

HEMISPHERIC ASYMMETRIES  
AND INTERHEMISPHERIC  
COMMUNICATION

by

DENISE DIAS CORREA

B.S., Pontificia Universidade Catolica,  
Sao Paulo, Brazil, 1984

A THESIS SUBMITTED IN PARTIAL FULFILLMENT  
OF THE REQUIREMENTS FOR THE DEGREE OF


MASTER OF SCIENCE

in the Department

of

Psychology

We accept this as conforming  
to the required standard

  
Dr. Roger Graves

  
Dr. Louis Costa

  
Dr. Stephen Eady

  
Dr. Donald Knowles

© DENISE DIAS CORREA, 1989

University of Victoria

All rights reserved. This thesis may not be reproduced  
in whole or in part, by mimeograph or other means,  
without the permission of the author.

ACCEPTED

FACULTY OF GRADUATE STUDIES

June 12, 1989  
DEAN

Supervisor: Professor Roger Graves

### Abstract

There are suggestions in the literature that, although the left hemisphere is dominant for the processing of language, the direction and degree of language lateralization vary in association with certain factors. First, the right hemisphere has some language abilities, particularly for verbal material that involves emotional content. Second, degree of lateralization of language functions may vary between right- and left-handers and, among left-handers, between those who use the inverted hand posture for writing and those who use the noninverted hand posture. Third, lateralization may be related to ability to transfer information between the hemispheres. The purpose of this study was to look for associations among: lateralization of word recognition ability as measured by a tachistoscopic lexical decision task; word type (function vs. emotional); handedness (right, left-inverted, left-noninverted); and interhemispheric transfer of visual and motor information. Results showed the expected left hemisphere superiority for word recognition in both right- and left-handed subjects, with no significant differences in measured lateralization between function and emotional words. Right-handed subjects showed stronger lateralization for word recognition than did left-

inverted subjects. No differences were observed between left-inverted and left-noninverted subjects, but relatively few left-noninverted individuals could be found. The measures of interhemispheric transfer skills did not reveal variations with respect to gender or handedness, nor with respect to degree of lateralization on the lexical decision task.

Examiners:



Dr. Roger Graves



Dr. Louis Costa



Dr. Stephen Eady



Dr. Donald Knowles

## Table of Contents

Abstract.....	ii
Table of Contents.....	iv
List of Tables.....	vi
List of Figures.....	vii
Acknowledgements.....	viii
Introduction.....	1
Hemispheric Asymmetries.....	1
Handedness.....	6
Interhemispheric Transfer.....	9
Purpose of the Study.....	11
Method.....	13
Subjects.....	13
Materials and Procedure.....	13
Lexical Decision Task.....	14
Line Drawing Task.....	17
Visual Matching Task.....	18
Results.....	19
Analysis for Right-Handed and Left-Inverted.....	19
Lexical Decision Tasks.....	19
Interhemispheric Transfer Tasks.....	32
Interhemispheric Transfer and Lexical Decision Tasks.....	33
Analysis for Right-Handed, Left-Inverted and Left-Noninverted.....	34
Discussion.....	36
References.....	48

Appendices.....	56
Appendix A - Task Instructions.....	56
Appendix B - Function, Emotional and Nonwords.....	59
Appendix C - Examples of Figures used in the Visual Matching Task.....	62
Appendix D - Correlations Between Accuracy and Reaction Time.....	63
Appendix E - Correlations Between Selected Variables (N=48).....	64
Appendix F - Correlations Between Selected Variables (N=23).....	65
Appendix G - Raw data.....	66

## List of Tables

<u>Table 1</u> .....	20
Statistics	

## List of Figures

<u>Figure 1</u> .....	23
Wordtype by Hand Interaction (N=48)	
<u>Figure 2</u> .....	24
Field by Hand Interaction (N=48)	
<u>Figure 3</u> .....	25
Wordtype by Field Interaction (N=48)	
<u>Figure 4</u> .....	28
Wordtype by Hand Interaction (N=23)	
<u>Figure 5</u> .....	29
Field by Hand Interaction (N=23)	
<u>Figure 6</u> .....	30
Field by Hand Interaction (N=23)	

## Acknowledgements

I would like to take this opportunity to thank the following people for their contributions to the completion of my thesis.

I would like to thank Dr. Roger Graves for his time and effort. His supervision was extremely relevant for the execution of this project. I would also like to thank Dr. Louis Costa for his attention and suggestions and Dr. Stephen Eady for his comments.

I would like to thank my family and Jorge Mahfuz for the "long distance" support and Nina Redding who helped me overcome many difficult periods.

Last but not least, I would like to mention Bill Seidel whose contributions, dedication and support were very important for the completion of this thesis.

## INTRODUCTION

### Hemispheric Asymmetries

The importance of the left hemisphere for the processing of language functions in the majority of right-handers is well established in the literature (Beaumont, 1982; Bryden, 1982; Geschwind, 1974). In 1865 Broca demonstrated that aphasia resulted after lesions confined to the left hemisphere but rarely occurred after right hemisphere lesions. Additional research has confirmed Broca's original statement that "humans speak with the left hemisphere" (Benson, 1979; Penfield & Roberts, 1959; Russel & Espir, 1961). It has also been demonstrated that the posterior portion of the left temporal lobe (i.e., planum temporale) is larger in most human brains (Geschwind & Levitsky, 1968). This asymmetry has been suggested to represent the neuroanatomical substrate for the left hemisphere's dominance for language in most individuals (Galaburda, Corsiglia, Rosen & Sherman, 1987; Geschwind & Galaburda, 1985). Left hemisphere dominance for language has also been shown by studies using the intracarotid injection of sodium amytal (Wada & Rasmussen, 1960). Furthermore, several investigations of the specific aspects of language functions that would be more efficiently processed by the left hemisphere have been performed. Recent studies (Benson, 1985) indicated that the syntactic aspect of language appeared to be correlated with left hemisphere functions. Other researchers (Bradshaw & Nettleton, 1981), however, argued that the left hemisphere is specialized for analytical and sequential functions.

The right hemisphere, on the other hand, has traditionally been associated with the processing of non-verbal material, particularly visuo-spatial information (Gazzaniga & Ledoux, 1978). As early as 1868

observation of remaining language abilities after left hemisphere damage led Jackson to conclude that the right hemisphere had some language representation. Understanding the role of the right hemisphere in the processing of language has been the subject of many recent studies. Although the nature of right hemisphere language function remains controversial, it is generally accepted that it has some ability for comprehending both spoken and written language (Chiarello, Senehl & Nuding, 1987; Gazzaniga, LeDoux & Wilson, 1977).

In the current literature various clinical populations have provided some information pertaining to the role of the right hemisphere in language comprehension. Patients who had undergone complete commissurotomy were found to have some limited comprehension of language that was presented to their right hemisphere (Bogen & Vogel, 1962; Gazzaniga, 1970; Sperry, 1982). Another source of information comes from the study of adults with left hemispherectomy who show severe deficits in expressive speech while retaining some ability for producing automatic speech (Burklund & Smith, 1977). Research involving the observation of severe aphasics suggests that massive lesions to the left hemisphere cause severe impairment in the use of language (Heilman & Rothi, 1985). Clinical observations, however, suggest that brief utterances of emotional content are produced by these patients. This type of speech has been attributed to the right hemisphere (Benson & Geschwind, 1971). Landis, Graves and Goodglass (1982), furthermore, observed that the reading and the writing of aphasic patients were significantly related to the emotional quality of words which was thought to be mediated in part by the right hemisphere.

Recent studies have shown that affective prosody is lateralized to the right hemisphere, while the more linguistic aspects of prosody are incompletely lateralized to the left hemisphere (Ross, 1988; Ross & Mesulam, 1979). Damage to the right hemisphere, therefore, might result in an inability to respond appropriately to emotional situations (Ross & Mesulam, 1979; Tucker, Watson & Heilman, 1977). Gardner, Brownell, Wapner and Michelon (1983), who studied aspects of linguistic and paralinguistic communication in right brain damaged patients, found that they had preservation of meaning but misinterpretation of metaphors and emotions.

Another line of research involves the investigation of hemispheric differences in the processing of language in individuals without brain damage. This approach generally relies upon three basic techniques which are noninvasive.

The first method utilizes event-related potentials (ERPs) to monitor cerebral activation during the execution of linguistic tasks. The results obtained with this approach appear to indicate that in most language tasks there is a greater left hemisphere than right hemisphere activation (Zaidel, 1985). There is some evidence, however, that the right hemisphere participates in some aspects of phonetic and semantic processing in lexical analysis (Molfese, Molfese & Parsons, 1983).

The second technique (i.e., dichotic listening) presents two auditory stimuli to each ear and measures response latency or accuracy to briefly presented stimuli. It is generally accepted in studies that use dichotic listening presentations that there is a right-ear advantage (left hemisphere) for speech discrimination and a left-ear advantage (right hemisphere) for nonverbal material (Kimura, 1961a, 1961b). On the other

hand, some of the studies that reported right-ear advantages for words also observed left-ear advantages for paralinguistic aspects of speech such as intonation (Bradshaw & Nettleton, 1983, cited in Zaidel, 1985; Graves, Landis & Goodglass, 1981; Graves, Morley & Marcopolus, 1987). An overall right hemisphere (i.e., left ear advantage) superiority for the detection of specific affects has also been demonstrated (Bryden & MacRae, 1989).

In tachistoscope presentation, the third technique, information presented to the right visual field (RVF) has direct access to the left hemisphere and information presented to the left visual field (LVF) is directly projected to the right hemisphere. Stimuli are presented to the left or right of a fixation point and the exposure duration must be short enough (i.e., 150 milliseconds or less) to prevent eye movements that would expose the stimulus to both visual fields (Sergent, 1983). There is some suggestion that in lexical decision tasks (i.e., word/nonword identification) processing is more efficient for the information with direct access to the hemisphere that is specialized in processing it (Bradshaw & Nettleton, 1981; Hellige, 1982). Tachistoscope studies generally report a RVF superiority for identification of letters and words while a LVF advantage is often reported for non-verbal material (Beaumont, 1982; White, 1972). On the other hand, there has been some indication of right hemisphere participation in the processing of new or unfamiliar linguistic material and in the recognition of concrete nouns (Bradshaw & Nettleton, 1983, cited in Zaidel, 1985; Goldberg & Costa, 1981).

Graves et al. (1981) found that both imageability and emotionality are important factors in determining right hemisphere reading. In this

study an overall RVF (i.e., left hemisphere) advantage for the processing of emotional words and nonemotional abstract words was observed. The male group, however, showed a smaller RVF advantage for emotional words than for nonemotional abstract words, suggesting some right hemisphere ability to recognize emotional words. A study by Strauss (1983) also observed RVF advantages for the recognition of both emotional and nonemotional words, but no gender differences were observed. Asymmetries in the processing of different categories of words were also reported by Day (1977) who observed a smaller RVF advantage in lexical and semantic decisions of concrete versus abstract nouns, and by Chiarello and Nuding (1987) who observed a smaller RVF advantage for processing content (referential meaning) as opposed to function (grammatical meaning) words. Some studies, however, have failed to replicate Day's (1977) observations of RVF advantages for concrete nouns (Moscovitch, 1983; Ornstein & Meighan, 1976). These findings in general are consistent with the view that the right hemisphere is more efficient in the processing of semantic (particularly visual and emotional) aspects rather than grammatical aspects of meaning.

In summary, although the left hemisphere superiority for language is well established in the literature, there is evidence that the right hemisphere has some ability to recognize verbal material particularly when it involves emotional content. One of the objectives of this study will be, therefore, to investigate hemispheric asymmetries in the processing of tachistoscopically presented function and emotional words in a normal population.

### Handedness

Another aspect that complicates the issue of lateralization of language function is the study of the cerebral organization with respect to handedness. The incidence of right-handedness in the population has been estimated to vary between 90% and 95% (Porac & Coren, 1978) while the estimates of left-handedness have varied between 8% and 10% (Hardyck & Petrinovich, 1977). The exact percentages, however, appear to vary as a function of the sample and the procedure for measuring handedness (Bryden, 1982).

The degree of lateralization in left-handers appears to be far from being completely understood. It is widely accepted that in approximately 95% of the right-handed population the left hemisphere is specialized for most aspects of language. Furthermore, in left-handers only 70% show this pattern of lateralization while 15% show a reversed and 15% a bilateral cerebral organization (Rasmussen & Milner, 1975). Annet (1978) suggested that in right-handers language functions are subserved primarily by the left hemisphere whereas for left-handers a more bilateral organization of language function would be expected.

Research has been dedicated to the study of which left-handers are more likely to show left hemisphere speech lateralization and which would show either the reversed pattern or a bilateral representation of function. Levy and Reid (1976, 1978) proposed that there was a relation between hand preference, motor control of writing and language organization. The authors observed that left-handers show two different types of posture during writing. The left non-inverted writer positions the hand below the line of writing with the pen tip pointing towards the

top of the page. The left-inverted writer positions the hand above the line of writing with the pen tip oriented towards the bottom of the page. Levy and Reid (1976) proposed that the inverted position was associated with left hemisphere language representation and the non-inverted position indicated right hemisphere representation. This theory was based on findings from tachistoscope studies that showed an overall RVF (left hemisphere) advantage for left-inverted and right handed subjects and a LVF (right hemisphere) advantage for left-noninverted. The authors also observed that left-inverted subjects were less lateralized than both left-noninverted and right-handed subjects in verbal and visuospatial tasks. There is some controversy, however, regarding their methods and conclusions (McKeever & Hoff, 1979).

The inverted hand posture appears to be more common than the non-inverted among left handers. The distribution of left-inverted posture reported by some studies has been shown to vary between 50% and 70% (Levy, Heller, Banich & Burton, 1983; McKeever & VanDeventer, 1980). Lower incidences of inverted hand posture, however, have been reported (Annet, 1982). Among right handers less than 1% show the inverted position (Tapley & Bryden, 1983).

A number of studies have failed to find any relation between handwriting posture and lateralized advantages on a variety of visual, auditory and verbal tasks (Levy, 1982; Weber & Bradshaw, 1981). It appears that when differences in hemispheric specialization do occur, however, they may be restricted to the visuomotor domain (Levy, 1982). Research employing the intracarotid injection of sodium amytal (i.e., Wada technique) to anaesthetize temporarily one hemisphere has also failed to

demonstrate a relationship between hand posture and lateralization of language (Strauss, Wada, Lapoint, Gaddes, & Kosaka, 1984).

Assuming (a) that left-inverted and left-noninverted writers have opposite language dominance, and (b) that the fine motor control resides in the hemisphere that is also dominant for language, Levy and Reid (1978) subsequently predicted that the control of fine movements must be contralateral to the writing hand in left-noninverted and ipsilateral to the writing hand in left-inverted writers. Moscovitch and Smith (1979) have observed that differences between left-inverted and left-noninverted writers are confined to the visuomotor domain. These later authors suggested that there is an anomaly in the integration of the visual and motor systems in left-inverted writers. This theory points to a disorder in the connection between visual and motor systems as opposed to one between language and motor organization. This theory has been challenged by Bradshaw, Nettleton and Spehr (1982) who could not find evidence that the left-inverted has a peculiar visuomotor organization. Another position was presented by McKeever and Hoff (1983) who noticed an absence of measurable interhemispheric transfer time in left-inverted but not in left-noninverted. They hypothesized a slowed visuo-motor integration associated with efficient interhemispheric transfer skills for the left-inverted group.

In summary, left-handers appear to be more variable than right-handers in their degree of hemispheric lateralization of language functions, although the majority of left-handers may show left hemisphere dominance for language. The hand posture used for writing (i.e., left-inverted vs left-noninverted) has been proposed as a measure of

hemispheric lateralization. Another objective of this study will be, therefore, to investigate hemispheric asymmetries in the processing of words in left-handers with respect to hand posture for writing.

### Interhemispheric Transfer

The study of the communication between the two hemispheres is also relevant since they both hemispheres participate in the execution of most functions. The degree of this participation presumably varies according to the task to be performed. This communication between right and left hemisphere occurs mainly via the corpus callosum and anterior commissure. The importance of these pathways for interhemispheric communication has recently become well documented through the study of patients who have undergone commissurotomy for the relief of epilepsy (Bogen, 1985; Bogen & Vogel, 1975; Preilowsky, 1975; Sperry & Gazzaniga, 1967). Bogen (1985) reports that the right-hander with complete commissurotomy is not able to name aloud objects felt with the left hand, is not able to read aloud written material presented to the LVF and is not able to execute actions with the left hand when they are verbally described. The association between the language dominant left hemisphere and right hand preference emerges from the fact that the left hemisphere is usually specialized for both language and skilled movements (Heilman & Rothi, 1985; Kimura & Archibald, 1974). Nonetheless, some studies question this assumption due to observations of patients with language specialization dissociated from motor specialization (Coslett, Rothi, Valenstein & Heilman, 1986).

Relatively little research has been dedicated to the study of interhemispheric transfer of information in normal populations. Potter

and Graves (1988) reported significant variation in performance on interhemispheric transfer tasks according to gender and handedness. Females performed better than males on a visual left-right matching task which required transfer of information. This finding is consistent with deLacoste-Utamsing's (1982) observation that the splenium of the corpus callosum is larger in females. The splenium corresponds to the posterior portion of the corpus callosum and is considered the site of interhemispheric transfer of visual information. Potter and Graves (1988) have also reported superior interhemispheric transfer of motor information among left-handers. This result is supported by Witelson (1985) who found the anterior portion of the corpus callosum to be larger in left handers. The anterior portion of the corpus callosum is responsible for the transfer of motor information. The existence of gender and handedness differences in callosal size remains controversial, however, since Witelson (1985) did not find a gender effect, and Kertesz, Polk, Howell and Black (1987) in an MRI study found neither gender nor handedness differences. Potter and Graves (1988) speculated that the strong lateralization of function in right-handed males may be associated with inefficient interhemispheric transfer.

In summary, there is some evidence that the efficiency of interhemispheric transfer varies with respect to gender and handedness. Another objective of this study will be, therefore, to attempt to replicate Potter and Graves (1988) findings.

### Purpose of the Study

The present research will examine both hemispheric differences in the processing of language and interhemispheric transfer of visual and motor information in a normal population. Both of these aspects will be analyzed for the overall group of subjects. Further analysis will be conducted in order to investigate differences according to gender and handedness. The left-handed group will be subdivided according to hand posture for writing.

A lexical decision task will be used to study hemisphere asymmetries. The processing of two categories of words will be assessed: function and emotional. According to Chiarello (1987) function words convey primarily grammatical meaning and are processed more efficiently by the left hemisphere. On the other hand, Graves et al. (1981) observed that the right hemisphere has some ability to recognize words with emotional content.

Two of the tasks reported in Potter and Graves (1988) will be used to examine the transfer of visual and motor information between the hemispheres: vertical lines and figure matching.

Based upon the above cited research the following hypotheses were conceived:

If in right-handed individuals there is a left hemisphere superiority for the recognition of words but some right hemisphere ability to recognize emotional words there will be (a) a RVF advantage for function words and a smaller RVF advantage for emotional words. If males are more strongly left hemisphere dominant for word recognition then the males will show a greater RVF advantage than the females.

If the findings of a more variable degree of lateralization of function are correct, the left handed group compared with the right-handed group will show a less marked visual field advantage. Nevertheless, the results should be in the same direction as those for right-handers since the majority of left-handers has left hemisphere specialization for language. If left-inverted subjects are less lateralized than left-noninverted subjects the latter will exhibit greater visual field effects.

If Potter and Graves (1988) findings are replicated then, (a) the left-handed group will show more efficient interhemispheric transfer of motor information than right-handers, (b) the female group will be more efficient in tasks involving transfer of visual information when compared to males, (c) the left-inverted group will show more efficient interhemispheric transfer than the left-noninverted group.

Finally, if strong lateralization of function is related to inefficient interhemispheric transfer of information, a negative correlation between visual field advantage in the lexical decision and interhemispheric tasks would be expected across all subjects.

## METHOD

### Subjects

Fifty-six University of Victoria students participated in this study. The subjects were classified into three groups according to gender, handedness and hand posture. Among 33 right-handed subjects initially screened to participate in the study only the ones who obtained scores greater than 35 on the handedness questionnaire were selected. Among 42 left-handed subjects screened only the ones who could be clearly classified according to hand posture for writing were selected to participate in the study. This procedure resulted in a sample of 24 right-handers (12 males and 12 females), 24 left-handers with inverted writing posture (12 males and 12 females) and 8 left-handers with non-inverted writing posture (3 males and 5 females).

### Materials and Procedures

In order to determine handedness, eight items were selected from a 20-item hand preference questionnaire which was subjected to factor analysis in a study by Steenhuis and Bryden (1987). Items with loadings of at least .7 were chosen to be used in the present research. Subjects rated their hand preference on a five point scale for each item (i.e., always, usually, or equal use of the right or left hand). A maximum score of 40 would indicate a strong preference for the right hand and a minimum score of eight would indicate a strong preference for the left hand. Individuals with scores greater than 24 were considered right-handed and those scoring 24 or less were considered left-handed.

Hand posture was assessed by asking the subjects to write their

names while being observed by the examiner. Subjects were classified in terms of hand position relative to line of writing and orientation of pen tip (Levy & Reid, 1976). According to the authors, subjects can be classified inverted or non-inverted. Some subjects, however, could not be clearly classified by posture and did not participate in the study.

Visual acuity was determined by asking the subjects to read a Snellen's Visual Chart presented in a tachistoscope projector screen. Reduction of the original size was necessary in order to meet the exact distance-letter size relation requirement. Accurate reading of at least six of the nine lines of letters was required (i.e., 20/20 binocular vision).

Four tasks were performed by each subject. The order of task presentation was the same for all subjects: (1) one set of lexical decision items (2) line drawing (3) visual matching (4) another set of lexical decision items. A rest period of five minutes was given after each task. The exact instructions for each task are presented in Appendix A.

#### Lexical decision task

Stimuli consisted of twenty function words and twenty emotional words matched for length (four letters). The function words consisted of adverbs, prepositions and adjectives eleven of which were reported in Chiarello and Nuding's (1987) study. Ten of the emotional words that were used in this study have previously been utilized by Graves et al., (1981).

The degree of emotionality of both types of words was determined by asking 30 people, who did not take part in the study, to rate them on a

seven point scale. The scale ranged from low emotion (1) to high emotion (7). In order to be considered emotional a word had to be rated 5 or greater and to be considered non-emotional a word had to be rated 2.5 or less. In addition, forty nonsense words were constructed by rearranging the letters of the forty words. The nonwords were pronounceable and matched in length to the word stimuli. The function, emotional and nonwords used are listed in Appendix B.

Two sets of eighty word and nonword stimuli were formed. They were both the same except that stimuli that appeared in one visual field in set one appeared in the opposite visual field in set two. This procedure guaranteed the presentation of information to both visual fields. The words/nonwords were arranged in random order with the restriction that no more than three successive items of the same category appeared in the same visual field. Each set presented half of the stimuli (i.e., words and nonwords) in the RVF and the other half in the LVF. The two sets were given separately and the presentation was balanced: half of the subjects in each of the three groups received set 1 first while the other half received set 2 first.

Stimuli were printed on 10 x 15 centimeter white cards using Letraset (3012 Helvetica Medium). Each letter string was presented laterally with a 2 degree angular separation between center and first letter. The information was presented on a three channel tachistoscope (Gerbrands Model G11 50A). One channel displayed the letter strings, another a fixation point which consisted of a dot in the center of a white card, and the last channel presented a masking card. The masking card contained a two-row sequence of g's printed bilaterally two degrees from

the left and right of the center of a white card.

The task started with a practice trial (10 words and 10 nonwords) that was designed to determine the adequate exposure duration to be employed for the actual task. All subjects started with a 100 ms time exposure. If accuracy was 80% or higher for either field, exposure duration was reduced to 70 ms. If accuracy was 60% or lower for both visual fields exposure duration was increased to 150 ms. Exposure duration was maintained at 100 ms if accuracy was above 60% and below 80%. Each subject received only one practice trial (i.e., 10 words and 10 nonwords). This procedure has been demonstrated to be acceptable in pilot work and was intended to avoid potential floor or ceiling effects by keeping performance close to 75% overall accuracy (i.e., halfway between chance 50% and 100% correct performance).

A set of 80 stimuli (40 words and 40 nonwords), with a two minute rest period given after the first 40 stimuli, followed the practice trial. A fixation dot was present continuously except during stimuli and mask exposure. The mask card followed the stimuli presentation with the purpose of making perception more difficult. In a pilot study the use of this mask was found to provide acceptable accuracy levels.

Subjects were instructed that four letters were going to appear briefly on the screen, half of the time to the left of fixation and half of the time to the right. They were also told that half of the stimuli would be words and half the stimuli would be nonwords. The importance of looking at the fixation dot during the whole time was emphasized. Bimanual response was required in order to minimize asymmetries in response control. In response to a word the subject was asked to press

two keys immediately after stimulus presentation using the index fingers of both hands. No response was required for nonwords. Both accuracy and reaction time were recorded. For an index of strength of the visual field (lateralization) effect the formula proposed by Marshall, Kaplan and Holmes (1975) was used. This laterality index was calculated for the function, emotional and the combination of both types of words. Reaction time was measured with a clock that stopped when either hand pressed a key (i.e., the faster hand stopped the clock).

#### Line drawing task

Subjects were blindfolded and were asked to stand facing a large drawing pad attached to the wall. They were given two pens, one to be held in each hand. The hands were placed at the top of the page, at body width apart. The instruction given was to draw two vertical lines down the page and to concentrate on keeping the hands moving parallel and at the same speed. Subjects were instructed by the examiner when to begin and when to stop based on markings on the paper. This task was repeated three times. The subjects were kept blindfolded throughout the execution of the task. The line pairs produced were approximately 50, 30 and 40 centimeters in length respectively. The difference between the two lines in length was obtained for each trial and a mean difference for the three trials calculated. A low score (i.e., two lines of approximately the same length) represented a more efficient performance than a high score (i.e., two lines of different lengths). This task has been previously used in a study by Potter and Graves (1988).

### Visual matching task

In this task a three-channel tachistoscope was used to present non-meaningful geometrical figures simultaneously to the left and right visual fields. The figures, drawn in black ink on a white card, were approximately 1.8 degrees wide and were centered approximately 2.7 degrees to the left and right of the central fixation dot. The same figures have been previously used by Potter and Graves (1988). Time exposure was 150 ms since longer exposures might allow sufficient time for a saccadic movement to occur. The subject was required to state whether or not the figures were different. Equal numbers of same and different figures were arranged randomly. The task started with a practice trial in which four pairs of figures were shown and was followed by the presentation of sixty pairs of figures. Scoring was done in terms of number of correct items. Examples of the figures used are in Appendix C.

## RESULTS

Due to the small number of subjects obtained for the left-noninverted group (n=8) most of the analyses were performed using only the right-handed (n=24) and the left-inverted (n=24) subjects. Analyses including all three groups are reported separately. Means and standard deviations for all subjects (n=56) in the interhemispheric transfer tasks, lexical decision tasks and reaction time are presented in Table 1.

Analyses for right-handed and left-invertedLexical Decision Tasks

Descriptive analysis conducted on the performance accuracy data for the lexical decision task revealed that many subjects had accuracies above the desired (i.e., approximately 75% correct) level. In order to investigate if this influenced the results two separate analyses were performed: (1) inclusion of all 48 subjects, (2) exclusion of subjects achieving greater than 90% accuracy in either field, for either emotional or function words. The 90% accuracy was arbitrarily chosen as a considerable deviation from the desired level, and would eliminate potential ceiling effects.

Analysis of variance was performed to test the association between sex and handedness, and accuracy on the

Table 1  
Statistics

Variables (units)	Right-handed (n=24)	Left-inverted (n=24)	Left-noninverted (n=8)
	Mean (SD)	Mean (SD)	Mean (SD)
Line (cm)	1.80 (.70)	1.69 (.69)	1.68 (.88)
Figure (number correct)	44.92 (3.59)	44.38 (3.54)	44.00 (3.16)
Function-LVF (number correct)	14.33 (2.88)	14.96 (2.49)	14.25 (3.99)
Emotional-LVF (number correct)	14.42 (2.32)	16.33 (1.97)	14.00 (3.07)
Nonword-LVF (number correct)	27.88 (3.85)	27.54 (4.34)	28.50 (4.14)
Function-RVF (number correct)	17.13 (1.78)	15.67 (2.50)	15.75 (2.38)
Emotional-RVF (number correct)	17.79 (1.61)	17.79 (1.53)	17.88 (1.96)
Nonword-RVF (number correct)	27.83 (3.53)	28.17 (4.50)	28.63 (2.77)
RT Function LVF (msec)	648.13 (106.23)	542.46 (94.57)	603.88 (132.67)
RT Emotional LVF (msec)	637.38 (96.78)	524.21 (91.37)	578.63 (141.13)
RT Function RVF (msec)	609.46 (96.14)	516.13 (77.78)	573.38 (103.98)
RT Emotional RVF (msec)	601.42 (93.48)	509.17 (89.64)	536.38 (98.71)

lexical decision task for 48 subjects. A repeated measures design was used to provide greater sensitivity by reducing subject variability. There were two between factors, handedness (i.e., right-handed and left-inverted) and sex, and two within factors, wordtype (i.e., function and emotional) and field (i.e., RVF and LVF). Because the within factors each had only two levels, multivariate and univariate tests of significance were identical. Results were therefore reported using univariate F tests. Neither the sex ( $F(1,44)=2.88$ ,  $p>.097$ ) nor the handedness ( $F(1,44)=0.37$ ,  $p>.543$ ) main effects were found to be significant, suggesting that these groups did not differ in overall accuracy. The sex by hand interaction was also nonsignificant ( $p>.708$ ). The wordtype main effect ( $F(1,44)=20.23$ ,  $p<.001$ ) was significant with higher accuracy for emotional words as opposed to function words. The wordtype by hand interaction ( $F(1,44)=8.47$ ,  $p<.006$ ) was also found to be significant. T-tests were performed in order to explore the wordtype by handedness interaction. The results suggested that the right-handed subjects did not differ in their performance when presented with function and emotional words ( $T(23)=1.24$ ,  $p>.226$ ). The left-inverted subjects, however, performed better when presented with emotional words ( $T(23)=4.86$ ,  $P<.001$ ) as opposed to function words. T-tests also suggested that left-inverted subjects were significantly more accurate than right-handed subjects in identifying emotional words

( $T(46)=-2.55$ ,  $p<.014$ ). No differences between the two groups for identifying function words were found ( $T(46)=.69$ ,  $P>.496$ ). These data for right-handed (RH) and left-inverted (LI) subjects are displayed in Figure 1. The sex by wordtype ( $p>.218$ ) and the sex by hand by wordtype ( $p>.599$ ) interactions were nonsignificant. The field main effect, however, was significant ( $F(1,44)=43.21$ ,  $p<.001$ ) revealing that the subjects overall were more accurate in identifying words presented to the RVF than to the LVF. The field by hand interaction was also found to be significant ( $F(1,44)=9.96$ ,  $p<.003$ ). T-tests were conducted to explore the field by hand interaction. The results suggested that right-handed subjects performed significantly better ( $T(23)=5.69$ ,  $p<.001$ ) in the RVF than in the LVF. The same pattern was found for left-inverted subjects ( $T(23)=3.26$ ,  $p<.003$ ). T-tests also suggested that the right-handed and the left-inverted groups did not perform significantly different in the RVF ( $T(46)=1.69$ ,  $p>.098$ ) or in the LVF ( $T(46)=-.197$ ,  $p>.055$ ). These data are displayed in Figure 2. The sex by field ( $p>.218$ ) and the sex by hand by field ( $p>.397$ ) interactions were nonsignificant. Finally, the wordtype by field interaction ( $F(1,44)=2.65$ ,  $p>.111$ ) was found to be nonsignificant revealing that the visual field advantage was the same for both words (see Figure 3). The interactions sex by wordtype by field ( $p>.919$ ), hand by wordtype by field ( $p>.840$ ) and sex by hand by wordtype by field ( $p>.269$ ) were nonsignificant.

FIGURE 1

wordtype by hand interaction

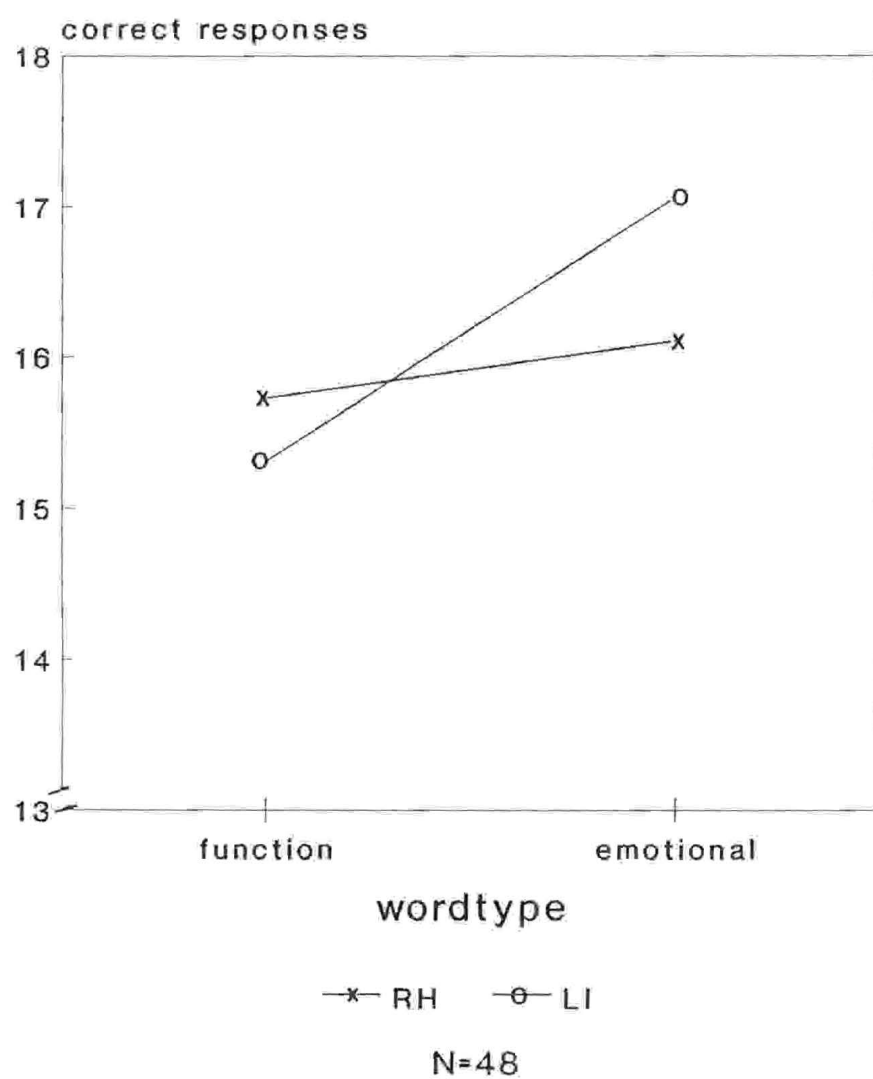


FIGURE 2

field by hand interaction

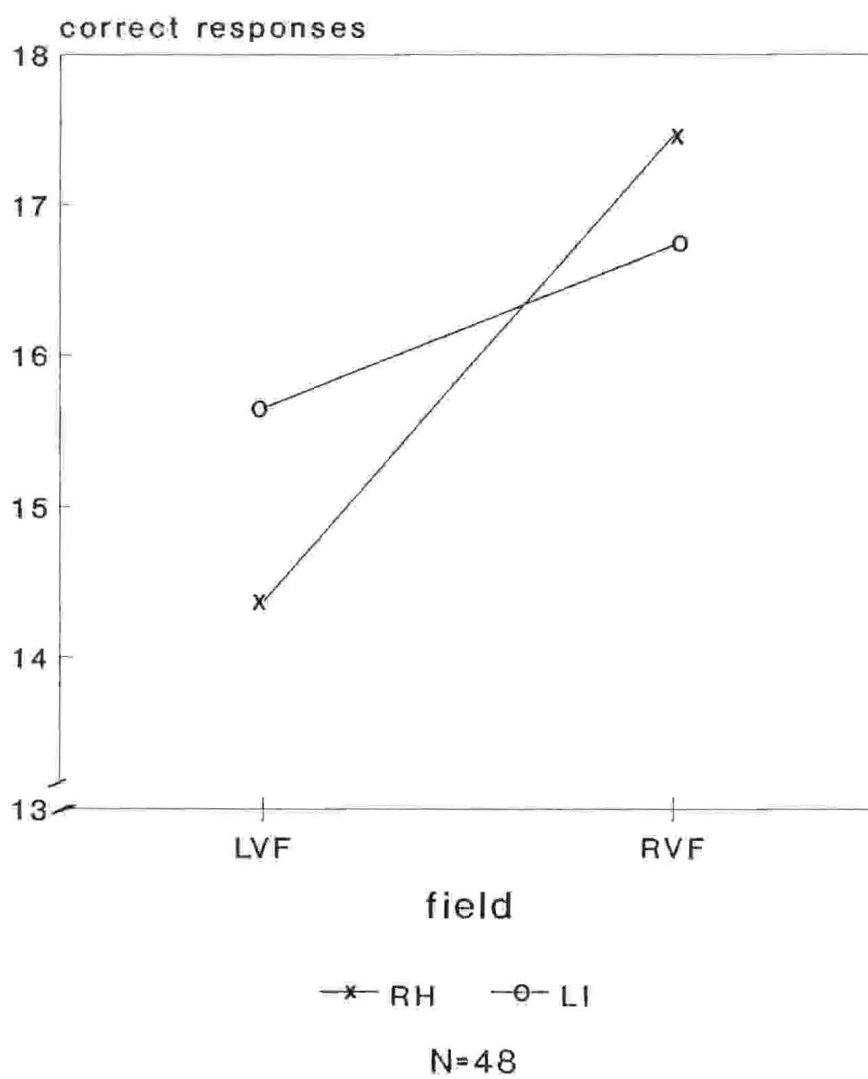
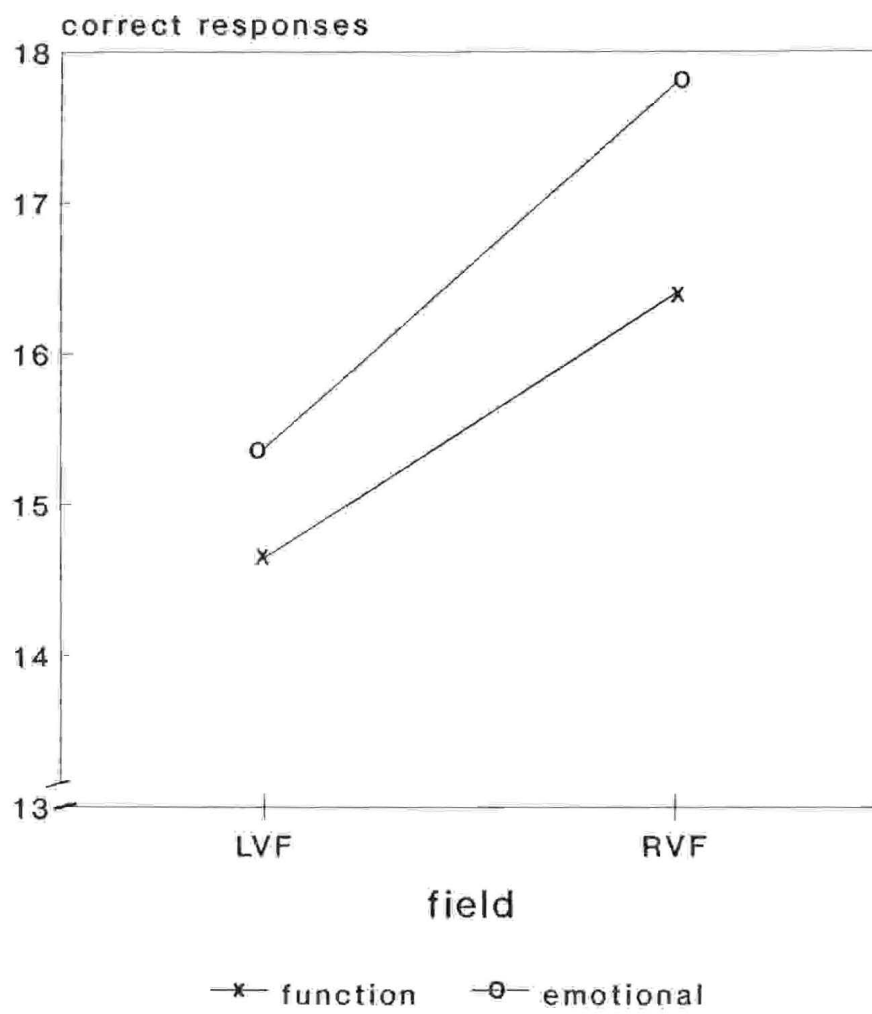


FIGURE 3

wordtype by field interaction



N=48

A separate analysis of variance was performed to investigate the specific hypothesis of a stronger RVF advantage for function words than for emotional words in the right-handed group. The results showed that the wordtype by field interaction ( $F(1,22)=.89, p>.355$ ) was not significant indicating that there was a similar RVF advantage for both categories of words. A T-test was performed to test the hypothesis of no marked visual field advantage in the left-inverted group. The results indicated that this group performed significantly better in the RVF than in the LVF ( $T(23)=3.26, p<.003$ ).

Analysis of variance was also used to test the association between sex and handedness, and accuracy on the lexical decision task excluding subjects who achieved accuracies greater than 90% in any conditions. This resulted in retaining 11 males (i.e., 6 right-handed and 5 left-inverted), 12 females (i.e., 5 right-handed and 7 left-inverted) subjects. Repeated measures analysis of variance indicated that the sex main effect was significant ( $F(1,19)=8.59, p<.009$ ) with females performing better than males in overall accuracy. The hand main effect ( $p>.087$ ) and the sex by hand interaction ( $p>.692$ ) were nonsignificant. Both the wordtype main effect ( $F(1,19)=14.19, p<.001$ ) and the wordtype by handedness interaction ( $F(1,19)=5.24, p<.034$ ) were found to be significant. T-tests were conducted in order to explore the wordtype by handedness interaction. The results

indicated that left-inverted subjects were more accurate in their identification of emotional words than function words ( $T(10)=3.99$ ,  $p<.003$ ). The right-handed subjects did not differ in their performance when presented with either type of words ( $T(11)=.95$ ,  $p>.364$ ). T-tests also indicated that right-handed subjects performed significantly better than left-inverted subjects when presented with function words ( $T(21)=2.44$ ,  $p<.024$ ), but not with emotional words ( $T(21)=.04$ ,  $p>.968$ ). These data are displayed in Figure 4. The sex by wordtype ( $p>.215$ ) and the sex by hand by wordtype ( $p>.695$ ) interactions were found to be nonsignificant. The field main effect was also significant ( $F(1,19)=20.41$ ,  $p<.001$ ) with better performance for words presented to the RVF as opposed to the LVF. The interactions field by hand ( $p>.243$ ) and wordtype by field ( $p>.552$ ) were not significant (see Figures 5 and 6, respectively). The interactions sex by hand ( $p>.218$ ), sex by hand by field ( $p>.397$ ), sex by wordtype by field ( $p>.919$ ), hand by wordtype by field ( $p>.840$ ) and sex by hand by wordtype by field ( $p>.269$ ) were all nonsignificant. Thus, the results of this analysis are similar to that for the full sample, except that the field by hand interaction was no longer significant, the wordtype by handedness interaction showed the reversed pattern with respect to wordtype and the sex effect was significant. Multivariate analysis of variance was also performed to investigate the relation between time to respond to the presented words (i.e., reaction

FIGURE 4

wordtype by hand interaction

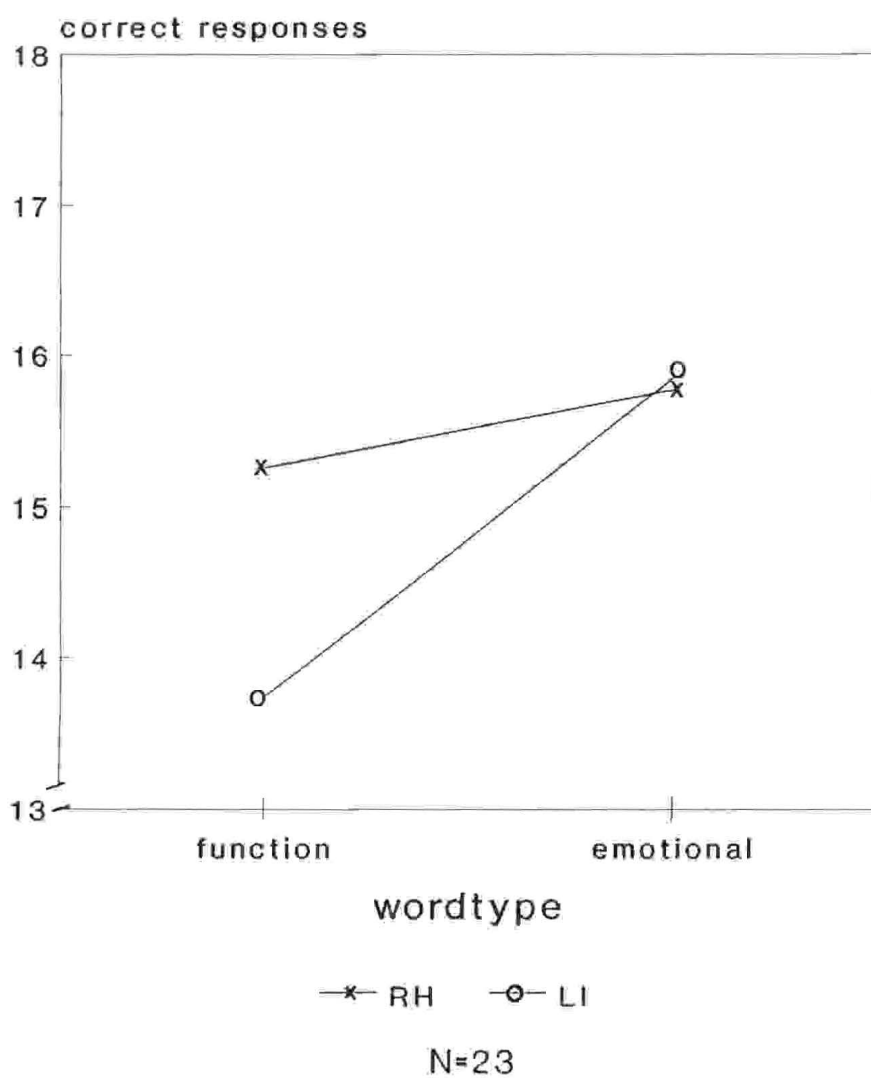


FIGURE 5

field by hand interaction

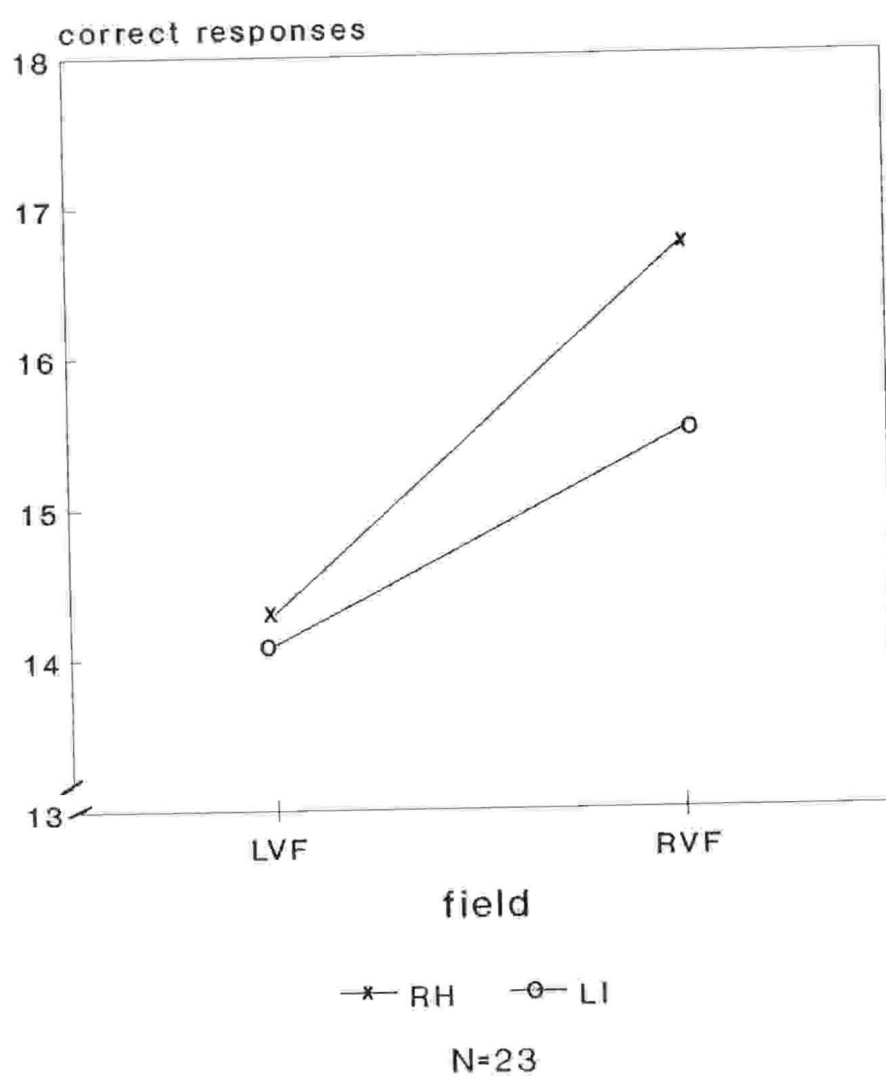
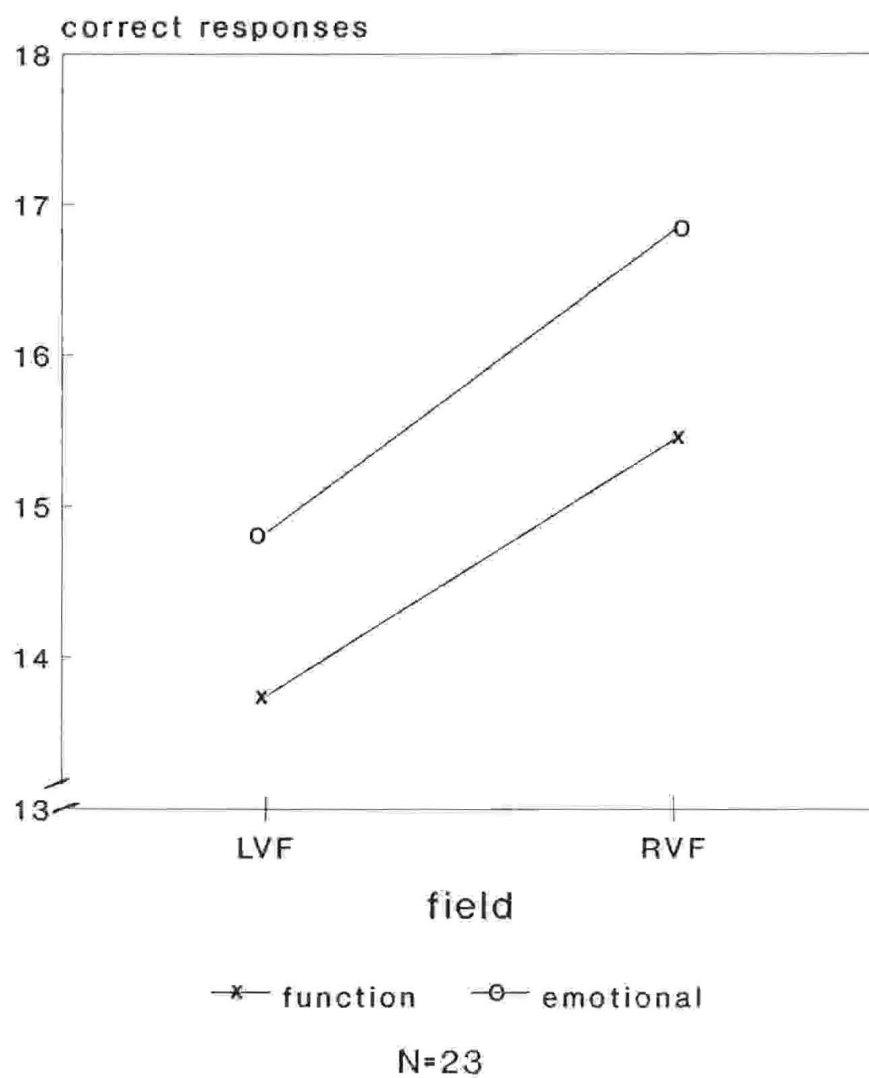


FIGURE 6

wordtype by field interaction



time), and sex and handedness. A repeated measures design with two between factors, handedness (i.e., right-handed and left-inverted) and sex, and two within factors, wordtype (i.e., function and emotional) and field (i.e., RVF and LVF) was used for the 48 subjects. Since the within factors again had only two levels each, multivariate and univariate tests of significance were identical. Results were therefore reported using univariate F tests. The handedness main effect was found to be significant ( $F(1,44)=16.37, p<.001$ ) with the left-inverted subjects responding faster than the right-handed subjects. The sex main effect was nonsignificant ( $F(1,44)=3.38, p>.073$ ). The wordtype main effect was significant ( $F(1,44)=5.90, p<.019$ ) revealing that the subjects responded faster when presented with emotional words than when presented with function words. The interactions sex by hand ( $p>.761$ ), sex by wordtype ( $p>.066$ ), hand by wordtype ( $p>.725$ ) and sex by hand by wordtype ( $p>.342$ ) were all nonsignificant. The field main effect was highly significant ( $F(1,44)=17.40, p<.001$ ) revealing that the subjects responded faster when the words were presented to the RVF as opposed to the LVF. The interactions sex by field ( $p>.734$ ), handedness by field ( $p>.238$ ), sex by handedness by field ( $p>.955$ ), wordtype by field ( $p>.404$ ), sex by wordtype by field ( $p>.474$ ), hand by wordtype by field ( $p>.608$ ) and sex by hand by wordtype by field ( $p>.359$ ) were all nonsignificant. Pearson correlations between accuracies and reaction times were also performed and

are presented in Appendix D. The correlations suggested that shorter reaction time was associated with higher accuracy for emotional words in the LVF.

#### Interhemispheric Transfer Tasks

A two by two between subjects multivariate analysis of variance was performed in order to investigate the relation between interhemispheric transfer (i.e., line drawing and figure matching), sex and handedness (i.e., right-handed and left-inverted). The dependent variables were line and figure, and sex and handedness were the independent variables. The manova revealed nonsignificant results for the main effects of sex ( $F(2,43)=.541, p>.586$ ) of handedness ( $F(2,43)=.262, p>.770$ ), and for the sex by handedness interaction ( $F(2,43)=.903, p>.112$ ). A T-test was performed to investigate the specific hypothesis of more efficient transfer of visual information in females than in males. Results indicated that males and females did not perform significantly different in the figure matching task ( $T(46)=-.69, p>.493$ ). T-tests were also performed to test the hypothesis of more efficient interhemispheric skills in left-handed subjects than in left-noninverted subjects. The results indicated that the two groups did not perform significantly different in either the line ( $T(30)=.02, p>.981$ ) or the figure ( $T(30)=.28, p>.782$ ) tasks.

Interhemispheric Transfer and Lexical Decision Tasks

Multiple regression was performed in order to investigate the correlation between visual field advantage (i.e., laterality coefficient) and interhemispheric transfer (i.e., line drawing and figure matching tasks). The laterality coefficient was the dependent variable and sex, handedness, line and figure were the independent variables. The results revealed a significant correlation between the laterality coefficient for the combined words (function and emotional), and the set of independent variables sex, handedness, line and figure ( $R^2 = .229$ ,  $F(4,43)=3.20$ ,  $p<.022$ ). Inspection of the partial correlations indicated that handedness was a significant contributor to the regression equation (partial correlation squared=.162,  $T=-2.89$ ,  $p<.006$ ). Inspection of the means suggested that the right-handed subjects were more lateralized (i.e., larger laterality coefficient) for the recognition of words than the left-inverted subjects. The variables sex (partial correlation squared=.036,  $T=-1.26$ ,  $p>.215$ ), line (partial correlation squared=.001,  $T=-.020$ ,  $p>.984$ ) and figure (partial correlation squared=.051,  $T=1.53$ ,  $p>.134$ ) all showed nonsignificant correlations with the laterality coefficient for the combined words. The correlation between laterality coefficient for emotional words ( $R^2 = .078$ ,  $F(4,43)=.908$ ,  $p>.468$ ) and for function words ( $R^2 = .149$ ,  $F(4,43)=1.88$ ,  $p>.131$ ) and the dependent variables were nonsignificant. Pearson correlations between sex,

handedness, interhemispheric transfer tasks (i.e., line and figure), laterality coefficient for the combined words (i.e.  $lct_{total}$ ) and reaction time difference (i.e., difference between time to respond to words presented in the RVF and response times to words presented in the LVF;  $rtdiff$ ) are reported in Appendix E.

Multiple regression was then repeated excluding subjects with accuracies greater than 90%. The results revealed that the correlation between the laterality coefficient for the combined words, and the set of independent variables was no longer significant ( $R^2 = .104$ ,  $F(4,18) = .52$ ,  $p > .721$ ). The correlation between the laterality coefficient for emotional words ( $R^2 = .086$ ,  $F(4,18) = .42$ ,  $p > .789$ ) and function words ( $R^2 = .121$ ,  $F(4,18) = .62$ ,  $p > .653$ ) and the dependent variables was also nonsignificant. Pearson correlations between sex, handedness, line, figure and laterality coefficient are reported in Appendix F.

#### Analyses for right-handed, left-inverted and left-noninverted

A oneway analysis of variance was performed to compare the performance of the left-noninverted group to the other handedness groups. The variable sex was not included in the analysis since the number of subjects in the left-noninverted group (i.e., 3 males and 5 females) was too small. The independent variable was handedness (i.e., right-handed, left-inverted and left-noninverted), and the dependent variables

were figure, line, laterality coefficient for the combined words and reaction time difference. The results indicated that the laterality coefficient ( $F(2,53)=4.47$ ,  $p<.016$ ) was significantly related to handedness. Scheffe's post-hoc paired comparisons revealed that the two groups significantly different from each other were the right-handed and the left-inverted. The left-noninverted group was not significantly different from the others. The variables figure ( $p>.827$ ), line ( $p>.773$ ) and reaction time difference ( $p>.484$ ) were not significantly related to handedness.

A T-test was conducted to investigate the specific hypothesis of greater visual field advantages in left-noninverted subjects than left-inverted subjects. The results indicated that the laterality coefficient for these groups was not significantly different ( $T(30)=-1.32$ ,  $p>.216$ ).

## DISCUSSION

The results for the lexical decision task revealed that subjects overall (i.e. right-handed and left-inverted) were more accurate when words were presented in the RVF than in the LVF. RVF advantages for verbal material in lexical decision tasks are well established in the literature and have been frequently associated with left hemisphere dominance for the processing of language (Beaumont, 1982; Bradshaw, Gates & Nettleton, 1977; Bryden, 1982; McKeever, 1986).

Both right-handed and left-inverted subjects revealed a RVF advantage for the recognition of words. Although this overall advantage was expected for right-handed subjects, the left-handed group was predicted to show a less marked visual field advantage. This was supported by a significant field by hand interaction that suggested that right-handed subjects showed a greater RVF advantage than left-inverted subjects. Furthermore, the laterality coefficient for words (i.e. both function and emotional) was significantly related to handedness. These results also suggested that the right-handed subjects were more lateralized (i.e. RVF advantage) for the recognition of words than the left-inverted subjects. These findings support studies that report stronger lateralization of function for right-handed individuals (Bryden, 1982; McKeever, & Vandeventer, 1977; Rasmussen & Milner, 1977; Searleman, 1977).

The left-handed sample, however, consisted of only left-inverted subjects because there were not enough left-noninverted subjects to form a group. It has been previously suggested (Levy & Reid, 1976) that left-handers vary in organization of function according to hand posture. These authors suggested that left-inverted subjects and right-handed subjects have left hemisphere language representation. The results of this study support these findings. The results are also consistent with the reported left hemisphere dominance for the majority of left-handers (Rasmussen & Milner, 1975).

Since neither the sex by field nor the sex by hand by field interactions were statistically significant, the hypothesized greater RVF advantage for males than females was not confirmed. The results indicated that both males and females showed a RVF advantage. This is consistent with other findings of no differences in the laterality coefficient for males vs. females (Bryden, 1982; McKeever, 1986). Other studies using tachistoscopic presentations of words have shown a greater RVF effect for males than for females (Bradshaw & Gates, 1979; Bryden, 1979; McKeever & Jackson, 1978;). In contrast, a review by McGlone (1981) provides evidence against the occurrence of significant simple sex differences in tachistoscopic and dichotic listening studies. The results of the present study appear to support McGlone's (1980) observations.

Differences in visual field advantage were also expected for the processing of function and emotional words. The results revealed a RVF advantage for function words. This result is consistent with Chiarello and Nuding (1987) who demonstrated a RVF superiority for the recognition of function words. The finding supports the assumption of left hemisphere dominance for the processing of words that convey grammatical meaning (Berndt & Caramazza, 1981).

A RVF advantage was demonstrated for emotional words. Graves et al. (1981) also found an overall RVF advantage for the processing of emotional words. However, for males the authors found a significant word type by field interaction revealing that emotional words were identified significantly better than non-emotional words, but only in the LVF. An unpublished study (Kastenholz, 1987) that compared recognition of German emotional and nonemotional words found a wordtype by field interaction like Graves et al. (1981). This particular interaction was not found to be significant in the present research. A study by Strauss (1983) observed a trend similar to Graves et al. but the effect failed to reach statistical significance. Strauss concluded that (a) emotional and nonemotional words were more accurately recognized in the RVF, (b) the emotional quality of the words did not improve recognition in the LVF. The current finding appears to be consistent with these conclusions. Differences among these studies, however, were present with respect to

word categories. In the present study function words were used instead of nonemotional abstract words. This may have influenced the results since the visual field advantages for emotional words were assessed with respect to another word category (i.e., nonemotional or function).

In the present study, no sex differences were observed for either accuracy or visual field advantage for emotional or function words. These results are consistent with Strauss (1983) who found no sex by field interaction. Although there is some evidence that the right hemisphere is more efficient than the left hemisphere in the processing of emotional material (Bryden & MacRae, 1989; Ley & Bryden, 1979; Natale, Gur & Gur, 1983; Ross, 1988), the present study failed to find evidence for a specific right hemisphere ability to recognize emotional words. The current findings therefore suggest that the processing of the emotional words most likely involved linguistic analysis which is more efficiently performed by the left hemisphere (Zaidel, 1985). It is also possible that the mode of presentation determined the hemisphere to which the information was lateralized. Emotional material presented verbally would, therefore, yield a left hemisphere lateralization (Kolb & Taylor, 1981). Furthermore, there is evidence from studies with normal individuals that they rely primarily on the left hemisphere's ability to process verbal information. This type of lateralization may occur either because the left hemisphere inhibits the right hemisphere with

respect to linguistic functions or the strategy used to process the verbal material is more efficiently executed by the left hemisphere (Moscovitch, 1983).

Analysis of the performance of subjects according to word category (i.e. function and emotional) indicated that overall they were more accurate in identifying emotional words than function words. However, further analysis determined that this effect was primarily due to the left-inverted subjects. The right-handed subjects, on the other hand, showed no significant differences in performance when presented with either type of word. The significantly better performance of the left-inverted subjects when presented with emotional words may indicate that emotional content was a relevant factor in the lexical decision. This suggests that the two categories of words are processed differently by the two handedness groups. Further investigation, however, will be necessary in order to replicate these findings and to clarify this issue.

The results for the lexical decision task were also analysed excluding subjects with accuracies greater than 90% in any condition. This was performed in order to determine if the same pattern of results would be obtained. The findings showed a similar overall pattern to those obtained with 48 subjects. Subjects were in general more accurate when words were presented in the RVF than in the LVF. It was determined that both handedness groups showed a RVF advantage. Again, it was found that the left-inverted subjects were more

accurate in identifying emotional words than function words while the right-handed group's performance did not differ significantly by word type. Right-handed subjects were, however, more accurate when presented with function words than left-handed subjects. It was also found that females were better than males in overall accuracy. This result may suggest that females are more efficient in tasks that involve verbal material (Beaton, 1985). On the other hand, this finding may also be an artifact as a consequence of the small number of subjects. The laterality coefficient for words was no longer significantly related to handedness. Due to the relatively small subject to variable ratio, these results must be considered with caution.

The results of the reaction time analysis indicated that, overall, subjects responded faster when presented with emotional words than function words. Additionally, subjects were faster when words were projected to the RVF. These findings partially support Strauss (1983) who observed shorter reaction times for emotional words than for non-emotional words. She, however, found no significant differences in response time according to visual field. On the other hand, shorter reaction times for linguistic stimuli presented in the RVF have been previously reported (Geffen, Bradshaw, & Nettleton, 1973; Moscovitch, 1973). These reports and the current findings provide further evidence for the left hemisphere dominance for language function. The current

results also indicated that left-inverted subjects were significantly faster to respond to words than right-handed subjects. As far as could be determined similar findings have not been reported in the literature. If these results are replicated, it might suggest that left-inverted subjects process verbal material faster than right-handed subjects. This conclusion should, however, be restricted to specific stimuli (i.e. function and emotional words) and type of presentation (i.e. tachistoscopic). Significant correlations between overall reaction time and accuracy for emotional words were found when these words were presented in the LVF. These correlations suggest that the subjects that were faster overall were also more accurate in identifying emotional words in the LVF. The emotional content, therefore, appeared to be a relevant aspect at least for those subjects with faster reactions (i.e., more attentive). This finding is consistent with the observed right hemisphere superiority in attentional processes and in mediating arousal (Heilman, Watson , & Valenstein, 1985).

Comparison of the left-noninverted subjects' performance with the left-inverted subjects revealed that they were not significantly different in degree of lateralization and time to respond. The hypothesis of stronger lateralization of function in left-noninverted individuals was not supported. These results, however, require replication due to the small number of subjects with noninverted hand posture.

This study did not find evidence of significant variations in performance on interhemispheric transfer tasks according to gender and handedness. The hypothesis of more efficient interhemispheric transfer skills among left-handed subjects was not supported. The expected efficiency in transferring visual information in females was also not demonstrated. In the present study, sex and handedness were not found to be related to interhemisphere transfer of either motor or visual material. The findings of Potter and Graves (1988) concerning superior interhemispheric transfer of motor information in left-handers and of visual information in females were thus not replicated. These results are consistent with the recent study of Kertesz et al. (1987) reporting that differences in callosal size were not correlated with sex or handedness.

These results also confirmed some of the findings of a recent study by Picard and Graves (1989). These authors also failed to demonstrate differences in efficiency of interhemispheric transfer of information between right-handed and left-inverted subjects and males and females. Picard and Graves (1989), however, did observe superior interhemispheric transfer skills in left-noninverted subjects. It is possible therefore that some of the significant findings reported in Potter and Graves (1988) were a consequence of a confounding with hand posture. The authors tested left-handers as a group without measuring their hand posture. The results of the

present study did not suggest that the left-noninverted group performed differently from the left-inverted group. This observation, however, requires further investigation due to the small number of subjects with noninverted hand posture. It would also be valuable to investigate the test-retest reliability of the interhemispheric transfer tasks by administering them again to some of the subjects. Furthermore, the use of alternative measures of interhemispheric transfer (i.e., finger tapping) could provide additional information to the understanding of the communication between the two hemispheres.

The hypothesis of a negative correlation between visual field advantage and interhemispheric transfer was not confirmed by the present study. This study thus did not find evidence that degree of lateralization of function is related to efficiency in transferring information across the corpus callosum. These results support Kertesz et al. (1987) who failed to demonstrate a significant correlation between measures of cerebral dominance (i.e. dichotic listening and visual field advantage) and callosal size. The authors suggested that degree of lateralization of function may not be related to the amount of information that crosses the corpus callosum. The results of the analysis excluding subjects with greater than 90% accuracies showed similar results suggesting that the findings were not influenced by high accuracies or ceiling effects. Additional studies that

associate behavioral (i.e., tachistoscopic studies) and neuroanatomical (i.e., MRI studies) investigations could, therefore, be a significant contribution to the understanding of this issue.

Considerable difficulty in finding left-handed subjects with noninverted hand posture prevented this study from obtaining a large enough group of these individuals. Among 42 potential left-handed subjects contacted only 8 (19%) were observed to use the noninverted hand position for writing. This difficulty may reflect the findings of some studies that reported the inverted hand posture as being more common than the noninverted (McKeever & Vandeventer, 1980; Levy et al., 1983). Other studies, however, observed that the incidence of the two types of hand posture in the population of left-handers appeared to be variable. A 30% to 70% incidence of inverted writing in left-handers has been reported in a number of studies (Coren & Porac, 1983; Levy et al., 1983; McKeever, 1979; McKeever & Vandeventer, 1980; Searleman, 1977). Annet (1982), however, reported that in a sample of 68 left-handers 8% used the left-inverted position when writing. This variability in the reported incidence of handwriting posture has made its reliability as an index of cerebral dominance questionable (Annet, 1982).

The above noted variability might be due to the method of classification. There is some evidence that classification of hand posture through self report (i.e. questionnaires)

differs from experimenter categorization of subjects (Picard & Graves, 1989). Additionally, Levy and Reid's (1976) criteria for classifying hand posture does not create two mutually exclusive categories. For example, it was observed that some left-handers write with the pen tip oriented to the side of the paper instead of to the top or bottom. These subjects therefore could not be classified in one of the two categories and were excluded. Similar observations were reported by Picard and Graves (1989). There has been some suggestion that other variables like pen angle and position of paper (Peters, 1983) should be taken into account for a more accurate classification of hand posture for writing.

In conclusion, the present study provided further support for the left hemisphere dominance in the processing of verbal material. Although this left hemisphere superiority was found for both handedness groups, right-handed subjects revealed stronger lateralization of language function than left-inverted subjects. Stronger lateralization of language in right-handers is also consistent with the literature. This research, however, did not find evidence for a specific right hemisphere involvement in the recognition of emotional words. Additionally, the investigation of interhemispheric transfer skills indicated that these were not related to gender, to handedness, nor to degree of lateralization of language function. No differences between left-inverted and left-noninverted subjects were observed, however, further

investigation due to the small number of left-noninverted subjects is required. The inferences regarding the results of both the lexical decision and the interhemispheric transfer tasks should be restricted to right-handed individuals who are consistently right-preferent for most unimanual activities (i.e., strongly right-handed) and to left-handed individuals who use the inverted hand posture for writing.

The results of this study, therefore, did not support previous findings regarding both the right hemisphere ability to identify emotional words and the differences in interhemispheric transfer skills with respect to gender and handedness. The results suggest that those issues are more complex than previously suggested and require further detailed investigation in order to be completely understood.

## REFERENCES

- Annet, M. (1978). Genetic and non-genetic influence on handedness. Behavior Genetics, 8, 227-249.
- Beaton, A. (1985). Sex differences in asymmetry. In Left side, right side: A review of laterality research. London: Yale University Press.
- Beaumont, J.M. (1982). Studies with verbal stimuli. In J.M. Beaumont (Ed.), Divided visual field studies of cerebral organization (pp. 57-86). New York: Academic Press.
- Benson, D.F., & Geschwind, N. (1971). The aphasias and related disturbances. In A.B. Baker and L.H. Baker (Eds.), Clinical Neurology, Vol. 1. New York: Harper Medical.
- Benson, D.F. (1979). Aphasia, alexia and agraphia. New York: Churchill Livingstone.
- Benson, D.F. (1985). Language in the left hemisphere. In D.F. Benson & E. Zaidel (Eds.), The dual brain: hemispheric specialization in humans (pp. 193-203). New York: Guilford Press.
- Benson, D.F. (1985). Aphasia. In K.M. Heilman & E. Valenstein (Eds.), Clinical Neuropsychology (pp. 17-40). New York: Oxford University Press.
- Berndt, R.S. & Caramazza, A. (1981). Syntactic aspects of aphasia. In M.T. Sarno (Ed.), Acquired Aphasia. New York: Academic Press.
- Bogen, J.E. (1985). The callosal syndromes. In K.M. Heilman & E. Valenstein (Eds.), Clinical Neuropsychology. New York: Oxford University Press.
- Bogen, J.E., & Vogel, P.J. (1975). Neurologic status in the long term following cerebral commissurotomy. In F. Michel & B. Schott (Eds.), Les Syndromes de disconnection calleuse chez l'homme. Lyon: Hopital Neurologic.
- Bradshaw, J.L., Nettleton, N., & Spehr, K. (1982). Sinistrals inverters do not possess an anomalous visuomotor organization. Neuropsychologia, 20(5), 605-609.

- Bradshaw, J.L., Gates, A. & Nettleton, N.C. (1977). Bihemispheric involvement in lexical decisions: handedness and a possible sex difference. Neuropsychologia, 15, 277-286.
- 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.
- Bradshaw, J.L. & Nettleton, N.C. (1981). The nature of hemispheric specialization in man. The Behavioral and Brain Sciences, 4, 51-91.
- Bryden, M.P. (1979). Evidence of 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. (1982). Laterality: functional asymmetry in the intact brain. New York: Academic Press.
- Bryden, M.P. & MacRae, L. (1989). Dichotic laterality effects obtained with emotional words. Neuropsychiatry, Neuropsychology, and Behavioural Neurology, 1(3), 171-176.
- Burklund, C.W., & Smith, A. (1977). Language and the cerebral hemispheres: observations of verbal and nonverbal responses during 18 months following left ("dominant") hemispherectomy. Neurology, 27, 627-633.
- Chiarello, C., & Nuding, S. (1987). Visual field effects for processing content and function words. Neuropsychologia, 25, 539-548.
- Chiarello, C., Senehl, J., & Nuding, S. (1987). Semantic priming with abstract and concrete words: Differential asymmetry may be postlexical. Brain and Language, 31, 43-60.
- Coslett, H.B., Rothi, L.J.G., Valenstein, E., & Heilman, K.M. (1986). Dissociations of writing and praxis: Two cases in point. Brain and Language, 28, 357-369.
- Day, J. (1977). Right hemisphere language processing in normal right handers. Journal of Experimental Psychology, 3, 518-528.
- deLacoste-Utamsing, C., & Holloway, R.L. (1982). Sexual dimorphism in the human corpus callosum. Science, 216, 1431-1432.

- Galaburda, A.M., Corsiglia, J., Rosen, G.D., & Sherman, G.F. (1987). Planum Temporale Asymmetry, Reappraisal Since Geschwind and Levitsky. Neuropsychologia, 25, 853-868.
- Gardner, H., Brownell, H.H., Wapner, W., & Michelow, D. (1983). Missing the point: The role of the right hemisphere in the processing of complex linguistic material. In E. Perecman (Ed.), Cognitive processing in the right hemisphere (pp. 169-191). New York: Academic Press.
- Gazzaniga, M.S. (1970). The bisected brain. New York: Appleton.
- Gazzaniga, M.S., & LeDoux, J.E. (1978). The integrated mind. New York: Plenum.
- Gazzaniga, M.S., LeDoux, J.E., & Wilson, D.H. (1977). Language, praxis, and the right hemisphere: clues to some mechanisms of consciousness. Neurology, 27, 1144-1147.
- Geschwind, N. (1974). Selected papers on language and the brain. Boston: Reidel.
- Geschwind, N., & Galaburda, A.M. (1985). Cerebral lateralization. Archives of Neurology, 42, 428-459.
- Geschwind, N & Levitsky, W. (1968). Human brain: left-right asymmetries in temporal speech region. Science, 161, 186-187.
- Getten, G., Bradshaw, J.L., & Nettleton, N.C. (1973). Attention and hemispheric differences in reaction time during simultaneous audiovisual tasks. Quarterly Journal of Experimental Psychology, 25, 404-412.
- Goldberg, E., & Costa, L.D. (1981). Hemisphere differences in the acquisition and use of descriptive systems. Brain and Language, 14, 144-173.
- Graves, R.E., Morley, S. & Marcopulos, A. (1987). Measurement of the dichotic listening ear advantage for intersubject and interstimulus comparisons. Journal of Clinical and Experimental Neuropsychology, 9(5), 511-526.
- Graves, R., Landis, T., & Goodglass H. (1981). Laterality and sex differences for visual recognition of emotional and non-emotional words. Neuropsychologia, 19, 95-102.
- Hardyck, C. & Petrinovitch, L. (1977). Left-handedness. Psychological Bulletin, 84, 385-404.

- Heilman, K.M., & Rothi, L.J.G. (1985). Apraxia. In K.M. Heilman & E. Valenstein (Eds.), Clinical Neuropsychology (pp. 131-147). New York: Oxford University Press.
- Heilman, K.M., Watson, R.T., & Valenstein, E. (1985). Neglect and Related Disorders. In K.M. Heilman & E. Valenstein (Eds.), Clinical Neuropsychology (pp. 243-293). New York: Oxford University Press.
- Hellige, J.B. (1982). Visual laterality and hemispheric specialization: Methodological and theoretical considerations. In Conditioning, Cognition and Methodology: Contemporary Issues in Experimental Psychology. Hillside, New Jersey: Erlbaum.
- Jackson, J.H. (1932). In J. Taylor (Ed.), Selected Writings. London: Hodder & Stoughton.
- Kastenholtz, H.G. Visuelle wahrnehmung und hemisphärenspezifische verarbeitung von emotionalen und nicht-emotionalen wörtern, thesis number ETH-Nr 83-920-082 of the Swiss Federal Polytechnium (ETH).
- Kertesz, A., Polk, M., Howell, J., & Black, S.C. (1987). Cerebral dominance, sex, and callosal size in MRI. Neurology, 37, 1385-1388.
- Kimura, D. (1961a). Some effects of temporal lobe damage on auditory perception. Canadian Journal of Psychology, 15, 156-165.
- Kimura, D. (1961b). Cerebral dominance and the perception of verbal stimuli. Canadian Journal of Psychology, 15, 166-171.
- Kimura, D., & Archibald, Y. (1974). Motor functions of the left hemisphere. Brain, 97, 337-350.
- Kolb, B., & Taylor, L. (1981). Affective behavior in patients with localized cortical excisions: Role of lesion site and side. Science, 214, 89-91.
- Landis, T., Graves, R., & Goodglass, H. (1982). Aphasic reading and writing: possible evidence for right hemisphere participation. Cortex, 18(1), 105-111.
- Levy, J. (1982). Handwriting posture and cerebral organization: How are they related? Psychological Bulletin, 91, 589-608.

- Levy, J., Heller, W., Banich, M.T., & Burton, L.A. (1983). Asymmetry of perception in free viewing of chimeric faces. Brain and Cognition, 2, 404-419.
- Levy, J., & Reid, M. (1976). Variations in writing posture and cerebral organization. Science, 194, 337-339.
- Levy, J., & Reid, M. (1978). Variations in cerebral organization as a function of handedness, hand posture in writing, and sex. Journal of Experimental Psychology: General, 107, 119-144.
- Ley, R.G. & Bryden, M.P. (1979). Hemispheric differences in recognizing faces and emotions. Brain and Language, 7, 127-138.
- Marshall, J.C., Caplan, D., & Holmes, J.M. (1975). The measure of laterality. Neuropsychologia, 13, 315-321.
- McGlone, J. (1980). Sex differences in human brain asymmetry: A critical review. The Behavioral and Brain Sciences, 3, 215-227.
- McKeever, W.F. & Jackson, T.L. (1979). Cerebral dominance assessed by object-and color-naming latencies: Sex and familial sinistrality effects. Brain and language, 7, 175-190.
- McKeever, W.F. & VanDeventer, A.D. (1977). Familiar sinistrality and degree of left-handedness. British Journal of Psychology, 68, 469-471.
- McKeever, W.F. & VanDeventer, A.D. (1980). Inverted handwriting position, language laterality and the levy-nagylaki genetic model of handedness and cerebral organization. Neuropsychologia, 18, 99-102.
- McKeever, W.F. (1979). Handwriting posture in left-handers: Sex, familial sinistrality, and language laterality correlated. Neuropsychologia, 17, 429-444.
- McKeever, W.F. (1986). Tachistoscopic methods in neuropsychology. In H.J. Hannay (Ed.), Experimental Techniques in Human Neuropsychology (pp. 167-211). New York: Oxford University Press.
- McKeever, W.F. & Hoff, A.L. (1979). Evidence of a possible isolation of left hemisphere visual and motor areas in sinistrals employing an inverted handwriting posture. Neuropsychologia, 17, 445-455.

- McKeever, W.F., & Hoff, A.L. (1983). Further evidence of the absence of measurable interhemispheric transfer time in left-handers who employ an inverted handwriting posture. Bulletin of the Psychonomic Society, 21, 255-258.
- McKeever, W.F., & Van Deventer, A.D. (1980). Inverted handwriting position, language laterality, and the Levy-Nagylaki genetic model of handedness and cerebral organization. Neuropsychologia, 18, 99-102.
- Molfese, V.J., Molfese, D.L., & Parsons, C. (1983). Hemisphere processing of phonological information. In S.J. Segalowitz (Ed.), Language Functions and Brain Organization (pp. 29-49). New York: Academic Press.
- Moscovitch, M. (1983). The linguistic and emotional functions of the normal right hemisphere. In Cognitive Processing in the Right Hemisphere. New York: Academic Press.
- Moscovitch, M. (1973). Language and the cerebral hemispheres: reaction time studies and their implications for models of cerebral dominance. In P. Pliner, L. Krames, & T. Alloway (Eds.), Communication and Affect: Language and Thought (pp. 89-126). New York: Academic Press.
- Moscovitch, M., & Smith, L.C. (1979). Differences in neural organization between individuals with inverted and non-inverted hand posture during writing. Science, 205, 235-238.
- Natale, M., Gur, R.E., & Gur, R.C. (1983). Hemispheric symmetries in processing emotional expressions. Neuropsychologia, 21(5), 555-565.
- Orenstein, H.B. & Meighan, W.B. (1976). Recognition of bilaterally presented words varying in concreteness and frequency: Lateral dominance or sequential processing. Bulletin of the Psychonomic Society, 7(2), 179-180.
- Penfield, W., & Roberts, L. (1959). Speech and Brain Mechanisms. New Jersey: Princeton University Press.
- Peters, M. (1983). Lefthanders compared on the basis of motor performance and measures related to the act of writing. Australian Journal of Psychology, 35, 405-416.

- Picard, E.M. & Graves, R.E. (1989). The interhemispheric transfer of visual and motor information in left-inverted (LI) and left-noninverted (LN) writers. Abstract published in Journal of Clinical and Experimental Neuropsychology, 11(1), 73.
- Porac, C., Coren, S., & Searleman, A. (1983). Inverted vs. straight hand writing posture: A family study. Behavioral Genetics, 13, 311-320.
- Porac, C. & Coren, S. (1978). Relationships among lateral preference behaviors in human beings. Behavioral and Brain Sciences, 2, 311-312.
- Potter, S.M., & Graves, R. (1988). Is interhemispheric transfer related to handedness and gender? Neuropsychologia, 26, 319-325.
- Preilowski, B. (1975). Bilateral motor interaction: perceptual-motor performance of partial and complete "split-brain" patients. In K.J. Zulch & G.S. Galbraith (Eds.), Cerebral Localization (pp. 115-132). Berlin: Springer.
- Rasmussen, T. & Milner, B. (1977). The role of early left-brain injury in determining lateralization of cerebral speech functions. Annals of the New York Academy of Sciences, 299, 355-369.
- Rasmussen, T., & Milner, B. (1975). Clinical and surgical studies of the cerebral speech areas in man. In K.J. Zulch, O. Creutzfeldt, & G.C. Galbraith (Eds.), Cerebral Localization. New York: Springer-Verlag.
- Ross, E.D. (1988). Prosody and brain lateralization. Fact vs Fancy or is it all just semantics? Archives of Neurology, 45, 338-339.
- Ross, E.D., & Mesulam M-M. (1979). Dominant language functions of the right hemisphere? Prosody and emotional gesturing. Archives of Neurology, 36, 144-148.
- Russell, W.R., & Espir, M.L.E. (1961). Traumatic aphasia-a study of aphasia in war wounds of the brain. London: Oxford University Press.
- Searleman, A. (1977). A review of right hemisphere linguistic capabilities. Psychological Bulletin, 84, 503-528.
- Sergent, J. (1983). Role of the input in visual hemispheric asymmetries. Psychological Bulletin, 43(3), 481-512.

- Sperry, R.W. (1982). Some effects of disconnecting the cerebral hemispheres. Science, 217, 1223-1226.
- Sperry, R.W., & Gazzaniga, M.S. (1967). Language following surgical disconnection of the hemispheres. In Brain Mechanisms Underlying Speech and Language. New York: Grune and Stratton.
- Steenhuis, R.E., & Bryden, M.P. (1987). Handedness: A matter of direction and degree. Paper presented at the Annual meeting of the Canadian Psychological Association, June, 1987.
- Strauss, E., Lapoint, J.S., Wada, J.A., Gaddes, W., & Kosaka, B. (1985). Language dominance: correlation of radiological and functional data. Neuropsychologia, 23 (3), 415-420.
- Strauss, E. (1983). Perception of emotional words. Neuropsychologia, 21(91), 99-103.
- Tapley, S.M., & Bryden, M.P. (1984). Writing hand posture and cerebral dominance for speech. Cortex, 20, 143-147.
- Tucker, D.M., Watson, R.T., & Heilman, K.M. (1977). Discrimination and evocation of affectively intoned speech in patients with right parietal disease. Neurology, 27, 947-950.
- Wada, J. & Rasmussen, T. (1960). Intracarotid injection of sodium amytal for the lateralization of cerebral speech dominance. Journal of Neurosurgery, 17, 266-282.
- Weber, A.M. & Bradshaw, J.L. (1981). Levy and Reid's neurological model in relating writing hand/posture: An evaluation. Psychological Bulletin, 90, 74-88.
- White, M.J. (1972). Hemispheric asymmetries in tachistoscopic information processing. British Journal of Psychology, 63(4), 479-508.
- Witelson, S.F. (1985). The brain connection: The corpus callosum is larger in left-handers. Science, 229, 665-668.
- Zaidel, E. (1985). Language in the right hemisphere. In D.F. Benson & E. Zaidel (Eds.), The dual brain: hemispheric specialization in humans (pp. 205-231). New York: Guilford Press.

## Appendix A

Lexical Decision Task Instructions

In the first part of the experiment I would like you to look through the viewer and to focus on the black dot in the middle of the screen (i.e., fixation point). In order for you to perform as best as you can, it is very important that you keep looking at the dot all the time. You will see four letters that will flash very briefly on the screen sometimes to the right of the dot sometimes to the left. Half the time the four letters will spell a real English word and half the time they will not. Your task will be to decide if you saw a real English word or not. In order to respond you will press down on the two response keys (point it out) as fast as you can using the index fingers of both hands only when you see a real English word. If you see a nonword you are not to respond. This task will take about 20 minutes and you will get a short rest before we proceed.

You have the right to withdraw from this experiment at any time. Any questions?

## Appendix A (continued)

Line Drawing Task Instructions

Now, I would like you to stand up facing this pad of paper. You are to hold one pen in each hand. Position hands, bodywidth apart, on the starting dots on the top of the page. When I say begin, you are to draw two vertical lines down the page. Concentrate on keeping your hands moving at the same rate so as to produce lines of equal length. I will say stop at any time , so be sure you try to keep your hands at the same point on the paper at all times. Also, you will be blindfolded during the task. this task will be repeated three times and each time and each time I will ask you not to remove the blindfold before the page you have just worked on is replaced. Any questions?

## Appendix A (continued)

Visual Matching Task Instructions

Again, I would like you to look through the viewer and to focus on the black dot in the middle of the screen (fixation point). In order to perform as best as you can, I would like you to keep looking at the dot at all times. In this task you will see two stimuli at the same time, one on each side of the fixation dot. What you will be seeing are two complex geometrical forms. Your task will be to decide whether the two geometrical forms presented to you are exactly the same or different, by simply responding "same" or "different". A shape can be considered as different if it differs in size, shape, shading or orientation. Are there any questions?

Note: A rest period of 5 minutes is provided before proceeding with the experiment. At the end of the resting period explain that the first task (i.e., word/nonword decision) will be presented again. The same instructions previously given for the lexical decision task should be repeated before starting the block.

## Appendix B

## Function Words

ALSO	SOME
DOES	SOON
EACH	SUCH
ELSE	THEN
FROM	THIS
LESS	UPON
MANY	WHAT
MOST	WHEN
MUCH	WITH
OVER	YOUR

## Appendix B (continued)

## Emotional Words

BEAT	KILL
DEAD	KISS
ENVY	LOVE
EVIL	LUST
FEAR	PAIN
GLAD	RAGE
HARM	RAPE
HATE	SEXY
HELL	STAB
HURT	WEEP

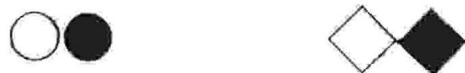
## Appendix B (continued)

## Nonwords

ALNY	FREN	MITH	STAM
BEAB	GLEP	MOES	SUME
BEVY	HAXY	OREN	THON
DAIN	HIPE	PEAD	THUR
DOCH	HUST	RALL	UPAT
EASS	KIGE	RASS	WEAD
ELOM	LECH	RELL	WHIS
ENTE	LOAR	SERT	WHUN
EVAT	LURT	SOCH	WOST
FEVE	MASO	SOSE	YOER

## Appendix C

Examples of figures used in the Visual Matching Task



## Appendix D

Correlations between accuracy and reaction time  
(n=48)

	FUNL	EMTL	FUNR	EMTR
RTFUNL	-.233	-.428*	.088	-.001
RTEMTL	-.162	-.381*	.132	-.020
RTFUNR	-.271	-.424*	-.011	-.121
RTEMTR	-.230	-.389*	.026	-.045

\*  $p < .05$

FUNL - function word in the left visual field

FUNR - function word in the right visual field

EMTL - emotional word in the left visual field

EMTR - emotional word in the right visual field

## Appendix E

Correlations between selected variables  
(n=48)

	SEX	HAND	FIG	LINE	LCTOTAL	RTDIFF
SEX	1.00	.000	.101	-.093	-.149	.051
HAND		1.00	-.077	-.087	-.405*	-.177
FIG			1.00	.200	.223	.275
LINE				1.00	.089	.103
LCTOTAL					1.00	.291*
RTDIFF						1.00

\*  $p < .05$

## Appendix F

Correlations between selected variables  
(n=23)

	SEX	HAND	FIG	LINE	LCTOTAL
SEX	1.00	.129	.227	-.114	-.113
HAND		1.00	-.031	-.317	-.243
FIG			1.00	.322	.112
LINE				1.00	.010
LCTOTAL					1.00

## Appendix G

## Raw Data

## DATA LIST

SUB 1-2 SEX 4 HAND 6 LINE 8-11 FIG 13-14 FUNL 16-17 EMTL 19-20  
 NONL 22-23 FUNR 25-26 EMTR 28-29 NONR 31-32 RTEUL 34-36  
 RTEML 38-40 RTPUR 42-44 RTEMR 46-48

VALUE LABELS SEX 1 'MALE' 2 'FEMALE' /  
 HAND 1 'RIGHT' 2 'LEFTIN' 3 'LEFTNON' /

03	1	1	0.90	45	16	16	24	16	19	24	734	670	669	597
04	1	1	2.07	44	07	11	29	17	18	23	590	564	540	514
06	1	1	1.87	42	10	13	25	17	19	25	574	479	537	558
07	1	1	1.37	47	14	14	22	20	15	27	726	697	692	700
08	1	1	1.13	48	15	16	27	20	19	32	545	562	534	500
09	1	1	1.33	48	09	09	30	13	19	27	764	614	771	712
10	2	1	2.10	36	16	16	23	17	16	19	741	692	691	716
11	2	3	2.87	45	09	12	25	15	20	25	858	856	686	666
12	1	3	1.70	40	07	08	31	12	15	27	656	486	614	515
13	2	1	1.73	46	17	15	30	17	19	32	543	551	501	536
14	1	2	1.67	40	09	14	22	12	18	20	604	563	595	572
15	2	1	1.17	45	14	13	21	19	19	23	594	630	567	574
16	2	1	2.50	49	13	15	32	16	18	28	788	740	678	628
17	2	1	2.23	51	14	13	33	19	20	35	622	661	580	628
18	2	2	0.40	37	13	14	24	11	17	33	646	648	626	688
19	1	1	0.97	44	15	12	24	16	16	28	771	729	601	616
20	2	1	0.93	43	14	14	22	17	16	28	759	731	684	650
21	2	1	2.93	50	15	16	33	18	17	29	604	601	545	580
22	1	1	2.03	43	12	16	31	15	18	31	532	598	591	634
23	2	2	1.13	41	14	17	23	17	19	20	503	480	453	471
24	2	3	2.20	42	16	16	30	17	19	31	606	641	612	608
25	2	2	0.87	49	14	14	30	18	18	27	658	670	634	631
26	1	2	2.07	44	16	15	30	15	19	32	597	510	573	532
27	1	1	2.20	45	17	14	26	19	20	28	681	676	491	489
28	1	2	2.03	42	19	18	21	20	18	19	467	440	442	444
29	1	2	1.77	49	11	14	29	13	18	30	629	522	561	537
30	1	2	1.40	40	15	13	21	17	18	26	513	548	520	508
31	1	2	2.40	42	13	14	20	12	16	25	279	296	301	326
32	2	3	0.70	46	16	18	31	15	18	30	477	478	499	471
33	1	2	1.27	48	15	17	29	16	19	32	605	663	539	537
34	2	2	1.07	43	16	19	27	16	20	25	566	549	534	552
35	1	3	1.03	46	18	14	23	18	15	26	612	536	512	489
36	2	2	0.83	43	13	17	35	14	16	35	624	540	561	587
37	2	3	2.63	44	17	13	23	18	18	27	414	418	413	394
38	2	2	3.33	44	14	16	28	14	14	29	443	468	417	393
40	1	2	1.73	47	16	16	26	12	15	29	497	515	533	438

## Appendix G (continued)

41	2	2	1.63	43	15	16	27	16	17	30	736	667	619	678
42	2	2	0.53	41	16	20	27	17	16	29	480	479	489	465
43	1	2	2.00	46	12	16	29	15	14	32	504	516	527	431
44	2	1	3.70	50	17	16	31	17	18	33	608	591	543	530
45	1	2	2.53	48	15	17	29	18	19	27	517	447	409	396
46	1	1	2.67	40	15	14	27	15	18	29	466	490	492	468
48	2	1	0.93	46	15	15	29	16	14	29	608	655	649	642
49	2	3	0.47	40	16	16	32	13	18	33	647	680	724	664
50	1	1	1.63	40	14	15	28	17	16	27	596	601	660	551
51	1	2	2.33	44	16	16	27	16	19	26	478	474	475	499
52	2	1	2.03	42	11	10	34	17	20	29	866	907	812	818
53	2	2	1.90	48	14	16	31	16	17	33	643	650	556	534
54	1	3	1.83	49	15	15	33	18	20	30	561	534	527	484
55	1	1	1.73	46	17	19	27	20	18	28	543	548	503	501
56	2	1	1.40	46	18	17	29	18	18	29	770	765	776	778
57	2	1	1.77	42	19	17	32	15	17	25	530	545	520	514
58	1	2	2.33	41	17	19	37	15	18	31	562	571	567	606
59	2	2	2.17	48	18	18	29	17	20	29	479	506	491	452
60	2	2	1.30	50	19	20	34	19	19	34	493	456	457	453

## VITA

Surname: Correa Given Names: Denise Dias

Place of Birth: Sao Paulo, Brazil

Date of Birth: June 25, 1962

Educational Institutions Attended:

PONCTIFICIA UNIVERSIDADE CATOLICA,  
SAO PAULO, BRAZIL 1980 to 1984

Degrees/Diplomas:

B.S. 1984 Ponctificia Universidade Catolica,  
Sao Paulo, Brazil

Honors and Awards:

The National Council for the Development of Science  
and Technology (CNPq) Scholarship (Brazil), 1987-1989

Publications:

Correa, D.D., & Gorenstein, C. (1988). Bateria de Memoria  
(I): Criterios de elaboracao e avaliacao. Arquivos  
Brasileiros de Psicologia, 40(2), 24-35.

Correa, D.D., & Gorenstein, C. (1988). Bateria de testes de  
memoria (II): Teste de homogeneidade e analise das  
funcoes mnemicas. Arquivos Brasileiros de Psicologia,  
40(3), 42-53.

Correa, D.D., & Graves, R. (1989). Lexical decisions from very  
short tachistoscopic exposures. Abstract published in  
Journal of Clinical and Experimental Neuropsychology,  
11(1), 72-73.

PARTIAL COPYRIGHT LICENSE

I hereby grant the right to lend my thesis (the title of which is shown below) to users of the University of Victoria Library, and to make single copies only for such users or in response to a request from the Library of any other university, or similar institution, on its behalf or for one of its users. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by me or a member of the University designated by me. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Title of Thesis:

Hemispheric Asymmetries and Interhemispheric

Communication

Author



Denise Dias Correa

May 30, 1989

National Library  
of Canada

Bibliothèque nationale  
du Canada

Canadian Theses Service    Service des thèses canadiennes

Ottawa, Canada  
K1A 0N4

The author has granted an irrevocable non-exclusive licence allowing the National Library of Canada to reproduce, loan, distribute or sell copies of his/her thesis by any means and in any form or format, making this thesis available to interested persons.

The author retains ownership of the copyright in his/her thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without his/her permission.

L'auteur a accordé une licence irrévocable et non exclusive permettant à la Bibliothèque nationale du Canada de reproduire, prêter, distribuer ou vendre des copies de sa thèse de quelque manière et sous quelque forme que ce soit pour mettre des exemplaires de cette thèse à la disposition des personnes intéressées.

L'auteur conserve la propriété du droit d'auteur qui protège sa thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

ISBN 0-315-53718-3