, 13, 434-444.
- Davidoff, J.B. (1977). Hemispheric differences in dot detection. Cortex, 13, 434-444.
- Dax, M. (1865). Lesions de la moitie gauche de l'encephale coincident avec l'oubli des signes de la pensee. Gazette Bebdom, 11, 259-260.

- Egeth, H., Jonides, J. & Wall, S. (1972). Parallel processing of multielement displays., Cognitive Psychology, 3, , 674-698.
- Ericksen, C.W., & Schultz, D.W. (1978). Temporal factors in visual informatoin processing: A tutorial review. In J. Requin (Ed.), Attention and Performance VII. Hillsdale, N.J.: Lawrence Erlbaum.
- Friedland, J., & Kershner, J. (1986). Sex-linked left lateralized central processor for hierarchically-structured material? Evidence from Broca's aphasia. Neuropsychologia, 24, 411-416.
- Gazzaniga, M. (1970). The bisected brain, New York: Appleton.
- Geschwind, N., & Levitsky, W. (1968). Human brain: Left-right asymmetries in temporal speech region. Science, 161, 186-187.
- Goldberg, E. & Costa, L.D. (1981). Hemispheric differences in the acquisition and use of descriptive systems. Brain & Language, 14, 144-173.
- Greenblatt, E.R. (1981). The assessment through backward masking of cognitive processing characteristics in the left and right visual fields. Dissertation Abstracts International.
- Hannay, H.J., Dee, H.L., Burns, J.W., & Maskek, B.S. (1981). Experimental reversal of a left visual field superiority for forms. Brain and Language, 13, 54-66.
- Hardyck, C. (1983). Seeing each other's points of view: Visual perceptual lateralization. In J,B, Hellige (Ed.), Cerebral hemisphere asymmetry: Method, theory and application. New York: Praeger.
- Harshman, R.A., Hampson, E. & Berenbaum, S.A. (1983). Individual differences in cognitive abilities and brain organization: I. Sex and handedness differences in ability. Canadian Journal of Psychology, 27, 144-192.
- Hays, W.L. (1973). Statistics for the social sciences. New York: Holt, Rinehart & Winston.
- Healey, J.M. (1981). Individual differences in the patterning and degree of cerebral lateralization of cognitive functioning. Dissertation Abstracts International.
- Hellige, J.B. (1976). Changes in same-different laterality patterns as a function of practice and stimulus quality. Perception 20, 267-273.

Hellige, J.B. (1980). Effects of perceptual quality and visual field of probe stimulus presentation on memory search for letters. Journal of Experimental Psychology: Human Perception and Performance, 6, 639-651.

Hellige, J.B., & Webster, R. (1979). Right hemisphere superiority for initial stages of letter processing. Neuropsychologia, 17, 653-660.

Hellige, J.B., & Webster, R. (1981). Case effects in letter-name matching: A qualitative visual field difference. Bulletin of the Psychonomic Society, 17, 179-182.

Herbst, L., & Petersen, A.C. (1979). Timing of maturation, brain lateralization and cognitive performance in adolescent females. Paper presented to the Fifth Annual Conference on Research on Women & Education, Cleveland.

Hubel, D.H., & Wiesel, T.N. (1963). Receptive fields of cells in striate cortex of very young visually inexperienced kittens. Journal of Neurophysiology, 26, 994-1002.

Jackson, J.H. (1879). On affectations of speech from disease of the brain. Brain, 1, 19.

Jonsson, J.E., & Hellige, J.B. (1986). Lateralized effects of blurring: a test of the visual spatial frequency model of cerebral hemisphere asymmetry. Neuropsychologia, 24, 329-340.

Kail, R.W., & Siegel, A.W. (1978). Sex and hemispheric differences in the recall of verbal and spatial information. Cortex, 14, 557-563.

Kimura, D. (1969). Spatial localization in left and right visual fields. Canadian Journal of Psychology, 23, 445-448.

Kimura, D. (1983). Sex differences in cerebral organization for speech and praxic functions. Canadian Journal of Psychology, 37, 19-35.

Kinchla, R.A., & Wolfe, J.M. (1979). The order of visual processing: "Top-down", "bottom-up", or "middle-out". Perception and Psychophysics, 25, 225-231.

Lacoste-Utaming, E.G. & Holloway, T. (1982). Sex differences in the human corpus callosum. Science, 235, 45-46.

Lake, D.A., & Bryden, M.P. (1976). Handedness and sex differences in hemispheric asymmetry. Brain and Language, 3, 266-282.

Lansdell, H. (1962). A sex difference in affect of temporal lobe neurosurgery on design preference. Nature, 194, 852-854.

Lansdell, H. & Urbach, N. (1965). Sex differences in personality measures related to size and side of temporal lobe ablations. Proceedings of the 73rd annual convention of the American Psychological Association, 113-114.

Landis, T., Assal, G. & Perret, E. (1979). Opposite cerebral hemisphere superiorities for visual associative processing of emotional facial expressions and objects. Nature, 27, 739-740.

Levy J. (1974). Psychobiological implications of bilateral asymmetry. In S. Dimmond & J. Beaumont (Eds.) Hemispheric functioning in the human brain, N.Y.: Halstead Press.

Levy, J., Heller., Banich, M.T., & Burton, L.A. (1983). Are variations among right handed individuals in perceptual asymmetries caused by characteristic arousal differences between hemispheres? Journal of Experimental Psychology, 9, 329-357.

Levy-Agresti, J., & Sperry, R.W. (1968). Differential perceptual capacities in major and minor hemispheres. Proceedings of the National Academy of Sciences, 61, 1151.

Luria, A.R. (1965). The higher cortical functions in man, New York: Basic Books.

Mapou, R.L. (1972). Tachistoscopic timing on the TRS-80. Behavior Research Methods & Instrumentation, 15, 534-538.

Mapou, R.L. (1985). Hemispheric specialization and visual processing of spatial frequencies as a function of stimulus exposure duration and strategy. Dissertation Abstracts International.

Martin, M. (1979a). Hemispheric specialization for local and global processing. Neuropsychologia, 17, 33-40. (a)

Martin, M. (1979b). Local and global processing: The role of sparsity. Memory and Cognition, 7, 476-484. (b)

McGlone, J. (1978). Sex differences in functional brain asymmetry. Cortex, 86, 889-918.

McGlone, J. (1980). Sex differences in human brain organization: A critical survey. The Behavioral and Brain Sciences, 3, 215-227.

McGlone, J., & Davidson, W. (1973). The relation between cerebral speech laterality and spatial ability with special reference to sex and hand preference. Neuropsychologia, 11 105-113.

McGlone, J., & Kertesz, A. (1973). Sex differences in cerebral processing of visuospatial tasks. Cortex, 9, 313-320.

Miller, J. (1980). Global Precedence in Attention and Decision. Journal of Experimental Psychology: Human Perception and Performance, 7, 1161-1174.

Milner, B. (1974). Hemispheric specialization: Scope and limits. In F.O. Schmitt & F.G. Worden (Eds.), The neurosciences: Third study program. Cambridge, Mass.: MIT Press.

Moscovitch, M. (1979). Information processing and the cerebral hemispheres. In M. Gazzaniga (Ed.), Handbook of neurobiology: Neuropsychology (Vol. 2). New York: Plenum.

Moscovitch, M., & Radzins, M. (1987). Backward Masking of lateralized Faces by Noise, Pattern, and Spatial Frequency. Brain and Cognition, 6, 72-90.

Navon, D. (1977). Forest before trees: The precedence of global features in visual perception. Cognitive Psychology, 9, 353-383.

Patterson, K., & Bradshaw, J.L. (1975). Differential hemispheric mediation of non-verbal stimuli. Journal of Experimental Psychology: Human Perception and Performance, 1, 246-252.

Paterson, A., & Zangwill, O.L. (1974). Disorders of visual space perception associated with lesions of the right hemisphere. Brain, 44, 331-338.

Penfield, W., & Roberts, L. (1959). Speech and brain mechanisms. Princeton, N.J.: Princeton Univ. Press.

Piazza, D.M. (1980). The influence of sex and handedness in the hemispheric specialization of verbal and nonverbal tasks. Neuropsychologica, 18, 163-176.

- Sagi, D. & Hochstein, S. (1985). Lateral inhibition between spatially adjacent spatial frequency channels?. Perception & Psychophysics, 37, 315-322.
- Sagi, D. & Julesz, B. (1984). Detection versus discrimination of visual orientation. Perception, 13, 619-628.
- Semmes, J. (1968). Hemispheric specialization: A possible clue to mechanism. Neuropsychologia, 6, 11-26.
- Sergent, J. (1982a). About face: Left-hemisphere involvement in processing physiognomies. Journal of Experimental Psychology: Human Perception and Performance, 8, 1-14. (a)
- Sergent, J. (1982b). Basic determinants of visual-field effects with special reference to the Hannay et al. (1981) study. Brain and Language, 16, 158-164.
- Sergent, J. (1982c). Influence of luminance on hemispheric processing. Bulletin of the Psychonomic Society, 20, 221-223.
- Sergent, J. (1982d). The cerebral balance of power: Confrontation or cooperation? Journal of Experimental Psychology: Human Perception and Performance, 8, 253-272.
- Sergent, J. (1982e). Theoretical and methodological consequences of variations in exposure duration in visual laterality studies. Perception and Psychophysics, 31, 451-461.
- Sergent, J. (1983a). Role of input in visual hemispheric asymmetries. Psychological Bulletin, 93, 481-512.
- Sergent, J. (1983b). The effects of sensory limitations on hemispheric processing. Canadian Journal of Psychology, 37, 345-366.
- Sergent, J., & Bindra, D. (1981). Differential hemispheric processing of faces: Methodological considerations and reinterpretation. Psychological Bulletin, 89, 541-554.
- Sergent, J., & Lorber, E. (1983). Perceptual categorization in the cerebral hemispheres. Brain and Cognition, 2, 39-54.
- Sherman, J.A. (1978). Sex related cognitive differences. Springfield: Charles C. Thomas.

Stroop, J. (1935). Studies of interference in serial verbal reactions. Journal of Experimental Psychology, 18, 643-662.

Thurstone, L.L. & Thurstone, T.G. (1941). The Primary Mental Abilities Tests. Chicago: Science Research Associates.

Tolhurst, D.J. (1975a). Reaction times in the detection of gratings by human observers: A probabilistic mechanism. Vision Research, 15, 1143-1149.

Tolhurst, D.J. (1975b). Sustained and transient channels in human vision. Vision Research, 15, 1151-1155.

Wada, J.A. (1976). Cerebral anatomical asymmetries in infant brains. Paper presented at the Fourth Annual Meetings of the International Neuropsychological Society, Toronto .

Wada, J.A. & Rasmussen, T. (1960). Intracarotid injections of sodium amytol for the lateralization of speech dominance. Journal of Neurosurgery, 17, 266-282.

Walter, J.L., Bryden, M.P. & Allard, F. (1976). Hemispheric differences for nonverbal visual material. Paper presented at the Annual Meeting of the Canadian Psychological Association, Toronto.

Zatore, R.J. (1979). Recognition of dichotic melodies by musicians and nonmusicians. Neuropsychologia, 17, 607-617.