

**Dichotic recall indices
of lateralized cerebral
processing of abstract,
concrete and emotional
Zulu word stimuli in
FS+ and FS- dextrals**

by

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ABSTRACT

This thesis reports a basic cognitive neuropsychological experiment which employed an original dichotic recall test to assess lateralized cerebral processing of abstract, concrete and emotional Zulu word stimuli among 32 male and 30 female dextral (right-handed) Zulu-speakers, consisting of 14 males and 12 females with sinistral (left-handed) blood relatives (FS+) and 18 males and 18 females with no sinistral blood relatives (FS-). The present dichotic listening experiment investigated whether abstract word stimuli are recalled more poorly or better than either concrete or emotional word stimuli, and whether concrete word stimuli are recalled better or more poorly than emotional word stimuli. It also investigated whether recall of abstract, concrete and emotional word stimuli yield a right ear advantage (REA) or left ear advantage (LEA).

The subjects were presented with dichotic stimulus words (N=72/2=36 pairs) at a sound intensity of 65 dB SPL, through calibrated stereo headphones (Digitech MH110) connected to a stereo cassette tape-player (Yorx PS-3). Each experimental trial was made up of six dichotic word stimuli: one abstract, one concrete and one emotional stimulus word per ear of presentation. The subjects reported in writing all the word stimuli heard at the end of the trial in any order, hence free-recall. Recall scores for abstract, concrete and emotional word stimuli were computed per ear of

presentation. Differences between recall scores for the word stimuli presented to the left ear (LE) and those presented to the right ear (RE) were computed by using the dichotic laterality formula: $RE-LE(100)/(RE+LE)$. A positive dichotic laterality index score was taken as an indicator of an REA, while a negative dichotic laterality index score was taken as an indicator of an LEA (Hugdahl & Andersson, 1989). The dichotic laterality index scores were then converted to Z-laterality index scores by using the Z-score formula: $Z=Score-Mean/StDev$. Data analysis involved performing a series of three-way and two-way Analysis of Variance (ANOVA) tests, with mean recall and mean laterality index scores serving as the dependent measures of cerebral processing.

It was observed that abstract word stimuli were recalled significantly more poorly than either concrete or emotional word stimuli, while virtually no difference existed between recall of concrete and emotional word stimuli overall. Recall of abstract word stimuli yielded an REA overall, while recall of concrete word stimuli yielded a significantly larger LEA among males and a significantly larger REA among females. Recall of emotional word stimuli yielded an LEA among males and an REA among females. The implications of the present findings are discussed in some detail. The observed LEA's were interpreted as suggesting right brain laterality and the REA's as suggesting left brain laterality in the processing of abstract, concrete and emotional word stimuli used (Bryden, 1988; Zatorre, 1989).

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CHAPTER 1

THE DICHOTIC LISTENING TECHNIQUE IN NEUROPSYCHOLOGICAL RESEARCH ON CEREBRAL LATERALITY IN VERBAL PROCESSING

1.1. Introduction

During the past four decades a number of experimental psychological research techniques have been adapted for use in neuropsychological assessment of the role of the right and the left half of the human brain in the processing of verbal stimulus materials. One such technique is the dichotic listening technique (Beaumont, 1983; Springer, 1986). The dichotic listening technique is currently used as one of the noninvasive neuropsychological procedures for assessing cerebral hemisphere laterality in auditory verbal (and nonverbal) stimulus processing (Annett, 1991). It involves presenting the subject with two auditory stimulus items simultaneously, one to each ear via a pair of calibrated stereo headphones connected to a stereo cassette tape-player from which the stimuli are played. The subjects respond either by pressing a response button upon hearing a target stimulus item from either ear (reaction time tests, Geffen & Caudrey, 1981), by selecting the stimulus items heard per trial from several items printed on a response answersheet (recognition memory tests, Zatorre, 1989), or by

reporting the stimulus items heard per trial in any order in writing or orally (free-recall memory tests, Strauss, 1986). In the case of reaction time dichotic listening tests, the mean reaction times normally serve as primary measures of cerebral laterality in the processing of the stimuli used (Mondor & Bryden, 1991). Mean recognition scores serve as primary measures of cerebral laterality in recognition memory dichotic listening tests (Zatorre, 1989), and mean recall scores as measures of cerebral laterality in the processing of stimulus materials used in free-recall memory dichotic listening tests (Strauss, 1986).

Several dichotic listening tests have been developed and used in both experimental and clinical neuropsychological research on cerebral laterality and auditory memory patterns in verbal processing among normal (brain-intact) subjects and brain-damaged patients, respectively (Beaumont, 1983; Spreen & Strauss, 1991). However, none of the existing dichotic listening tests has been standardized as part of any neuropsychological or psychometric test battery. As a result, all dichotic listening researchers have to develop their own dichotic listening test materials, normally in the native language of the target subject population. Dichotic listening tests for assessing cerebral speech laterality have been developed for and used with native speakers of several languages, such as English (Spreen & Strauss, 1991), French (Lassonde, Lorte, Ptito & Geoffroy, 1981), German (Jancke, Steinmetz & Volkman, 1992), Greek (Tzavaras,

Kaprinis & Gatzoyas, 1981) and Portuguese (Castro & Morais, 1987). A variety of linguistic materials have been used as dichotic verbal stimuli. These include abstract, concrete and emotional words (Ely, Graves & Potter, 1989), words or phrases spoken in a sad, angry, happy or emotionally-neutral tone of voice (Bryden, Free, Gagne & Groff, 1991; Strauss & Goldsmith, 1987), nonsense consonant-vowel (CV) syllables (Emmerich, Harris, Brown & Springer, 1988) and spoken digits (Bryson, Mononen & Yu, 1980).

Dichotic listening studies employing such verbal stimulus materials as nonsense CV syllables and spoken digits, have normally been designed to investigate left brain laterality in auditory verbal processing (Springer, 1986; Wexler & Halwes, 1985). By contrast, dichotic listening studies employing such verbal stimuli as abstract and concrete words or emotional and nonemotional words, have been designed to investigate left brain laterality in abstract and nonemotional verbal processing and right brain laterality in concrete and emotional verbal processing (Ely et al., 1989; McFarland, McFarland, Bain & Ashton, 1978; Prior, Cumming & Hendy, 1984; Wexler, Warrenburg, Schwartz & Janer, 1992).

The dichotic listening technique has been shown to serve as a robust clinical tool, providing clinicians with reliable information about dysfunction of subcortical auditory pathways resulting from traumatic head injuries or cerebrovascular diseases (Pujol, Junque, Vendrell, Garcia,

Capdevilla & Marti-Vilalta, 1991). Dichotic speech tests have been used by a few forensic neuropsychologists working with brain-damaged individuals claiming compensation for their injuries in the work-place (Varney & Smith-Shepherd, 1991). According to Bryden (1988) one of the advantages of the dichotic listening technique is that it allows the investigator to assess the influences of such factors as sex and familial sinistrality on patterns of cerebral laterality in verbal processing. The word sex is used here to refer to biological distinctions which differentiate male from female subjects (Reber, 1985). Familial sinistrality refers to the presence or absence of left-handedness among one's blood relatives, including parents and siblings (Hardyck & Petrinovich, 1977; Yeo & Cohen, 1983). In neuropsychological research, dextral (right-handed) or sinistral (left-handed) subjects with sinistral blood relatives are said to have positive familial sinistrality (FS+), and subjects with no sinistral blood relatives are said to have negative familial sinistrality (FS-) (Andrews, 1977; Piazza, 1980).

During the past two decades numerous dichotic listening studies have investigated the effects of sex and familial sinistrality, amongst other subject factors, on cerebral laterality in verbal processing (Bryden, 1988; Hiscock & Hiscock, 1988; Kraft, 1981). Studies on sex differences have found conflicting results, with some researchers observing stronger left brain laterality among males than among females (Piazza, 1980) and others observing stronger left

brain laterality among females than among males (Hiscock & Hiscock, 1988). On a cognitive level, some researchers have found males to perform better than females on verbal tasks (Hiscock & MacKay, 1985), while other researchers have found females to outperform their male counterparts on verbal tasks (Hirst, 1982; Piazza, 1980; Springer & Searleman, 1978). To date there is no firmly established evidence as to whether males possess stronger or weaker cerebral laterality for speech than do females, and whether females or males possess better verbal abilities.

Conflicting evidence has also been found in studies on the differences between FS+ and FS- subjects in relation to cerebral laterality in verbal processing. While it has been shown that FS+ subjects are less left-brain lateralized than FS- subjects in verbal processing (Bradshaw, 1980; Hiscock & MacKay, 1985; Springer & Searleman, 1978), other researchers have failed to find any notable differences between FS+ and FS- subjects on cerebral laterality in verbal processing (Hugdahl & Andersson, 1989; McKeever, 1986; Orsini, Satz, Soper & Light, 1985). This has led Orsini et al. (1985) to conclude (prematurely) that familial sinistrality does not influence cerebral laterality in verbal processing in both dextral and sinistral individuals. The basic problem with many of these studies which have so far failed to find any effect of familial sinistrality is that they did not control for the confounding effects of handedness of subjects

(Beaumont, 1988; Kolb & Whishaw, 1985). For example, Orsini et al. tested dextral and sinistral FS+ and FS- subjects, but do not indicate clearly whether or not dextrals differed from sinistrals overall. Bryden and Steenhuis (1991) assert that it has been found that the effects of positive familial sinistrality are more pronounced among dextrals than among sinistrals. They suggest that researchers interested in the differences between FS+ and FS- subjects on cerebral speech laterality needs to recruit dextrals to serve as subjects, rather than sinistrals. It is in fact not so easy to find enough willing sinistral individuals to serve as subjects. More basic research with dextrals and sinistrals is needed to establish the exact role of the left and the right brain in the processing of verbal stimuli belonging to different semantic categories, such as abstract, concrete and emotional words. Such research needs to control for the effects of subject variables such as sex and familial sinistrality on cerebral laterality in verbal processing.

1.2. The objectives and structure of the present thesis

The present thesis reports an empirical dichotic listening study which involved developing of a free-recall dichotic listening test, with abstract, concrete and emotional Zulu words as verbal stimuli. Individuals who acted as subjects in this study were dextral male and female native speakers

of isiZulu (Zulu language), consisting of individuals with sinistral blood relatives (FS+) and individuals with no sinistral blood relatives (FS-). The present research was designed with three major objectives in mind. First, it was designed to develop a preliminary list of abstract, concrete and emotional Zulu words for use in neuropsychological research on cerebral laterality and verbal memory. Second, it was designed to develop a dichotic listening test which can be used with a variety of subject populations who speak isiZulu, including literate and semiliterate or illiterate individuals. It was decided that a test more suitable for this purpose is the dichotic recall test, which was then developed. The third objective of the present research was to administer the developed dichotic recall test to a sample of Zulu-speaking dextral FS+ and FS- males and females.

Since the present research employed an original dichotic recall test, methodological and scoring issues in research with dichotic recall tests are discussed in the remainder of this chapter. First, the apparatus and administration of a dichotic recall test are described. Second, the scoring of dichotic recall test responses is described. Finally, the interpretation of dichotic recall test results is discussed in terms of a model called the structural model.

Chapter 2 discusses some of the published dichotic listening studies on cerebral laterality in abstract and concrete word stimulus processing. Evidence of left brain

laterality in abstract verbal processing and right brain laterality in concrete verbal processing from studies involving visual stimulus-presentations is also discussed. Finally, a handful of studies which found better performance with concrete than with abstract verbal stimuli among subjects is also discussed.

Chapter 3 discusses several of the published dichotic listening studies on cerebral laterality in emotional and nonemotional verbal stimulus processing. Evidence of right brain laterality in emotional verbal processing from studies involving visual stimulus-presentations is also discussed. Some evidence suggesting sex differences in emotional processing is discussed. Finally, some evidence from clinical auditory and visual studies among brain-damaged patient populations is discussed.

Chapter 4 discusses the methodology used in the present dichotic listening study. First, details of the pilot study which involved the development of the dichotic word stimuli used are provided. Second, the exact questions which were investigated by the present dichotic listening experiment are outlined. Third, the characteristics of subjects, the design, the stimuli and apparatus and the procedure employed are described. The scoring and analysis of results using statistical tests are described.

Chapter 5 presents the results of statistical analyses of the present data. Each of the six research questions

addressed is stated, and the results from the statistical tests performed to address it are then presented.

Chapter 6 discusses the findings of the present dichotic listening experiment and their implications. It is indicated that among female subjects, familial sinistrality was associated with better performance with abstract and concrete word stimuli but not with emotional word stimuli, while among males it is associated with a higher incidence of right brain laterality overall. The latter was inferred from their dichotic laterality and Z-laterality indices.

1.3. The dichotic recall test

The dichotic recall test is one of the most widely used memory-based dichotic listening procedures, which employ meaningful words as verbal stimuli, rather than nonsense (CV) syllables. Spreen and Strauss (1991) describe the dichotic recall test as primarily an indicator of cerebral speech laterality, and secondarily a measure of temporal lobe functional integrity. This means that the function of this test is twofold. It is a research tool for assessing patterns of cerebral laterality in auditory verbal stimulus processing, and for assessing the abilities of the right and the left temporal lobe to process and retain auditory verbal information in the memory storage system (Jones, 1981; Reber, 1985). As a behavioral research tool, this test can

be used to investigate the influences of such subject variables as sex and familial sinistrality on both cerebral laterality and recall memory in verbal processing. Compared to some other dichotic listening tests, this test is easier to develop and administer to subjects, be they literate or illiterate, sighted or blind, young or old. This contrasts with recognition memory-based dichotic listening tests which are restrictedly suitable for use with literate, sighted individuals. It also contrasts with reaction time dichotic listening tests which are less suitable with such subject populations as the elderly. The methodological and scoring issues in research with a dichotic recall test discussed below are based primarily on Spreen and Strauss (1991).

1.3.1. Apparatus and administration

The apparatus of a dichotic recall test includes amongst other items, a stereo cassette tape-player, two calibrated pairs of stereo headphones (one for the subject and one for the experimenter), a cassette tape containing the dichotic word stimuli, and an amplifier of a split-type to allow both the subject(s) and the experimenter to connect their headphones to it and listen to the dichotic word stimuli simultaneously. Spreen and Strauss (1991) states that the administration of a typical dichotic recall test involves presenting the subject with a series of trials of three

dichotic stimulus word-pairs via a pair of headphones. The earphone worn by the subject on the right ear is marked 'RIGHT' and that worn on the left ear is marked 'LEFT'. The subject responds immediately at the end of each trial by writing down or reporting orally the dichotic word stimuli heard, in any order and is not required to indicate whether a given stimulus word was heard in the left or the right ear, hence free-recall. The length of time intervals between dichotic word-pairs is predetermined by the experimenter, as is the sound intensity at which the dichotic stimuli are presented. The latter is expressed in decibel sound pressure level (dB SPL) (Spreeen & Strauss, 1991; Springer, 1986). Several researchers have used a 5 sec time interval between dichotic stimulus-pairs (e.g. Emmerich et al., 1988). Sound intensities which have been used to date include 65 dB SPL (Piazza, 1980), 80 dB SPL (Pipe, 1983), 84 dB SPL (Hugdahl & Andersson, 1989) and 94 dB SPL (Bergman, Costeff, Koren, Koifman & Reshef, 1984).

Subjects participating in a dichotic recall test or in any other dichotic listening test are first screened for any hearing impairments. Screening for hearing deficits involves administering the subject with a monaural-presentation task prior to participating in the actual experiment (Strauss, 1986; Wexler et al., 1992). This task involves presenting the subjects with a series of stimulus items to the left and the right ear separately, and then ask them to report all the stimuli they have just heard. Subjects who are free from

any hearing impairments normally perform well above average with monaural presentations. The experimenter then presents them with one or more dichotic stimulus-pairs to familiarize them with the dichotic presentations. After the successful completion of practice, the subject is then administered a series of dichotic presentation trials. Spreen and Strauss assert that dichotic listening effects are fairly robust in the presence of minor hearing impairments. They suggest however that subjects who are suspected of having any hearing deficits should be subjected to audiometric screening. Normally, individuals with hearing impairments are not included in the subject pool. If included, their data are analyzed separately from those of other subjects.

The dichotic recall test is normally made up of even trials, such that it is divided into two equal halves. At the end of the first half, the subjects are allowed a short break during which time they change the orientation of their headphones. As such, subjects who had participated in the first half of the test wearing the earphone marked 'LEFT' on the left ear, are instructed to wear this earphone on the right ear. Similarly, subjects who had participated in the first half of the test wearing the earphone marked 'RIGHT' on the right ear, are instructed to wear it on the left ear during the second half of the test. This counterbalancing procedure has been employed by almost all dichotic listening researchers. It balances out any effects of poor earphone

calibration or similar confounding factors (Piazza, 1980; Spreen & Strauss, 1991). The administration of a dichotic recall test usually takes about 10 to 20 minutes, depending primarily on whether subjects are required to write down their responses or to respond orally.

Both the oral and the written response mode have strengths and weaknesses. The oral response mode is suitable for use with a wide variety of normal subject populations, including illiterate (Castro & Morais, 1987) and blind individuals (Ittyerah, 1993). Its weaknesses include the fact that only one subject can be tested at a time in an experimental room. Furthermore, the experimenter may be required to tape-record the oral responses of the subjects for later scoring, and this means the experimenter requires more time and blank cassette tapes. The written response mode on the other hand, allows the experimenter to test subjects in groups of two or more (see also Eling, Marshall & Van Galen, 1981). It is thus more cost-effective in terms of time, particularly if many subjects have to be tested. It is however suitable only with literate, sighted individuals.

1.3.2. Scoring of dichotic recall test results

The dichotic word stimuli reported by the subjects are marked for accuracy. One credit is given per correctly reported stimulus word, and these credits are summed up to

yield a recall score per ear track. The recall score for stimuli presented to the left ear is often added to that for stimuli presented to the right ear to yield a total recall score across ear of presentation. A difference between the recall score for word stimuli presented to the left ear (LE) and that for word stimuli presented to the right ear (RE) is then computed by using the dichotic laterality index score formula: $(RE-LE)(100)/(RE+LE)$ (Pujol et al., 1991; Tzavaras et al., 1981). The result (quotient) of this computation provides the researcher with a clue about the underlying cerebral laterality in the processing of the stimuli used. The dichotic laterality index score can be negative, zero or positive. A negative dichotic laterality index score is taken as an indicator of a left ear advantage (LEA), a zero dichotic laterality index score as an indicator of a no ear advantage (NEA), and a positive dichotic laterality index score as an indicator of a right ear advantage (REA) (Hugdahl & Andersson, 1989). According Hugdahl and Andersson an LEA is taken as an indicator of right brain laterality, and an REA as an indicator of left brain laterality in the processing of dichotic stimulus materials used.

At least one group of dichotic listening researchers (Prior et al., 1984) has investigated the distribution of significantly larger and non-significant LEA's and REA's per individual subject, by converting their dichotic laterality index scores to Z-laterality index scores. They employed the

Z-value formula which can be expressed as: $Z = \frac{DL - ML}{SD}$, where DL represents a given dichotic laterality index score, ML the mean dichotic laterality index score of the sample, and SD the standard deviation dichotic laterality index score of the sample. From this formula, a subject is said to show a significantly larger LEA if he or she obtains a calculated Z-laterality score of -1.97 or above, while a subject who obtains a calculated Z-laterality score of 1.97 or above is said to show a significantly larger REA (see Porkess, 1988).

1.3.3. Interpretation of dichotic recall test results

The mean recall scores are normally taken as measures of recall memory of verbal stimuli used, while mean laterality index scores are taken as measures of lateralized cerebral processing of verbal stimuli used. The laterality index score data of the dichotic recall and many other dichotic listening tests have been interpreted in terms of a neurologically-oriented theoretical model known as the structural model (Emmerich et al., 1988; Wale & Geffen, 1986). According to these authors the structural model makes two important assumptions. First, it assumes that under a dichotic listening situation verbal stimuli presented to the left ear ascend primarily to the contralateral right brain (right temporal lobe). They are then transferred to the left brain via the corpus callosum for processing to take place.

By contrast, verbal stimuli presented to the right ear ascend primarily to the contralateral left brain (left temporal lobe), and are processed within this hemisphere rather than being transferred for processing in the opposite hemisphere. Second, the structural model assumes that verbal stimuli transmitted along the contralateral auditory pathways, particularly from the right ear to the left brain, are more powerful than verbal stimuli transmitted along ipsilateral auditory pathways, namely from the left ear to the left brain. It argues that the strength of contralateral auditory pathways allows stimuli travelling along them to suppress stimuli travelling along ipsilateral auditory pathways. This means that most of the dichotic information reached the brain for processing through the contralateral than the ipsilateral auditory pathways.

Both the first and the second assumption of the structural model do have some empirical neurological backing. For example, Risberg (1986) reports a study which involved presenting the subjects with a series of word stimuli monaurally, during which time changes in blood flow in the brain were monitored by means of a neurological test called the regional cerebral blood flow test. It was observed that right ear presentations led to significantly larger blood flows in the auditory receptive areas in the left temporal cortex. Conversely, higher blood flows were observed in the right temporal cortex during left ear presentations. With

regard to the second assumption, Handel (1991) reports some neurological data which show that about 70% of auditory information arriving at either ear ascends primarily to the contralateral temporal cortex, and only about 30% to the ipsilateral temporal cortex. Some recent empirical evidence from neuropsychological and neurological studies however suggests that the first of the two assumptions of the structural model is too simplistic and outdated.

It is a fact that numerous neuropsychological studies have found left brain laterality in verbal processing among most dextral and many sinistral subjects (Kolb & Whishaw, 1985; Kimura, 1987; Murdoch, 1990). But this does not mean that the left brain is the sole processor of verbal information, particularly among individuals whose native language is not English (Villardita, Grioli & Quattropani, 1988). Many of the studies published in English-medium journals like *Cortex* and *Neuropsychologia*, which found left brain laterality in verbal processing involved native speakers of English, who are unlikely to be representative of native speakers of that language. They are certainly not representative of people whose first language is not English. Thus the existing evidence for left brain laterality in verbal processing cannot be sensibly generalized to all human beings. In fact, several studies have found the right brain to play an active role in verbal processing among some native speakers of several languages, such as some speakers of native American

languages (Springer & Deutsch, 1981), some Spanish-speakers (Junque, Litvan & Vendrell, 1986) and some French-speakers (Demeurisse, Hublet, Coekaerts, Derouck & Capon, 1986; Lassonde et al., 1981). These findings suggest that the phenomenon of left brain laterality for speech functions may not be as universal as some behavioral neuroscientists think of it (Villardita et al., 1988).

A few experimental neuropsychological studies among native speakers of English have found the right brain to play a prominent role in the processing of such verbal stimuli as concrete words (Rastatler, Dell, McGuire & Loren, 1987) and emotional words and phrases (Joseph, 1992; Bryden et al., 1991; Strauss & Goldsmith, 1987). Furthermore, some native speakers of English have been found to exhibit some right brain laterality in the processing of verbal stimuli which are neither concrete nor emotional, such as nonsense (CV) syllables (O'Boyle & Benbow, 1990). This and other findings should further strengthen the argument that the issue of left brain as the sole processor of verbal information is too simplistic and outdated.

A few clinical neurological studies have supported the assumption that a dichotic LEA indicates the underlying right brain laterality, NEA the underlying bilaterality and REA the underlying left brain laterality in verbal processing (Strauss, Gaddes & Wada, 1987; Zatorre, 1989). One of the neurological tests which have been used in validating dichotic listening test results is known as the

sodium amytal test (Zatorre, 1989). The sodium amytal test is one of the most sensitive but invasive neurological procedures for establishing cerebral laterality in verbal processing (Beaumont, 1983). It is normally administered by a neurosurgeon to special patients who are to undergo brain surgery to establish the cerebral hemisphere primarily lateralized for language functions.

The administration of this test involves injecting the patient's carotid artery on each side of the neck (Hole, 1993) with the anesthetic drug called the sodium amytal, which has the effect of disrupting normal functioning of the ipsilateral cerebral hemisphere (Springer & Deutsch, 1981). In this case, injection of the left carotid artery leads to disruption in the functioning of the left brain, and injection of the right carotid artery to disruption in the functioning of the right brain. Only one carotid artery is injected at a time, and the patient is then presented with a series of language tasks, such as reading and counting days of the week (Zatorre, 1989). If the anesthetized hemisphere is the one controlling speech functions, the patient would normally exhibit aphasic disturbances for few minutes, and is thus unable to continue with the presented language tasks (Beaumont, 1988; Zatorre, 1989). By contrast, if the anesthetized hemisphere is not the one controlling speech functions, the patient exhibits no notable signs of aphasic disturbances. The sodium amytal test results obtained by the

patient are then compared with his or her dichotic listening test results. The dichotic listening test used is judged to be sensitive if its results correlate positively with those of the sodium amytal test.

Strauss et al. (1987) compared the sodium amytal test results of English-speaking dextral and sinistral male and female epileptic patients with their dichotic recall test laterality data. A total of 86% of the patients who had exhibited left brain speech laterality in the sodium amytal test, exhibited an REA in the dichotic recall test. By contrast, only 50% of the patients who had exhibited right brain speech laterality in the sodium amytal test, exhibited an LEA in the dichotic recall test. The poor correlation between the two test results, particularly as regards to right brain speech laterality, might have been influenced by uncontrolled effects of such subject variables as sex and handedness. This finding may also suggest that the Spreen and Strauss dichotic recall test is either biased towards left brain speech laterality, or is not sensitive enough to tap right brain speech laterality.

Higher positive correlations between sodium amytal test and dichotic listening test results were observed by Zatorre (1989) among native English-speaking dextral and sinistral epileptic patients. He found that 94% of the patients who had exhibited left brain speech laterality in the sodium amytal test, exhibited an REA in the dichotic listening

test. All (100%) of the patients who had exhibited right brain speech laterality in the sodium amytal test, exhibited an LEA in the dichotic listening test. Zatorre also observed that patients who had exhibited bilaterality in language processing in the sodium amytal test, showed smaller ear asymmetries in the dichotic listening test. While handedness of the subjects did not appear to have influenced their dichotic laterality scores, sinistral subjects exhibited some bias towards the left ear. This finding is consistent with the evidence that sinistral individuals tend to exhibit right brain laterality in verbal processing, as assessed by dichotic listening and other neuropsychological tests (Bradshaw & Nettleton, 1983; Kolb & Whishaw, 1985). Zatorre concluded that dichotic REA's and LEA's provide important clues of unilateral left or right brain speech laterality respectively, and that weaker ear advantages provide clues of bilateral speech representation. It could thus be argued that the dichotic listening technique is indeed one of the robust behavioral procedures for establishing cerebral speech laterality in a variety of human subject populations.

1.4. Conclusion

The structural model has been used by many dichotic listening researchers to explain the possible neurological basis of dichotic ear advantages. This model has however

proved to be too simplistic and outdated in its assumption of the left brain as the only processor of verbal stimulus materials. It has also been criticized by several dichotic listening researchers for placing too much emphasis on the underlying neurological aspects of dichotic ear advantages, while failing to acknowledge the fact that attentional factors may influence the subject's performance in a given dichotic listening task (Mondor & Bryden, 1991). These critics argue that subjects can bias their attention towards the right ear, resulting in an REA which may have little underlying neurological basis.

One way of dealing with such a bias among subjects has been to present them with randomly paired semantically and phonetically heterogeneous dichotic stimuli, such as nonsense syllables paired with musical notes (Kallman, 1978). A few dichotic listening researchers interested primarily in left and right brain laterality in verbal processing have used randomly paired dichotic abstract and concrete or emotional and nonemotional word stimuli (Ely et al., 1989; Wexler, Schwartz, Warrenburg, Servis & Tarlatzis, 1986). The remainder of this thesis discusses evidence from some of these dichotic listening studies.

CHAPTER 2

DICHOTIC LISTENING STUDIES ON CEREBRAL LATERALITY IN

ABSTRACT VS CONCRETE STIMULUS WORD PROCESSING

The left brain has long been regarded as the 'verbal cerebral hemisphere' and the right brain as the 'nonverbal (visuospatial) cerebral hemisphere' (Springer & Deutsch, 1981). The assumption of the left brain as a speech processor and the right brain as a nonverbal processor is based partly on evidence from numerous neuropsychological studies on cerebral laterality in verbal and nonverbal processing among normal subjects (Beaumont, 1988; Cohen, Levy & McShane, 1989). It is also based on evidence from clinical neurological and neuropsychological studies among brain-damaged patients, indicating that left brain-damage often results in some gross receptive and expressive speech deficits (Frisk & Milner, 1990), and right brain-damage in some deficits in nonverbal visuospatial processing (Martin, Meador, Loring, Bowers & Heilman, 1990).

Some of the recent neuropsychological evidence has shown however that the right brain plays a more active role than the left brain in the processing of concrete word stimuli, amongst other verbal stimuli (Villardita et al., 1988). This evidence comes from dichotic listening and visual studies which used abstract and concrete words as verbal stimuli.

This chapter discusses some of these published studies. First, a theoretical model known as the dual coding model which attempts to give an explanation of the basis of right brain laterality in concrete verbal processing is discussed. Second, few of the published dichotic listening and visual studies among normal subjects are discussed. Finally, two clinical studies among brain-damaged patients involving auditory or visual presentation of abstract and concrete word stimuli are discussed.

2.1. The dual coding model

Before discussing the dual coding model, it is important to give a working definition of abstract and concrete words. Abstract words can be defined as words that are the least concrete or not concrete at all, difficult to understand, or words that have no reference to known material objects (Paivio & Te Linde, 1982; Reber, 1985; Villardita et al., 1988). By contrast, concrete words can be defined as words that refer to specific events, actions, situations, or particular objects. They refer to things which can be experienced by the sense organs or imagined in the mind's eye (Paivio & Te Linde, 1982). Abstract and concrete word lists for neuropsychological research purposes have been developed by recruiting a sample of speakers of the target language to rank each word for abstractness and concreteness

of English include monosyllabic words like goat, horse, tree and sky (Ely et al., 1989). Abstract and concrete word lists for neuropsychological research purposes have been developed by recruiting a sample of speakers of the target language to rank each word for abstractness and concreteness on a continuous rating scale. For example, Ely et al. asked a group of university students to rank each of the words on a seven-point scale, ranging from 1 to 7. Bradshaw, Nettleton and Taylor (1981) also asked a group of university students to rank abstract and concrete English words for abstractness and concreteness on a four-point continuous scale.

Several abstractness and concreteness scales have been developed by researchers using abstract and concrete words in other languages, such as Italian (Villardita et al., 1988) and Japanese (Elman, Takahashi & Toksaku, 1981). As a basic condition, abstract words are required to rate higher than concrete words on the abstractness scale and lower than concrete words on the concreteness scale. On the other hand, concrete words are required to rate higher than abstract words on the concreteness scale and lower than abstract words on the abstractness scale.

The dual coding model has been put forward primarily to give a cognitive neuropsychological explanation of the basis of right brain laterality in concrete stimulus word processing, and of the dual nature of these stimuli. According to Paivio and Te Linde (1982) the dual coding model holds that

concrete words are represented in the human brain both by their semantic properties (the verbal code) and the stored image of their referents (the imaginal code), while abstract words are only represented by their semantic properties. This model argues that representation of concrete words by an imaginal code makes them more suitable for processing in the right brain via imagery-based processing mechanisms, and their representation by a verbal code in addition to an imaginal code makes them equally suitable for processing in the left brain via verbally-based processing mechanisms (Eviatar, Menn & Zaidel, 1990). On the other hand, representation of abstract words in the human brain by their verbal code only makes them more suitable for processing in the left brain via verbally-based processing mechanisms (Duhamel & Poncet, 1986). But they are not suitable for processing within the right brain since their referents are quite difficult to visualize in the mind's eye, presumably mediated primarily by the right brain.

The dual coding model makes two basic assumptions. First, it assumes that the right brain is lateralized for concrete verbal processing. It also argues that concrete verbal stimuli can be processed more efficiently within both the right and the left brain of a normal person. Second, it assumes that the left brain is lateralized for abstract verbal processing. It also argues that the fact that abstract verbal stimuli are processed more efficiently in

one brain half only (usually the left), leads to a situation where performance with abstract word stimuli becomes poorer than that with concrete word stimuli.

A hypothesis known as the concreteness effect hypothesis has been formulated and tested by a few neuropsychological and cognitive psychological researchers (Eviatar et al., 1990; Ho & Chen, 1993). This hypothesis agrees with the basic assumptions of the dual coding model, by arguing that subjects performed better with concrete than with abstract verbal stimuli due to the former being represented in their brains both by the imaginal and the verbal code. On the other hand, it argues that subjects perform more poorly with abstract verbal stimuli due to these verbal stimuli being represented in their brains by the verbal code only. The concreteness effect hypothesis however differs from the dual coding model in that its primary focus is on cognitive than on neuropsychological aspects of abstract versus concrete verbal stimulus processing. In other words, it is primarily concerned with memory or performance abilities in abstract versus concrete processing, rather than with their unilateral or bilateral representation in the human brain. In addition to neuropsychological evidence for concreteness effect (Eviatar et al., 1990), this hypothesis has also been supported by a few cognitive psychological studies on memory for abstract and concrete sentences (Ho & Chen, 1993). A few empirical neuropsychological studies will now be discussed.

2.2. Dichotic listening studies among normal subjects

To date there has been very little dichotic listening research with abstract and concrete word stimuli. To investigate cerebral laterality in the processing of abstract and concrete English words, McFarland et al. (1978) administered a dichotic listening task to dextral speakers of English. Data analysis revealed that subjects performed better with abstract word stimuli presented to the right ear, but performed more poorly with abstract word stimuli presented to the left ear. They performed better with concrete word stimuli presented to the left ear, but performed more poorly with concrete word stimuli presented to the right ear. The results were interpreted as consistent with the dual coding model. Subjects showed an overall right ear advantage (REA) for abstract word stimuli, suggesting left brain laterality in the processing of these stimuli. They showed an overall left ear advantage (LEA) for concrete word stimuli, suggesting right brain laterality in the processing of these stimuli. Overall analysis of performance data revealed that they performed better with concrete word stimuli than with abstract word stimuli.

This study is one the first few dichotic listening studies to find some evidence of right brain laterality in concrete verbal processing among native speakers of English, a group that has long been thought of as possessing left brain laterality for speech functions. It is also one of the

first few studies to provide empirical support to the dual coding model and to the concreteness effect hypothesis. It is however limited in several ways. For example, the authors do not indicate the sex of the subjects, and whether or not effects of subject variables like sex and familial sinistrality were controlled for.

Prior et al. (1984) conducted a recognition memory-based dichotic listening study among native English-speaking dextral males and females. The verbal stimuli were abstract and concrete English words. Data analysis revealed that females exhibited an LEA for abstract word stimuli, while males exhibited an LEA for concrete word stimuli. Males also showed an REA for abstract word stimuli. Overall analysis of performance data revealed that females recognized more abstract and concrete word stimuli than did their male counterparts. Finally, it was observed that male and female subjects performed better with concrete than with abstract word stimuli overall. These data suggest two basic issues. First, they suggest that while the laterality data for males were consistent with the dual coding model, those for females were not. Second, better performance among females compared with males is consistent with evidence from other cognitive neuropsychological studies on differences between males and females on verbal abilities (Filskov & Catanese, 1986). There is however no clear indication as to whether effects of factors like familial sinistrality were

controlled for. Finally, these data of this study are also consistent with the concreteness effect hypothesis insofar as they showed better overall performance with concrete than with abstract word stimuli among subjects across sex group.

2.3. Evidence from visual studies among normal subjects

A few visual-presentation studies employing abstract and concrete word stimuli have also been undertaken among normal subjects. Most of these studies have used a behavioral technique known as the tachistoscopic technique (Van Strien & Morpurgo, 1992; Yoshizaki & Hatta, 1987). This technique involves presenting the subject with a series of visual stimuli via a tachistoscope to the left and the right visual field, at a duration of about 150 to 200 msec per presentation (Beaumont, 1983). A higher mean performance scores for stimuli presented to the left visual field is taken as an indicator of a left visual field advantage (LVFA), while a higher mean performance scores for stimuli presented to the right ear is taken as an indicator of a right visual field advantage (RVFA) in the processing of stimuli used (Beaumont, 1983; Yoshizaki & Hatta, 1987).

To test the plausibility of the dual coding model, Elman et al. (1981) administered a tachistoscopic task to dextral and sinistral male and female Japanese-speakers. The verbal

stimuli were abstract and concrete Japanese words. Data analysis revealed that abstract word stimuli yielded an RVFA, while concrete word stimuli yielded an LVFA. The results of this experiment are thus consistent with the dual coding model's assumption of left brain laterality in abstract verbal processing and the right brain laterality in concrete verbal processing. No information is however given by these authors on whether any differences were observed between males and females, or between dextral and sinistral subjects on laterality patterns. These authors also did not indicate clearly whether subjects performed better with concrete word stimuli or with abstract word stimuli.

Rastatler et al. (1987) conducted a tachistoscopic study among English-speaking dextral males and females. The verbal stimuli were abstract and concrete English words. Analysis of data revealed that abstract word stimuli yielded a significantly larger RVFA, while concrete word stimuli yielded a significantly larger LVFA. The results of this study were thus consistent with the assumption of the dual coding model that the left brain is lateralized for abstract verbal processing, and the right brain for concrete verbal processing. These authors did not however indicate whether any differences were observed between males and females on the magnitude or strength of visual field advantages, as well as on overall performance. They also did not indicate whether subjects performed better with concrete word stimuli

or with abstract word stimuli overall. Finally, no mention was made of whether the effects of familial sinistrality, amongst other factors, were controlled for.

One of the studies that controlled for the effects of familial sinistrality is that of Bradshaw et al. (1981) among English-speaking male and female FS+ and FS- dextral and sinistral subjects. The verbal stimuli were abstract and concrete English words. Analysis of data revealed that FS-dextrals as a group performed better than the other subject groups overall, while FS+ sinistrals performed more poorly than all the other subject groups overall. Inspection of laterality data revealed that FS- sinistrals exhibited the smallest cerebral lateralities. It also revealed that FS+ dextrals were no less lateralized than FS- dextrals overall. This study failed to come out with any clear set of data concerning left and right brain laterality in abstract and concrete verbal processing. It also failed to find any effects of sex and familial sinistrality on cerebral laterality patterns.

Nevertheless, performance data suggest that FS- dextral subjects possessed better abstract and concrete verbal abilities than other subject groups. This finding is consistent with other studies among native English-speaking dextrals which found poorer performance on verbal and nonverbal tasks among FS+ subjects than among FS- subjects (Springer & Searleman, 1978; Yeo & Cohen, 1983). Bradshaw et

al.'s finding could thus be seen as suggesting a notable role of factors like familial sinistrality in influencing the performance of subjects on a given cognitive task. It is therefore possible that such factors can also influence the predicted pattern of cerebral laterality in abstract versus concrete verbal stimulus processing.

2.4. Evidence from studies among brain-damaged patients

A few clinical studies involving auditory presentation of abstract and concrete word stimuli have been conducted among left and right brain-damaged patients. Duhamel and Poncet (1986) administered a dichotic listening task to a dextral male French-speaking left brain-damaged patient. He was administered the task as part of clinical neuropsychological assessment of the effect of left brain-damage on language functions. He performed satisfactorily well with word stimuli presented to the left ear, especially concrete ones. By contrast, he hardly identified correctly any abstract or concrete word stimuli presented to the right ear. Duhamel and Poncet interpreted this finding as suggesting that this patient's intact right brain was able to process concrete word stimuli presented to it via the contralateral left ear, more efficiently than abstract word stimuli. On the other hand, the damaged left brain was unable to process both abstract and concrete word stimuli. This finding is

basically consistent with the assumptions of the dual coding model in that it suggests that the lesions left brain was lateralized for abstract verbal processing.

The effects of right brain-damage on lateralized processing of abstract and concrete word stimuli has been investigated by Villardita et al. (1988) among 15 Italian-speaking right brain-damaged patients. They were presented with abstract and concrete word stimuli in their native language. The word stimuli were read out aloud by the examiner, and the subjects were asked to report them in any order after their presentation (free-recall memory task). Data analysis revealed that they recalled significantly fewer concrete word stimuli. By contrast, their performance with abstract word stimuli was satisfactorily well above chance level. Villardita et al. interpreted this finding as suggesting that the intact left brain was able to process abstract word stimuli more efficiently than concrete word stimuli. The implication of this finding is that in these patients, the intact left brain was somewhat lateralized for abstract word processing, and the lesioned right brain for concrete word processing. If so, then it can be argued that this study provides some clinical empirical evidence which supports the basic assumptions of the dual coding model.

2.5. Conclusion

All of the studies discussed in this chapter are to a larger extent consistent with the assumption of the dual coding model of left brain laterality in abstract word processing, and right brain laterality in concrete word processing. Many of these studies among normal subjects are also consistent with the concreteness effect hypothesis. They observed that subjects performed better with concrete than with abstract word stimuli. Such a preferential concrete word processing has been associated with imageability of referents of these stimuli, and poor abstract word processing with nonimageability of referents of these stimuli.

One of the limitations of many of the studies discussed above is their failure to control for effects of such variables as sex and familial sinistrality on performance and laterality data among subjects. Those that did control for these subject variables found some differences between males and females or between FS+ and FS- subjects. The implication of these findings is that sex and familial sinistrality, amongst other factors, do influence the performance of subjects on certain neuropsychological tasks, particularly of a verbal nature.

CHAPTER 3

DICHOTIC LISTENING STUDIES ON CEREBRAL LATERALITY IN EMOTIONAL VS NONEMOTIONAL VERBAL STIMULUS PROCESSING

The active involvement of the right brain in the processing of visually presented nonverbal emotional stimuli, such as human face photographs expressing distinct emotions, has long been established (Code, 1987; Morrow, Vrunski, Kim & Boller, 1981; Wittling, 1990). This evidence comes from studies with normal subjects and from clinical studies with brain-damaged patients. A few dichotic listening and visual studies employing emotional and nonemotional word stimuli have also been conducted, mostly among dextral subjects. Many of these studies have found that the right brain laterality in emotional verbal processing, and left brain laterality in nonemotional verbal processing (Bryden et al., 1991; Ely et al., 1989; Van Strien & Morpurgo, 1992).

This chapter discusses several of the published dichotic listening and visual studies on cerebral laterality in emotional versus nonemotional stimulus word processing. First, evidence on the role of the right brain and the limbic system in emotional stimulus processing is discussed. Second, dichotic listening studies among normal subjects are discussed. Third, evidence from visual studies among

normal subjects is discussed. Finally, evidence from clinical studies among brain-damaged patients is discussed.

3.1. The right brain and the limbic system

According to Joseph (1992) the right brain has been found to have a special functional relationship with the subcortical limbic system. This evidence suggests that in human infants, the right brain and the limbic system are initially dominant in regard to vocal communication. Babbling and melodic speech in babies have been referred to as limbic language in that they are regulated in the limbic system and expressed via the right brain (Joseph, 1992). Evidence from electrophysiological and other neuroscientific studies among human infants indicates that the right brain matures earlier than the left brain (Rothbart, Taylor & Tucker, 1989). It has also been shown that as the left brain matures, it takes over control of many of the developing linguistic functions. The rate at which the left brain matures appears to be related to the sex of the individual. Evidence from several studies suggests that left brain maturity and its control of language processing occurs somewhat faster in girls than in boys (Hirst, 1982; Springer & Deutsch, 1981). By contrast, right brain maturity has been found to occur somewhat faster in boys than in girls. Early maturity of the left brain in girls has been associated with better expressive language

abilities, while early maturity of the right brain in boys has been associated with better visuospatial abilities (Bradshaw & Nettleton, 1983). Sex differences on cerebral laterality in emotional processing have been found to emerge at around the age of 10 months, and to continue through to adulthood (Rothbart et al., 1989). Recent evidence suggests that a special relationship between the right brain and the limbic system which emerges at infancy is maintained through to adulthood (Code, 1987). Code indicates that this evidence has come from observations of manifestations of limbic communicative functions among certain neuropathological and brain-damaged human subjects, such as epileptic patients.

The limbic system plays a key role in emotional processing, including the expression of such automatic signals as rage, surprise, fear and alarm (Code, 1987). It also plays a crucial role in the regulation of social interactions, including the expression of dominance, submission, aggression and friendship (Joseph, 1992). According to Code emotionally-charged speech appears to originate in the limbic system due to its affective responsibilities and referential meaning, and is expressed via the right brain. He argues that such speech relieves affective pressures in the speaker and evoke limbic responses in the hearer.

Two of the limbic structures that play a crucial role in the processing of emotional materials are the amygdala and the hippocampus (Joseph, 1992). Joseph describes the

amygdala as a limbic structure located beneath the temporal cortex. It is highly involved in the ability to experience moods and emotional feelings, including the ability to discern emotional and motivational significance of all sensory events. It enables the individual to detect a variety of emotions in facial expressions of people around, such as anger, sadness and happiness. It is also the limbic structure controlling the capacity to feel and act in an aggressive and murderous manner (Joseph, 1992; Kalat, 1984). Joseph asserts that the amygdala plays an active role in the reception and comprehension of verbal and nonverbal auditory information, such as cursing and singing.

The hippocampus has been described as a long twisted limbic structure which lies deep within the temporal cortex (Jones, 1981). It is intimately involved in emotional processing, motivation and learning, as well as in the establishment of long-term memory (Reber, 1985). The right hippocampus is believed to be concerned with visual, emotional and tactile memories, and the left hippocampus with verbal and mathematical memories (Joseph, 1992). It is however important to state here that empirical evidence showing right brain laterality in verbal processing suggests that the right hippocampus also plays a role in verbal memories, particularly concrete and emotional verbal memories. Several studies which found right brain laterality in concrete verbal processing have already been discussed in chapter 2.

A few of the published dichotic listening and visual studies which found right brain laterality in emotional verbal stimulus processing will now be discussed.

3.2. Dichotic listening studies among normal subjects

There has been very little research with emotional and nonemotional verbal stimuli among normal subjects. Before discussing the few published dichotic listening studies, it is essential to provide a working definition of emotional and nonemotional words. Emotional words can be defined as words with an emotional content, connotation or association, and nonemotional words as words with no emotional content, connotation or association. Reber (1985) states that the word emotion comes from the Latin *emovere*, which translates to move, to stir up, or to agitate. It is presently used in neuropsychology as an umbrella term for any of the various subjectively experienced affect-laden states, such as anger, happiness, and sadness. Emotional English words which have been used as verbal stimuli in neuropsychological studies include both negative emotional words such as stab, slap, pain, hate and rage (Graves et al., 1981) and positive emotional words such as money and hugging (Reuterskiold, 1991). Studies with speakers of other languages have also used negative and positive emotional words. For example, Van Strien and Morpurgo (1992) used Dutch equivalents of words

such as humiliated, assault, failure, cheerful, pleasure, happiness and delight. Emotional and nonemotional word lists for neuropsychological research purposes have been developed by asking speakers of the target language to rank each word for emotionality and nonemotionality on a continuous scale. For example, Ely et al. (1989) asked university students to rate each of the words for emotionality on a scale ranging from 1 to 7. Nonemotional English words which have been used include abstract words such as span, main and time (Graves et al., 1981) and concrete words such as knitting, washing and fencing (Reuterskiold, 1991). Three of the published dichotic listening studies are discussed hereunder.

Ely et al. (1989) administered a dichotic listening task involving emotional and nonemotional abstract and concrete English word stimuli to dextral male speakers of the language. It was predicted that both emotional and nonemotional concrete word stimuli would yield a smaller right ear advantage (REA) or a left ear advantage (LEA). On the other hand, it was predicted that nonemotional abstract word stimuli would yield a larger REA. Analysis of data revealed that emotional word stimuli yielded an LEA, while nonemotional concrete word stimuli yielded a smaller REA. As expected, abstract word stimuli yielded a significantly larger REA. The results of this study are impressive insofar as they show that the magnitude of the predicted left brain laterality in nonemotional stimulus word processing could be

differentially influenced by their semantic properties. In the present context, abstract word processing seems to be more left brain lateralized than does concrete word processing. Unfortunately, this study is quite restricted in that only dextral males served as subjects. These investigators also did not control for the effects of familial sinistrality among subjects.

One of the recent studies which involved both male and female dextral subjects is that of Wexler et al. (1992). Wexler et al. presented their subjects with a recognition memory-based dichotic listening task with emotional and nonemotional English word stimuli. It was observed that subjects recognized more emotional word stimuli presented to the left ear than those presented to the right ear. By contrast, nonemotional word stimuli presented to the right ear tended to be recognized better than those presented to the left ear. These data were interpreted as suggesting that the right brain played a more active role in the processing of emotional than nonemotional word stimuli. This finding is consistent with Ely et al.'s (1989) finding and with the assumption that the right brain is specialized for emotional speech functions, and the left brain for nonemotional speech functions (Joseph, 1992). Wexler et al. did not however control for effects of factors like familial sinistrality. It is possible that factors like this influenced the size of

the observed ear advantages for emotional word stimuli or nonemotional word stimuli, or both stimulus word categories.

Dichotic listening studies on cerebral laterality in emotional versus nonemotional verbal processing have also been conducted among sinistral subjects. One such study was conducted by Bryden et al. (1991) among male and female English-speaking dextrals and sinistrals. Subjects were presented with English dichotic words spoken in a sad, angry happy (emotional) and neutral (nonemotional) tone of voice. Subjects indicated whether or not a specific target stimulus word was present in a given dichotic presentation (verbal task), and then indicated whether one of the presented dichotic word stimuli was spoken in an angry, happy, sad or neutral tone of voice (emotion task).

Analysis of data revealed a left ear advantage (LEA) with the emotion task, and a right ear advantage (REA) with the verbal task. Sinistral subjects across sex group exhibited a slightly larger LEA than did dextral subjects with the emotion task. The observed LEA with the emotional task was interpreted as suggesting right brain laterality, and the observed REA with the verbal task as suggesting left brain laterality. There were no significant sex differences with either the emotion or the verbal task. These data are consistent with those of the studies discussed above insofar as they suggest an active involvement of the right brain in emotional auditory speech processing, and active involvement

of the left brain in nonemotional auditory speech processing. They are also consistent with Zatorre's (1989) finding in that they show a more pronounced right brain laterality in (emotional) verbal processing among sinistral individuals compared with dextral individuals. These two studies support the assumption that right brain speech laterality is more likely in sinistrals than in dextrals (Bradshaw, 1980). One of the limitations of Bryden et al.'s study is that they did not control for the effects of familial sinistrality, more particularly among dextral subjects. It may be possible that some dextral subjects with sinistral blood relatives also exhibited somewhat larger LEA's with the emotion task.

3.3. Evidence from visual studies among normal subjects

Of the numerous published visual-presentation studies on cerebral laterality in emotional and nonemotional stimulus processing among normal subjects, very few used emotional and nonemotional verbal stimuli. One of these few studies on emotional verbal processing was conducted by Graves et al. (1981) among English-speaking male and female dextrals. The stimuli were English emotional and nonemotional words, and were presented via a tachistoscope. The task was a recognition memory task, and the subjects' mean recognition scores per visual field of presentation served as measures

of lateralized cerebral processing. Recognition score data for males were analyzed separately from those for females. It was observed that males exhibited a significantly larger left visual field advantage (LVFA) with emotional word stimuli, but not with nonemotional word stimuli. This finding was interpreted as suggesting a stronger right brain laterality in emotional verbal processing in these male dextrals. By contrast, females exhibited a significantly larger right visual field advantage (RVFA) with emotional word stimuli, but not with nonemotional word stimuli. This finding was interpreted as raising a question of whether in these dextral females the left than the right brain was more lateralized for emotional language processing.

Analysis of recognition score data for the subjects combined revealed that they performed better with emotional than with nonemotional word stimuli overall. This study is one of the relatively few neuropsychological studies on emotional versus nonemotional verbal stimulus processing to find right brain laterality among males and left brain laterality among females in emotional word processing. It is also one of the few neuropsychological studies among normal subjects to find better overall performance with emotional than with nonemotional word stimuli. It however failed to control for potential effects of such subject variables as familial sinistrality on laterality patterns in emotional versus nonemotional processing. Nonetheless, its finding of sex differences makes a significant contribution towards the

neuropsychological thinking that males differ from females with respect to cerebral speech laterality.

In addition to sex differences on laterality patterns, some evidence from studies on cerebral processing of emotional human face photographs suggests that males and females differ in their cognitive abilities to identify particular expressed emotions accurately. For example, Ladavas, Umilta and Ricci-Bitti (1980) presented dextral males and females with human face photographs expressing happiness, surprise, fear, sadness, anger and disgust, via a tachistoscope. The subjects' task was to compare each stimulus item to a mental representation of an affective nature, irrespective of the face actually presented. Data analysis revealed that males had slower latencies compared with females. This finding was interpreted as suggesting better emotional abilities among female subjects compared with male subjects.

In recent years there has been little neuropsychological research on sex differences in relation to emotional abilities. It is doubtful whether evidence from studies which used nonverbal visual emotional stimuli could be used to predict sex differences on verbal emotional abilities. This is due mainly to the fact that the human brain does not process auditory information in exactly the same way as it processes visual information (Paivio & Te Linde, 1982). According to Paivio and Te Linde several memory studies have found that subjects perform better with visual stimuli than

with auditory stimuli. More neuropsychological research is needed to investigate the effects of these variables on cerebral processing of auditory and visual emotional verbal stimulus materials among normal and brain-damaged subjects.

2.4. Evidence from studies among brain-damaged patients

Reuterskiold (1991) investigated whether performance with emotional stimuli was better than that with nonemotional stimuli among English-speaking male left brain-damaged aphasic patients. They were administered an auditory verbal task, with emotional and nonemotional English words and the matching pictures as stimuli. The word stimuli were read out aloud to the subjects, who were asked to select a matching picture from an array of seven pictures. Analysis of data revealed that 55% of emotional word stimuli and 38% of nonemotional word stimuli were identified correctly. The difference between performance scores for emotional word stimuli and those for nonemotional word stimuli was statistically significant. This finding was interpreted as suggesting that presentation of emotional word stimuli could enhance verbal processing and retention even in the presence of severe receptive aphasia. Reuterskiold speculated that the observed better performance with emotional word stimuli might have been due to increased arousal or motivation, active involvement of the right brain, or a combination of

both factors. It was concluded that the use of emotional verbal stimuli in neuropsychological tests developed for assessing receptive aphasia in brain-damaged patients could prove to be very beneficial. There has not been any intensive neuropsychological research on the effects of emotionality of verbal stimuli on recall or recognition memory among normal subjects.

The effects of right and left brain-damage on cerebral processing of visual emotional stimuli have been assessed by Morrow et al. (1981) in a sample of male English-speaking left brain-damaged and right brain-damaged patients. The subjects were presented with color slides of emotional-laden objects or situations, such as a soldier in battle and a cut (bleeding) hand, as well as color slides of nonemotional objects, such as a parked car and landscapes. Galvanic skin responses were monitored during random presentation of these emotional and nonemotional slides. Significantly smaller galvanic skin responses were observed among both left and right brain-damaged patients compared with normal control subjects. Comparison of left and right brain-damaged patients revealed that the latter exhibited galvanic skin responses which were significantly smaller than those shown by the former. Presentation of emotional compared to nonemotional slides yielded significantly larger galvanic skin responses among both normal control subjects and left brain-damaged patients. By contrast, virtually no galvanic

skin response was found among right brain-damaged patients in response to both emotional and nonemotional slides. Morrow et al. interpreted these data as suggesting that left brain-damage decreased arousal responses to emotional slides, while right brain-damage suppressed arousal responses altogether.

The findings of this study suggest two issues of primary importance to the present discussion of lateralized cerebral processing of emotional versus nonemotional stimuli. First, these data suggest that in these right brain-damaged male patients, the damaged right brain was originally lateralized for emotional processing. Its damage led to severe deficits in emotional processing. Second, these data suggest that in these left brain-damaged male patients, the damaged left brain played an active but not dominant role in the processing of emotional information. Its damage led to some deficits in emotional processing, which were incidentally compensated for by the intact right brain. These data provide empirical clinical support to the assumption that the right brain is lateralized for emotional processing, at least in some English-speaking male dextrals.

One of the recent clinical studies which found that the right brain plays an active role in the processing of visually presented emotional human face photograph stimulus materials was conducted by Mandal, Tandon and Asthana (1991) among right and left brain-damaged dextral patients. The subjects were speakers of any of several native languages of

India, and were presented with human face photographs expressing distinct emotions to match. It was observed that left brain-damaged patients were more accurate in matching the face photograph stimuli than did right brain-damaged patients. A group of normal control subjects performed better than both left and right brain-damaged patients. These clinical data further strengthen the assumption that emotional information is largely processed in the right brain, and that damage to this cerebral hemisphere results in deficits in the comprehension and processing of emotions.

3.5. Conclusion

The studies discussed in this chapter found some evidence of right brain laterality in emotional stimulus processing. Two of the studies discussed above found that subjects perform better with emotional word stimuli than with nonemotional word stimuli overall. This evidence suggests that an intact right brain plays an active role in the processing of both auditory and visual emotional verbal stimuli. It challenges the assumptions of theoretical models like the structural model that the left brain was the sole processor of verbal information, and that the right brain was not capable of processing stimulus materials of a linguistic nature. A few of the published studies on cerebral processing of emotional stimulus materials suggest that some differences exist

between dextral males and females in relation to emotional abilities and laterality of those abilities. One such study discussed above suggests that females may possess better emotional abilities than males, while the other study suggests that in dextral females the left brain may play a dominant role in emotional verbal processing.

None of the studies discussed above controlled for the potential effects of subject variables like familial sinistrality on cerebral laterality in the processing of emotional versus nonemotional stimulus materials. The only study in which data on familial sinistrality was collected but not used, is that of Mandal et al. (1991). Many of the previous neuropsychological studies have failed to find any notable influence of familial sinistrality on cerebral laterality in the processing of emotional verbal stimuli. Evidence from studies like that of Bryden et al. (1991) suggests that sinistrality may be positively related to the strength of right brain laterality in emotional verbal processing. Since dextrals with sinistral blood relatives (FS+) are believed to possess some inherited genetic trait for sinistrality (Bradshaw & Nettleton, 1983), collecting data on familial sinistrality subjects could enable the neuropsychological investigator to determine whether familial sinistrality influences patterns of cerebral laterality in the processing of emotional versus nonemotional verbal stimuli.

CHAPTER 4

THE PRESENT DICHOTIC LISTENING RESEARCH

The empirical evidence discussed in the first three chapters of this thesis could be interpreted as suggesting that in dextral subjects, particularly male native English-speakers, (1) the left brain is lateralized for the processing of abstract and nonemotional verbal stimuli, (2) the right brain is lateralized for the processing of concrete and emotional verbal stimuli, (3) performance with concrete verbal stimuli is better than performance with abstract verbal stimuli, and (4) performance with emotional verbal stimuli is better than performance with nonemotional verbal stimuli. It could also be interpreted as suggesting that some differences exist between males and females and between FS+ and FS- dextrals with respect to verbal abilities and laterality of those abilities in the brain. The exact nature of such effects of sex and familial sinistrality on patterns of cerebral processing of verbal stimuli among dextrals and sinistrals is yet to be established.

This thesis reports a basic cognitive neuropsychological study which used a dichotic recall test in its investigation of free-recall memory and cerebral laterality of abstract, concrete and emotional stimulus Zulu words among male and female FS+ and FS- dextral native Zulu-speakers. The present

study is described as a "basic cognitive neuropsychological study" in that it assessed cognitive and neuropsychological aspects of cerebral processing of Zulu verbal stimuli among normal (as opposed to brain-damaged) native Zulu-speakers. This research was designed with three primary objectives in mind. The first objective was to develop a list of abstract, concrete and emotional Zulu words for neuropsychological research purposes. The second objective was to develop a dichotic listening test for assessing both recall memory and cerebral laterality of abstract, concrete and emotional stimulus Zulu words amongst a wide variety of Zulu-speaking subject populations. The dichotic recall test was judged to be the most suitable test for this purpose. It was then developed. The third objective was to administer the developed dichotic recall test to a sample of high school and university going male and female native Zulu-speaking FS+ and FS- dextrals.

This subject population was chosen for two main reasons. First, the word stimuli used were rated for abstractness, concreteness and emotionality by a sample of volunteer raters from the same age group, dialectical, geographical and educational backgrounds as the subjects. Second, these high school and university going students were currently studying or have studied isiZulu as one of their major high school subjects. The reason for choosing dextrals as opposed to sinistrals has to do with the fact that the incidence of sinistrality appears to be too low among Zulu-speakers. The

potential effects of familial sinistrality were stringently controlled for in the present dichotic listening experiment.

This chapter discusses the methodology employed in the execution of the present research. First, brief relevant information on Zulu orthography and usage is given. Second, details of the pilot study are given. Third, the questions addressed by the present dichotic listening experiment are outlined. Fourth, the characteristics of subjects, the design, stimuli and apparatus, and the experimental procedure employed are described. Finally, the scoring and the statistical analyses of data are described.

4.1. The Zulu orthography and usage

IsiZulu is one of the oldest native languages of South Africa. It derives its name from the word 'Zulu' which is the clan name (surname) of the hereditary Zulu kings. IsiZulu is non-tonal in its spoken form, and does not employ polyphonic consonants and vowels in its orthography. In this context, consonants such as 'c' and vowels such as 'a' have only one phonetic value each. (This contrasts with polyphonies found in languages such as English, as in 'call' and 'cell' or 'at', 'all' and 'along'). The consonant 'r' is not part of the Zulu orthography, and consonants like 'x' are not used as frequently as consonants like 'm'. It is important to state that consonants like 'c', 'b' and 'k' are

pronounced differently from consonants like 'ch', 'bh' and 'kh', and they mean totally different things. For example, 'ukubala' (to count) is both phonetically and semantically different from 'ukubhala' (to write).

All Zulu words end with a vowel (a, e, i, o, u), and no two or more vowels are allowed to follow each other at the beginning, the middle or the end of the word. Up to four consonants are allowed to follow each other in a given word. For example, the word 'ntshebe' (beard) has four consonants 'ntsh' following each other. The Zulu language is largely oriented towards meaning: semantic properties of words are normally considered more important than their phonetic properties. Most of the Zulu words are disyllabic, trisyllabic or polysyllabic, and begin with a vowel or vowel-consonant-vowel prefix such as 'uku' or 'isi'. Almost all of the words beginning with 'uku' are verbs, and almost all of the words beginning with 'isi' are nouns. Words used as verbal stimuli in the present research were developed from verbs and nouns, such that the meaning of the word was retained. For example, from the word 'ukuhleka' (to laugh), removing 'uku' left 'hleka' (laugh) which carries the semantic properties of the source word 'ukuhleka'. Similarly, from the word 'izihlungu' (the pain), removing 'izi' (plural of 'isi') left 'nhlungu' (pain). All the words used as dichotic word stimuli in this study were disyllabic after removing the vowel or vowel-consonant-vowel prefix.

4.2. The pilot study

The pilot study served as a preliminary phase of the present research. First, it involved developing a list of disyllabic abstract, concrete and emotional words (N=120) from Zulu nouns and verbs. Second, it involved recruiting a sample of high school, college and university going male and female native Zulu-speakers (N=48) to rate each of the target words thrice: for abstractness, concreteness and emotionality. On the abstractness scale, the raters indicated whether a given target word was not abstract, slightly, moderately or highly abstract. The same rating procedure was applied with the concreteness and the emotionality scale. For the purpose of inclusion in the final lists of abstract, concrete and emotional word stimuli, the rated target words had to meet the basic inclusion requirements. To be included in the final abstract stimulus words list, a given word was required to rate higher on the abstractness scale, but lower on the concreteness and the emotionality scale. The same procedure was applied in the selection of concrete and emotional stimulus words (see also Appendix G).

The scoring of the responses given by raters involved converting rating codes to numerical ratings, and then computing mean abstractness, concreteness and emotionality ratings. The numerical ratings ranged from 0-3 (Wittling, 1990). The response option 'not abstract/concrete/emotional' was represented by 0, slightly abstract/concrete/emotional

was represented by 1, moderately abstract/concrete/emotional was represented by 2, and highly abstract/concrete and very emotional by 3. Concrete word stimuli were further rated for imageability on a scale ranging from highly nonimageable (1) to highly imageable (7) (Prior et al., 1984). The final list of 24 abstract, 24 concrete (imageable) and 24 emotional word stimuli appear in Tables 1, 2 and 3 respectively.

Observations made among the raters included the following: First, most of the raters tended to give relatively smaller ratings on the abstractness scale, while relatively larger ratings were given on the concreteness and emotionality scales. Second, some differences were observed among male and female raters. Male raters tended to give relatively larger ratings on the abstractness and concreteness scales, while female raters tended to give relatively larger ratings on the emotionality scale. Target words with a negative as opposed to positive emotional association or content were given larger ratings on the emotionality scale by these individuals. Third, concrete verbs with some emotional connotation were judged to be more highly imageable. Further rating of these word stimuli would be needed before being used with different subject populations, who may judge their semantic properties (especially abstract words) somewhat differently. This may be particularly true of individuals from a different age group or dialectical background.

Table 2. Concrete word stimuli and their mean concreteness and mean imageability ratings

Stimulus word	Concreteness (imageability) mean rating	Source word	English equivalent of the stimulus word used
hlinza	2.20 (4.50)	ukuhlinza	dissect a carcass
bamba	2.41 (5.60)	ukubamba	catch something
dlelo	2.20 (4.64)	idlelo	pasture/any open grassland
futha	2.30 (4.73)	ukufutha	pump in air
hleba	2.91 (4.90)	ukuhleba	whisper to the ear/gossip
vala	1.91 (5.41)	ukuvala	close up something
chama	2.10 (6.40)	ukuchama	pass out urine/urinate
bhema	2.04 (5.82)	ukubhema	smoke tobacco
phuza	2.14 (6.10)	ukuphuza	drink something liquid
thinta	2.73 (5.54)	ukuthinta	touch something
guga	2.00 (4.40)	isaguga	elderly person
guqa	2.04 (5.64)	ukuguqa	kneel
chitha	2.32 (5.54)	ukuchitha	spill out something
lala	2.41 (6.45)	ukulala	sleep
siza	2.41 (5.20)	ukusiza	give a hand/help someone
songa	2.54 (4.64)	ukusonga	wrap up something
jova	2.36 (5.50)	ukujova	inject
hloma	2.45 (4.40)	ukuhloma	hang up something
ndlala	2.64 (6.20)	ukundlala	lay down a flat object
thenga	2.32 (5.80)	ukuthenga	engage in transaction
bopha	2.10 (5.91)	ukubopha	tie up something
gazi	2.30 (5.04)	igazi	blood
bumba	2.20 (5.10)	ibumba	clayish soil
thutha	2.32 (5.30)	ukuthutha	transport goods/passengers

Table 3. Emotional word stimuli and their mean emotionality ratings

Stimulus word	Emotionality mean rating	Source word	English equivalent of the stimulus word used
hleka	2.00	ukuhleka	laugh
ngozi	2.23	ingozi	tragic accident/danger
nhlungu	2.70	izinhlungu	the pain
lamba	2.70	ukulamba	to be hungry
mufi	2.45	umufi	deceased/dead
minza	2.41	ukuminza	drown
dinwa	2.30	ukudinwa	to be angry
gqubu	2.20	igqubu	grudge
khonza	2.32	ukukhonza	bid goodbye
khala	2.32	ukukhala	weep/cry
bonga	2.10	ukubonga	give thanks
shona	2.14	ukushona	die/pass away
feba	2.30	ubufebe	sexual promiscuity
thuka	2.54	ukuthuka	insult/curse
jabha	2.45	ukujabha	to be sad
thanda	2.41	ukuthanda	love/like
gwaza	2.14	ukugwaza	stab
bhubha	2.80	ukubhubha	to be destroyed totally
cula	2.73	ukucula	sing
shaya	2.04	ukushaya	beat/strike something
zila	2.54	ukuzila	mourn the death
zonda	2.60	ukuzonda	hate
gula	2.70	ukugula	to be ill/sick
ngcwaba	2.50	ukungcwaba	bury a corpse

4.3. The present dichotic listening experiment

The three main objectives of the present research have already been discussed, and need not be repeated here. The present dichotic listening experiment was designed to serve as a preliminary experimental investigation of both recall memory and cerebral laterality indices of abstract, concrete and emotional stimulus Zulu words among normal dextral male and female native Zulu-speakers. It was not designed to try to replicate any of the published dichotic listening studies. Furthermore, no predictions or hypotheses could be formulated on the basis of published evidence. The reason is that none of the published experimental neuropsychological studies employed abstract, concrete and emotional stimulus Zulu words or similar stimuli in a cognate language. Also, none of the published studies on lateralized verbal stimulus processing involved native speakers of isiZulu as subjects. The present experiment addressed the following questions:

- (1) Are abstract word stimuli recalled more poorly or better than concrete word stimuli?
- (2) Are abstract word stimuli recalled more poorly or better than emotional word stimuli?
- (3) Are concrete word stimuli recalled better or more poorly than emotional word stimuli?

- (4) Does recall of abstract word stimuli yield a right ear advantage (REA) or left ear advantage (LEA)?

- (5) Does recall of concrete word stimuli yield a left ear advantage (LEA) or right ear advantage (REA)?

- (6) Does recall of emotional word stimuli yield a left ear advantage (LEA) or right ear advantage (REA)?

It was anticipated that the findings of the present dichotic listening experiment would provide some clues about recall memory and cerebral laterality indices of abstract, concrete and emotional stimulus Zulu words among dextrals. The importance of this research rests on the fact that basic knowledge of patterns of memory and cerebral laterality in verbal processing could assist in the development of further tests for assessing cerebral processing of speech among both normal and brain-damaged speakers of isiZulu.

4.4. Methodology

The present dichotic listening experiment employed the standard experimental design procedures, which included random assignment of subjects to one of the two experimental groups and counterbalancing of the order of headphone

orientation. The influences of sex and familial sinistrality were controlled for, and potential influences of handedness were eliminated by excluding sinistral individuals from the subject pool. Only four sinistral individuals participated in this experiment, but their data were excluded from the main statistical analyses. Only the dichotic recall test data for dextral subjects are discussed in this thesis.

4.4.1. Subjects

The subjects were 32 male and 30 female native Zulu-speaking dextral high school and university students aged between 16 and 27 (Mean=20.08, SD=2.67) years. The majority (94%) of the subjects lived in the province of KwaZulu Natal, and the remainder (6%) consisted of students from the provinces of the Orange Free State and the Eastern Transvaal. Most of the university going subjects were students at the University of Cape Town. All the high school going subjects were students in KwaZulu Natal schools, such as Vukile High School.

Subjects first indicated on a questionnaire whether or not they have suffered from any hearing impairments, and whether or not they had any sinistral blood relatives, such as parents or siblings. None of the subjects reported having suffered from any hearing disabilities or ear diseases. Absence of hearing deficits was confirmed by administering the subjects a monaural screening task before the beginning of the actual dichotic listening task (see section 4.4.4).

A total of 14 males and 12 females reported having sinistral blood relatives, and were then classified as FS+ subjects. A total of 18 males and 18 females did not have any sinistral blood relatives, and were then classified as FS- subjects. Subjects also indicated on a handedness inventory the hand they normally used to (1) write on paper, (2) hold a pair of scissors when using it, (3) catch a small (tennis-sized) ball, (4) hold a hammer when using it (Fennell, 1986). Analysis of their responses confirmed their dextrality, and all of them wrote their responses with the right hand during the experimental session. Subjects were given a small cash in return for participating in this experiment.

4.4.2. Design

The experiment employed a series of 2x2x2 repeated-measures and 2x2 between-subjects factorial designs (Myers, 1979). For the three-way mixed designs, the between-subjects factor was Familial sinistrality (FS+, FS-) and the within-subject factors were Ear of presentation (left, right) and Stimulus category (abstract, concrete; abstract, emotional; and concrete, emotional). The dependent variables were the mean percent recall scores for abstract, concrete and emotional word stimuli per ear of presentation. For the two-way randomized designs, the between-subjects factors were Sex (male, female) and Familial sinistrality (FS+, FS-). The dependent variables were the mean dichotic laterality index

scores and the mean Z-laterality index scores for abstract, concrete and emotional word stimuli.

4.4.3. Stimuli and Apparatus

The dichotic word stimuli were 24 abstract, 24 concrete (imageable) and 24 emotional Zulu words, which were randomly paired to form 36 dichotic stimulus word-pairs. The dichotic word stimuli were paired according to similarity in phonetic characteristics or length of utterance, regardless of whether one member of the pair was an abstract word and another a concrete or emotional word. For example, 'bamba' (concrete word) was paired with 'lamba' (emotional word) and 'phunza' (abstract word) was paired with 'minza' (emotional word). Similarly, 'ndlanzi' (abstract word) was paired with 'gazi' (concrete word).

The apparatus consisted of a stereo FOSTEX Multitracker (model X-30), an ELLIS Unidirectional Dynamic Microphone (model DM-106S), a MAICO sound-level meter (model MA 41), new TDK D60 cassette tapes, a pair of PHILIPS stereo headphones (model SBC 3150), three pairs of DIGITECH stereo headphones (model MH 110), a stereo audio cassette player (YORX model PS-3), and an amplifier split-adaptor which had previously been constructed in one of the University of Cape Town's electronic laboratories. The dichotic word stimuli were recorded into the left and the right ear track separately, and then paired and aligned for onset accuracy

using the FOSTEX Multitracker which contained a cassette tape. Recording of the dichotic word stimuli was carried out by a male native speaker of isiZulu. It was carried out inside a sound-proof booth in the Department of Logopaedics, University of Cape Town, Groote Schuur Hospital, Observatory, Cape Town. The dichotic word stimuli were read onto the ELLIS microphone which was 7cm away from the reader's mouth, and the FOSTEX Multitracker's built-in timer was used to time the reading of each dichotic pair and intervals between pairs. Dichotic stimulus word-pairs were separated from each other by an interval of 5 sec. Four original dichotic stimulus words tape-recordings were developed on separate occasions. They were judged by independent individuals for audibility and accuracy in onset and offset alignment.

The headphones were calibrated on the MAICO sound-level meter, so as to produce balanced auditory outputs. The left earphones were then marked with stickers marked "LEFT" and the right earphones with stickers marked "RIGHT" (as in Spreen & Strauss, 1991). The dichotic word stimuli were not synthesized or digitized, but were presented to the subjects as natural competing auditory (dichotic) speech stimuli.

4.4.4. Procedure

Subjects were first informed briefly about the purpose of the task and that they were to hear some Zulu words which

they had to report in writing. But they were not told that those words consisted of abstract, concrete and emotional words. They were given a standard two-page answersheet on which to write their responses to the monaural and dichotic presentations constituting the practice trials, and dichotic presentations constituting the experimental trials. Responses to practice trials were written on one side of the answersheet and responses to experimental trials on the other side of the answersheet. Three words were presented monaurally to the left ear and three to the right ear, and three dichotic word-pairs were then presented. All of the subjects performed well, and were allowed to proceed with the experimental dichotic presentation trials.

Subjects were randomly assigned to one of the two experimental groups: the Forward-Reversed (FR) and the Reversed-Forward (RF) group. Half of the male and half of the female subjects were assigned to the FR group, and half of the male and half of the female subjects to the RF group. They were tested in a quiet room, individually or in small groups of two or three (as in Eling et al., 1981). For those who were tested in groups of two or three, each subject was seated at a desk about 2m away from others. Subjects in the FR group participated in the first half of the experiment (channel A) while wearing the earphone marked RIGHT on the right ear and the earphone marked LEFT on the left ear. By contrast, those in the RF group participated in the first half of the experiment while wearing the earphone marked

LEFT on the right ear, and the earphone marked RIGHT on the left ear. They were presented with 12 experimental trials, each of which was made up of 3 dichotic stimulus word-pairs. Each of these trials was made up of one abstract, one concrete and one emotional stimulus word per ear of presentation. The dichotic word stimuli were presented to the ears of the subject via a pair of DIGITECH stereo headphones connected to the amplifier split-adapter, which was in turn plugged into the appropriate outlet on the YORX stereo cassette tape-player from which the stimuli were played. The three dichotic stimulus word-pairs constituting an experimental trial were separated from each other by an interval of 5 sec. The word stimuli were presented at a sound intensity of 65 dB SPL (as in Piazza, 1980).

The auditory output of the word stimuli was monitored by the experimenter who was wearing a pair of PHILIPS stereo headphones connected to the YORX cassette tape-player via an amplifier split-adapter, throughout a given testing session. He stopped the cassette tape-player temporarily at the end of each experimental trial, during which time the subjects wrote their responses on the answersheet. They were given sufficient time (20-50 sec) to respond at the end of each trial. At the end of the first half of the experiment, subjects were allowed a short break of 180 sec. During this time they were asked to take off the headphones in order to allow their ears to get some relaxation.

Subjects in the Forward-Reversed group participated in the second half of the experiment (channel B) while wearing the earphone marked RIGHT on the left ear, and the earphone marked LEFT on the right ear. By contrast, subjects in the Reversed-Forward group participated in the second half of the experiment while wearing the earphone marked RIGHT on the right ear, and the earphone marked LEFT on the left ear. This kind of counterbalancing of earphone orientation has been employed widely, as indicated in numerous published dichotic listening studies (Piazza, 1980; Wexler et al., 1992). The presentation of the dichotic word stimuli during the second half of the experiment was exactly the same as that in the first half of the experiment. Subjects wrote their responses after the end of each experimental trial as they did in the first half of the experiment. The duration of the experimental session was approximately 25 min.

4.4.5. Scoring of the subjects' responses

Responses of subjects who were randomly assigned to the FR experimental group were scored according to the datasheet in Table 4, and those of subjects in the RF experimental group according to the datasheet in Table 5. Each of the correctly reported dichotic word stimuli received 1 credit. The obtained credits were summed up per ear track to yield recall scores for the left and the right ear-presented abstract, concrete and emotional word stimuli. The highest

Table 4. Responses of subjects in the Forward-Reversed (FR) experimental group were scored on this datasheet. (Abstract word stimuli appear in *italic*, concrete word stimuli in **bold**, and emotional word stimuli in uppercase letters).

Trial	Left-ear word stimuli	Right-ear word stimuli
Channel A		
1.	<i>guqa mvunge</i> THANDA	<i>guga ndlondlo</i> JABHA
2.	songa FEBA <i>njinga</i>	<i>thenga HLEKA</i> <i>nginga</i>
3.	KHALA bamba <i>lembe</i>	<i>lala LAMBA</i> <i>mfumbe</i>
4.	bumba <i>mfumfu</i> ZONDA	phuza DINWA <i>mbodla</i>
5.	<i>njongo</i> BONGA ndlala	<i>ndondo</i> vala SHAYA
6.	ZILA thutha <i>nkambo</i>	jova BHUBHA <i>khamo</i>
Channel B		
7.	MINZA hleba <i>ngcwenga</i>	<i>phunza</i> bopha NGCWABA
8.	MUFI dlelo <i>nkuna</i>	NGOZI siza <i>lunda</i>
9.	<i>nkasa</i> KHONZA hloma	<i>liba</i> SHONA bhena
10.	gazi GULA <i>futho</i>	<i>ndlanzi</i> CULA futha
11.	chitha NHLUNGU <i>mopho</i>	chama GQUBU <i>mongo</i>
12.	THUKA <i>nhlonhlo</i> hlinza	GWAZA <i>dladla</i> thinta
Recall scores Laterality index scores		
Abstract words:	LE_____ RE_____	$100(RE-LE)/(RE+LE)=$ _____
Concrete words:	LE_____ RE_____	$100(RE-LE)/(RE+LE)=$ _____
Emotional words:	LE_____ RE_____	$100(RE-LE)/(RE+LE)=$ _____
Date.....	Subj code.....	Sex: M F Age....
Fam sinistrality:	FS+ FS-	Institution.....

Table 5. Responses of subjects in the Reversed-Forward (RF) experimental group were scored on this datasheet. (Abstract word stimuli appear in *italic*, concrete word stimuli in **bold**, and emotional word stimuli in uppercase letters).

Trial Left-ear word stimuli Right-ear word stimuli

Channel A

1.	<i>guga</i> <i>ndlondlo</i> JABHA	<i>guga</i> <i>mvunge</i> THANDA
2.	thenga HLEKA <i>nginga</i>	songa FEBA <i>njinga</i>
3.	<i>lala</i> LAMBA <i>mfumbe</i>	KHALA bamba <i>lembe</i>
4.	phuza DINWA <i>mbodla</i>	bumba <i>mfumfu</i> ZONDA
5.	<i>ndondo</i> VALA shaya	<i>njongo</i> BONGA ndlala
6.	jova BHUBHA <i>khamo</i>	ZILA thutha <i>nkambo</i>

Channel B

7.	<i>phunza</i> bopha NGCWABA	MINZA <i>hleba</i> <i>ngcwenga</i>
8.	NGOZI siza <i>lunda</i>	MUFI <i>dlelo</i> <i>nkuna</i>
9.	<i>liba</i> SHONA bhema	<i>nkasa</i> KHONZA hloma
10.	<i>ndlanzi</i> CULA futha	gazi GULA <i>futho</i>
11.	chama GQUBU <i>mongo</i>	chitha NHLUNGU <i>mopho</i>
12.	GWAZA <i>dladla</i> thinta	THUKA <i>nhlonhlo</i> hlinza

Recall scores Laterality index scores

Abstract words: LE_____ RE_____ 100(RE-LE)/RE+LE=_____

Concrete words: LE_____ RE_____ 100(RE-LE)/RE+LE=_____

Emotional words: LE_____ RE_____ 100(RE-LE)/RE+LE=_____

Date..... Subj code..... Sex: M F Age....

Fam sinistrality: FS+ FS- Institution.....

possible recall score per ear track was 12 for abstract word stimuli, 12 for concrete word stimuli, 12 for emotional word stimuli, and 36 for the word stimuli combined. The highest possible recall score for all the dichotic word stimuli combined across ear of presentation was 72, and 24 for each stimulus word category across ear of presentation.

From recall scores for abstract, concrete and emotional word stimuli, dichotic laterality index scores were computed by using the formula: $RE-LE(100)/(RE+LE)$. As discussed in chapter 1, RE represents the recall scores for dichotic word stimuli presented to the right ear, and LE the recall scores for dichotic word stimuli presented to the left ear. A negative dichotic laterality index score was regarded as an indicator of a left ear advantage (LEA), and a positive dichotic laterality index score as an indicator of a right ear advantage (REA) (Hugdahl & Andersson, 1989). From these dichotic laterality index scores, Z-laterality index scores were computed using the Z-value formula: $Z=(DLS-Mean)/SD$, where DLS represents a given dichotic laterality index score, Mean the sample mean, and SD the sample standard deviation score. The rationale for computing Z-laterality index scores was to determine the percent distribution of subjects who exhibited significantly larger ear advantages (see Prior et al., 1984).

The recall scores were then converted to percentage recall scores. For example, a recall score of 9 for concrete word stimuli presented to the left ear was converted to 75

percent recall score for left ear-presented concrete word stimuli. Average recall scores for dichotic word stimuli across ear of presentation were also converted to average percent recall scores.

4.4.6. Statistical analyses of data

The recall and laterality index score data were analyzed statistically using a series of three-way and two-way Analysis of Variance (ANOVA) tests. For the first, second and third research questions, mean percent recall scores for abstract, concrete and emotional word stimuli served as the dependent measures of recall memory for these word stimuli. For the fourth, fifth and sixth research questions, mean dichotic laterality and mean Z-laterality index scores for abstract, concrete and emotional word stimuli served as the dependent measures of lateralized cerebral processing of these word stimuli. The statistical data analyses were carried out on MINITAB and PSYCHOSTATS statistical programs. All of the significant two-way and three-way interaction effects were analyzed on PSYCHOSTATS statistical program. A series of descriptive and inferential statistical analyses were performed as part of the preliminary data analyses (see Appendices A to F). In the inferential statistical analysis, a series of two-way ANOVA tests were used, with Experimental group, Sex, Familial sinistrality, and Educational institution as the between-subjects factors.

As part of the preliminary inferential data analyses, the recall and laterality index score data for subjects assigned to the FR group were compared to those of subjects assigned to the RF group. There was virtually no difference between subjects in the two experimental groups on all the dependent measures, as indicated by the main effect of 'Group' and interaction effects involving 'Group' which failed to reach the conventional level of statistical significance ($p > 0.05$). Finally, additional statistical data analyses were performed on both percentage recall score and Z-laterality index score data for abstract, concrete and emotional word stimuli for FS+ subjects with male sinistral blood relatives, such as a father or a brother, versus FS+ subjects with female sinistral blood relatives, namely a sister (see Chapter 6).

CHAPTER 5

RESULTS OF THE PRESENT DICHOTIC LISTENING EXPERIMENT

The present dichotic listening experiment investigated dichotic recall memory and cerebral laterality indices of abstract, concrete and emotional Zulu stimulus words among male and female FS+ and FS- dextrals. This chapter reports the results of the series of statistical analyses of data performed on MINITAB and PSYCHOSTATS statistical programs. The results of three-way ANOVA tests performed to address Questions 1-3 are first reported, followed by the results of two-way ANOVA tests performed to address Questions 4-6. Finally, percent distribution of LEA's and REA's for abstract, concrete and emotional word stimuli is given.

5.1. Are abstract word stimuli recalled more poorly or better than concrete word stimuli?

A Familial sinistrality (FS+ vs FS-) by Ear of presentation (left vs right) by Stimulus category (abstract vs concrete) ANOVA test was performed per subject group to address this question. The dependent variables were mean percent recall scores for abstract and concrete word stimuli presented to the left and the right ear.

5.1.1. High school going male subjects

The ANOVA summary table appears below as Table 1. The main effect of Familial sinistrality was not significant ($F < 1$), as was the main effect of Ear of presentation ($p > 0.05$). The main effect of Stimulus category was highly significant ($F(1, 15) = 42.927$, $p < 0.000$), indicating that abstract word stimuli are recalled more poorly than concrete word stimuli. All the interaction effects were not significant ($p > 0.05$). Mean and standard deviation recall score data for abstract and concrete word stimuli are shown in Table 2.

Table 1. ANOVA summary table of mean recall scores for abstract vs concrete word stimuli per ear of presentation among high school male subjects

Source	DF	SS	MS	F	P
Familial sinistrality(A)	1	314.057	314.057	0.85	ns
SubWG	15	5531.891	368.793		
Ear of presentation(B)	1	205.073	205.073	2.70	ns
AB	1	78.005	78.005	1.03	ns
B*SubWG	15	1137.875	75.858		
Stimulus category(C)	1	7760.408	7760.408	42.93	0.000
AC	1	78.502	78.502	0.43	ns
C*SubWG	15	2711.719	180.781		
BC	1	401.451	401.451	3.85	ns
ABC	1	85.252	85.252	0.82	ns
BC*SubWG	15	1563.766	104.251		

Table 2. Mean (and standard deviation) recall scores for abstract vs concrete word stimuli for high school males

	Abstract words		Concrete words	
	Left ear Mean score	Right ear Mean score	Left ear Mean score	Right ear Mean score
FS+	25.00(21.23)	33.25(18.47)	46.87(11.84)	49.87 (9.80)
FS-	18.44 (9.17)	26.89(13.05)	49.11 (6.25)	43.33(13.22)

5.1.2. University going male subjects

The ANOVA summary table appears overleaf as Table 3. The main effect of Familial sinistrality was not significant ($F < 1$), as also the main effect of Ear of presentation ($F < 1$). The main effect of Stimulus category was highly significant ($F(1, 13) = 154.672, p < 0.000$), indicating that abstract word stimuli are recalled significantly more poorly than concrete word stimuli. The Familial sinistrality by Stimulus category interaction effect was significant ($F(1, 13) = 9.768, p < 0.01$), but all the other interaction effects were not statistically significant ($p > 0.05$). Analysis of the Familial sinistrality by Stimulus category interaction effect revealed a statistically significant simple effect of Familial sinistrality on recall of both abstract and concrete word stimuli ($F(1, 13) = 15.005, p < 0.005$ and $F(1, 13) = 6.068, p < 0.05$). The simple effect of Stimulus category was

significant in FS+ subjects ($F(1, 13)=831.833, p<0.000$), as well as in FS- subjects ($F(1, 13)=752.488, p<0.000$). Mean and standard deviation recall score data appear in Table 4.

Table 3. ANOVA summary table of mean recall scores for abstract vs concrete word stimuli per ear of presentation among university male subjects

Source	DF	SS	MS	F	P
Familial sinistrality(A)	1	139.373	139.373	0.45	ns
SubWG	13	4013.047	308.696		
Ear of presentation(B)	1	86.034	86.034	0.56	ns
AB	1	82.195	82.195	0.54	ns
B*SubWG	13	1977.063	152.082		
Stimulus category(C)	1	11000.280	11000.280	154.67	0.000
AC	1	6.947	6.947	9.77	0.01
C*SubWG	13	924.562	71.120		
BC	1	136.912	136.912	1.78	ns
ABC	1	84.079	84.079	1.09	ns
BC*SubWG	13	1000.328	76.948		

Table 4. Mean (and standard deviation) recall scores for abstract vs concrete word stimuli for university males

	Abstract stimuli		Concrete stimuli	
	Left ear Mean score	Right ear Mean score	Left ear Mean score	Right ear Mean score
FS+	33.33(10.59)	29.17 (8.68)	62.33(10.29)	56.83(8.11)
FS-	32.33(17.32)	37.78(15.71)	64.78(12.54)	59.22(7.79)

The simple effect of Stimulus category was significant on recall of both abstract and concrete word stimuli presented to the left ear ($F(1, 13)=978.423, p<0.000$), as well as for both abstract and concrete word stimuli presented to the right ear ($F(1, 13)=624.664, p<0.000$). The simple effect of Stimulus category was statistically significant among both FS+ and FS- subjects ($F(1, 13)=978.423$ and $545.685, p<0.000$). The simple effect of Ear of presentation was statistically significant on recall of both abstract and concrete stimuli among FS+ subjects ($F(1, 13)=8.968, p<0.025$ and $F(1, 13)=15.676, p<0.005$), as well as among FS- subjects ($F(1, 13)=15.392$ and $16.020, p<0.005$). These data indicate that overall abstract and concrete word stimuli presented to the left ear are recalled more poorly than abstract and concrete word stimuli presented to the right ear.

5.1.3. High school going female subjects

The ANOVA summary table appears overleaf as Table 5. The main effect of Familial sinistrality was statistically significant ($F(1, 21)=8.206, p<0.01$), indicating that FS+ subjects recalled significantly more abstract and concrete word stimuli than did FS- subjects. The main effect of Ear of presentation was significant ($F(1, 21)=8.143, P<0.01$), indicating that abstract and concrete word stimuli presented to the right ear are recalled significantly better than

those presented to the left ear. The main effect of Stimulus category was also significant ($F(1, 21)=42.649, p<0.000$), indicating that abstract word stimuli are recalled significantly more poorly than concrete word stimuli. Mean and standard deviation recall score data appear in Table 6.

Table 5. ANOVA summary table of mean recall scores for abstract vs concrete word stimuli per ear of presentation among high school female subjects

Source	DF	SS	MS	F	P
Familial sinistrality(A)	1	3223.373	3223.373	8.21	0.01
SubWG	21	8248.328	392.777		
Ear of presentation(B)	1	1559.658	1559.658	8.14	0.01
AB	1	16.139	16.139	8.43	0.01
B*SubWG	21	4022.266	191.536		
Stimulus category(C)	1	12483.600	12483.600	42.65	0.000
AC	1	427.446	427.446	1.46	ns
C*SubWG	21	6146.735	292.702		
BC	1	19.197	19.197	8.74	0.01
ABC	1	235.680	235.680	1.07	ns
BC*SubWG	21	4613.766	219.703		

Table 6. Mean (and standard deviation) recall scores for abstract vs concrete word stimuli for high school females

	Abstract stimuli		Concrete stimuli	
	Left ear Mean score	Right ear Mean score	Left ear Mean score	Right ear Mean score
FS+	27.60(22.37)	40.90(23.35)	50.90(14.34)	55.90(15.75)
FS-	15.38(14.39)	20.54(13.52)	40.92 (9.34)	50.69(17.81)

The Familial sinistrality by Ear of presentation interaction effect was significant ($F(1, 21)=8.426, p<0.01$). The Ear of presentation by Stimulus category interaction effect was also significant ($F(1, 21)=8.738, p<0.01$), but all the other interaction effects were not significant ($p>0.05$). Analysis of the two interaction effects revealed a significant simple effect of Familial sinistrality on recall of abstract word stimuli presented to the right ear ($F(1, 21)=12.232, p<0.005$). The simple effect of Ear of presentation was significant on recall of abstract word stimuli across ear of presentation ($F(1, 21)=5.03, p<0.05$) among FS+ subjects ($F(1, 21)=4.94, p<0.05$). The simple effect of Stimulus category was significant among both FS+ and FS- subjects ($F(1, 21)=21.64, p<0.001$ and $F(1, 21)=45.760, p<0.000$).

5.1.4. University going female subjects

The ANOVA summary table appears overleaf as Table 7. The main effect of Familial sinistrality was statistically significant ($F(1, 5)=24.18, p<0.005$), indicating that overall FS+ subjects recalled significantly more abstract and concrete word stimuli than did FS- subjects. The main effect of Ear of presentation was not significant ($p>0.05$). The main effect of Stimulus category was highly significant ($F(1, 5)=111.253, p<0.000$), indicating that abstract word stimuli are recalled significantly more poorly than concrete

word stimuli. All of the interaction effects failed to reach statistical significance ($p > 0.05$). Mean and standard deviation recall scores appear in Table 8.

Table 7. ANOVA summary table of mean recall scores for abstract vs concrete word stimuli per ear of presentation among university female subjects

Source	DF	SS	MS	F	P
Familial sinistrality(A)	1	2189.610	2189.610	24.18	0.005
SubWG	5	452.824	90.565		
Ear of presentation(B)	1	282.003	282.003	1.20	ns
AB	1	130.285	130.285	0.55	ns
B*SubWG	5	1174.426	234.885		
Stimulus category(C)	1	2835.290	2835.290	111.25	0.000
AC	1	1.289	1.289	5.06	ns
C*SubWG	5	127.426	25.485		
BC	1	88.036	88.036	1.44	ns
ABC	1	30.887	30.887	0.50	ns
BC*SubWG	5	305.824	61.165		

Table 8. Mean (and standard deviation) recall scores for abstract vs concrete word stimuli for university females

	Abstract stimuli		Concrete stimuli	
	Left ear Mean score	Right ear Mean score	Left ear Mean score	Right ear Mean score
FS+	46.00 (5.65)	42.00(0.00)	62.50(6.36)	71.00 (5.65)
FS-	19.80(15.05)	30.00(9.43)	40.00(7.17)	53.40(11.03)

5.2. Are abstract word stimuli recalled more poorly or better than emotional word stimuli?

A Familial sinistrality (FS+ vs FS-) by Ear of presentation (left vs right) by Stimulus category (abstract vs emotional) ANOVA test was performed per subject group to address this question. The dependent variables were mean percent recall scores for abstract and emotional word stimuli presented to the left and the right ear.

5.2.1. High school going male subjects

The ANOVA summary table appears overleaf as Table 9. The main effect of Familial sinistrality was not significant ($p > 0.05$). The main effect of Ear of presentation was also not significant ($p > 0.05$). The main effect of Stimulus category was however significant ($F(1, 15) = 14.515, p < 0.005$), indicating that abstract word stimuli are recalled significantly more poorly than emotional word stimuli. All of the interaction effects failed to reach statistical significance ($p > 0.05$). Mean and standard deviation recall score data for abstract and emotional word stimuli are presented in Table 10.

Table 9. ANOVA summary table of mean recall scores for abstract vs emotional word stimuli per ear of presentation among high school male subjects

Source	DF	SS	MS	F	P
Familial sinistral.(A)	1	3.573	3.573	1.27	ns
SubWG	15	4207.500	280.500		
Ear of presentat.(B)	1	355.880	355.880	2.42	ns
AB	1	113.054	113.054	0.77	ns
B*SubWG	15	2201.000	146.733		
Stimulus category(C)	1	5798.118	5798.118	14.51	0.005
AC	1	609.882	609.882	1.53	ns
C*SubWG	15	5992.000	399.467		
BC	1	240.014	240.014	2.24	ns
ABC	1	104.708	104.708	0.98	ns
BC*SubWG	15	1604.063	106.937		

Table 10. Mean (and standard deviation) recall scores for abstract vs emotional word stimuli for high school males

	Abstract words		Emotional words	
	Left ear Mean score	Right ear Mean score	Left ear Mean score	Right ear Mean score
FS+	25.00(21.23)	33.25(18.47)	43.75(10.65)	39.50(14.51)
FS-	18.44 (9.17)	26.89(13.05)	44.22(13.15)	50.11(18.62)

5.2.2. University going male subjects

The ANOVA summary table appears below as Table 11. The main effect of Familial sinistrality was not significant ($p > 0.05$), as was the main effect of Ear of presentation ($F < 1$). The main effect of Stimulus category was however significant ($F(1, 13) = 29.01, p < 0.001$), indicating that abstract word stimuli are recalled more poorly than emotional word stimuli. None of the interaction effects were significant ($F < 1$). Mean and standard deviation recall scores for abstract and emotional word stimuli appear in Table 12.

Table 11. ANOVA summary table of mean recall scores for abstract vs emotional word stimuli per ear of presentation among university male subjects

Source	DF	SS	MS	F	P
Familial sinistral.(A)	1	487.673	487.673	1.37	ns
SubWG	13	4637.266	356.713		
Ear of presentat.(B)	1	38.025	38.025	0.18	ns
AB	1	119.025	119.025	0.58	ns
B*SubWG	13	2638.375	202.952		
Stimulus category(C)	1	6511.015	6511.015	29.01	0.001
AC	1	58.394	58.394	0.26	
C*SubWG	13	2917.930	224.456		
BC	1	13.999	13.999	0.14	ns
ABC	1	53.669	53.669	0.53	ns
BC*SubWG	13	1319.930	101.533		

Table 12. Mean (and standard deviation) recall scores for abstract vs emotional word stimuli for university males

	Abstract words		Emotional words	
	Left ear Mean score	Right ear Mean score	Left ear Mean score	Right ear Mean score
FS+	33.33(10.59)	29.17 (8.68)	49.67(18.86)	51.33(12.32)
FS-	32.33(17.32)	37.78(15.71)	56.55(14.14)	60.11(16.05)

5.2.3. High school going female subjects

The ANOVA summary table appears overleaf as Table 13. The main effect of Familial sinistrality was not significant ($p > 0.05$). The main effect of Ear of presentation was also not significant ($p > 0.05$). The main effect of Stimulus category was highly significant ($F(1, 21) = 127.507, p < 0.000$), indicating that abstract word stimuli are recalled more poorly than emotional word stimuli. The Familial sinistrality by Stimulus category interaction effect was statistically significant ($F(1, 21) = 10.059, p < 0.005$), but all the other interaction effects were not significant ($p > 0.05$). Analysis of the Familial sinistrality by Stimulus category interaction revealed a significant simple effect of Familial sinistrality on recall of abstract and concrete word stimuli across ear of presentation ($F(1, 21) = 6.589, p < 0.025$ and $F(1, 21) = 8.707, p < 0.01$).

The simple effect of Familial sinistrality was significant on recall of abstract word stimuli ($F(1, 21)=25.019$, $p<0.001$) presented to both ears ($F(1, 21)=7.039$ and 6.127 , $p<0.025$). The simple effect of Ear of presentation was statistically significant on recall of abstract word stimuli ($F(1, 21)=8.032$, $p<0.025$), particularly among FS+ subjects ($F(1, 21)=8.338$, $p<0.01$). The simple effect of Stimulus category was statistically significant among FS+ subjects ($F(1, 21)=32.969$, $p<0.001$) as well as among FS- subjects ($F(1, 21)=104.612$, $p<0.000$). Mean and standard deviation recall score data for abstract and emotional word stimuli are presented in Table 14.

Table 13. ANOVA summary table of mean recall scores for abstract vs emotional word stimuli per ear of presentation among high school female subjects

Source	DF	SS	MS	F	P
Familial sinistral.(A)	1	1825.056	1825.056	2.72	ns
SubWG	21	14096.910	671.281		
Ear of presentat.(B)	1	947.335	947.335	3.49	ns
AB	1	8.875	8.875	0.03	ns
B*SubWG	21	5699.594	271.409		
Stimulus category(C)	1	15288.010	15288.010	127.51	0.000
AC	1	1206.099	1206.099	10.06	0.005
C*SubWG	21	2517.875	119.898		
BC	1	171.453	171.453	0.84	ns
ABC	1	268.500	268.500	1.29	ns
BC*SubWG	21	4357.375	207.494		

Table 14. Mean (and standard deviation) recall scores for abstract vs emotional word stimuli for high school females

	Abstract words		Emotional words	
	Left ear Mean score	Right ear Mean score	Left ear Mean score	Right ear Mean score
FS+	27.60(22.36)	40.90(23.35)	52.50(15.16)	53.40(23.26)
FS-	15.38(14.39)	20.54(13.52)	48.00(14.93)	54.54(15.73)

5.2.4. University going female subjects

The ANOVA summary table appears overleaf as Table 15. The main effect of Familial sinistrality was not significant, as was the main effect of Ear of presentation ($F < 1$). The main effect of Stimulus category was significant ($F(1, 5) = 69.106$, $p < 0.001$), indicating that abstract word stimuli are recalled significantly more poorly than emotional word stimuli. The Familial sinistrality by Stimulus category interaction effect was significant ($F(1, 5) = 34.150$, $p < 0.005$), but all the other interaction effects were not significant ($p > 0.05$). Analysis of the Familial sinistrality by Stimulus category interaction effect revealed a statistically significant simple effect of Familial sinistrality on recall of both abstract and emotional word stimuli across ear of presentation ($F(1, 5) = 30.892$, $p < 0.005$ and $F(1, 5) = 7.324$,

p<0.05). Mean and standard deviation recall score data for abstract and emotional word stimuli appear in Table 16.

Table 15. ANOVA summary table of mean recall scores for abstract vs emotional word stimuli per ear of presentation among university female subjects

Source	DF	SS	MS	F	P
Familial sinistral.(A)	1	137.201	137.201	0.52	ns
SubWG	5	1323.301	264.660		
Ear of presentat.(B)	1	74.057	74.057	0.53	ns
AB	1	179.202	179.202	1.28	ns
B*SubWG	5	698.301	139.660		
Stimulus category(C)	1	2331.658	2331.658	69.11	0.001
AC	1	1152.229	1152.229	34.15	0.005
C*SubWG	5	168.699	33.739		
BC	1	1.434	1.434	3.03	ns
ABC	1	12.851	12.851	0.27	ns
BC*SubWG	5	236.496	47.299		

Table 16. Mean (and standard deviation) recall data for abstract vs emotional word stimuli for university females

	Abstract words		Emotional words	
	Left ear Mean score	Right ear Mean score	Left ear Mean score	Right ear Mean score
FS+	46.00 (5.65)	42.00(0.00)	50.00(11.31)	50.00(0.00)
FS-	19.80(15.05)	30.00(9.43)	55.20(12.60)	63.40(9.61)

The simple effect of Ear of presentation was statistically significant among FS- subjects ($F(1, 5)=7.167, p<0.05$). The simple effect of Stimulus category was significant on recall of both abstract and emotional word stimuli across ear of presentation ($F(1, 5)=53.059$ and $47.234, p<0.001$). This simple effect of Stimulus category was more pronounced among FS- subjects ($F(1, 5)=100.209, p<0.000$). These data indicate that emotional word stimuli are recalled better than abstract word stimuli across ear of presentation.

5.3. Are concrete word stimuli recalled better or more poorly than emotional word stimuli?

A Familial sinistrality (FS+ vs FS-) by Ear of presentation (left vs right) by Stimulus category (concrete vs emotional) ANOVA test was performed per subject group to address this question. The dependent variables were mean percent recall scores for concrete and emotional word stimuli presented to the left and the right ear.

5.3.1. High school going male subjects

The ANOVA summary table appears overleaf as Table 17. The main effect of Familial sinistrality was not significant ($F<1$), as was the main effect of Ear of presentation

($p > 0.05$). The main effect of Stimulus category not significant either ($p > 0.05$). All of the interaction effects failed to reach statistical significance ($p > 0.05$). Mean and standard deviation recall scores are presented in Table 18.

Table 17. ANOVA summary table of mean recall scores for concrete vs emotional word stimuli per ear of presentation among high school male subjects

Source	DF	SS	MS	F	P
Familial sinistral.(A)	1	48.623	48.623	0.02	ns
SubWG	15	4284.891	285.659		
Ear of presentat.(B)	1	1.373	1.373	1.19	ns
AB	1	1.952	1.952	1.70	ns
B*SubWG	15	1717.094	114.473		
Stimulus category(C)	1	142.726	142.726	1.23	ns
AC	1	250.776	250.776	2.16	ns
C*SubWG	15	1738.719	115.915		
BC	1	20.671	20.671	0.15	ns
ABC	1	378.910	378.910	2.77	ns
BC*SubWG	15	2047.891	136.526		

Table 18. Mean (and standard deviation) recall scores for concrete vs emotional word stimuli for high school males

	Concrete words		Emotional words	
	Left ear Mean score	Right ear Mean score	Left ear Mean score	Right ear Mean score
FS+	46.87(11.84)	49.87 (9.80)	43.75(10.65)	39.50(14.51)
FS-	49.11 (6.25)	43.33(13.22)	44.22(13.15)	50.11(18.62)

5.3.2. University going male subjects

The ANOVA summary table appears below as Table 19. The main effect of Familial sinistrality was not significant ($p > 0.05$). The main effect of Ear of presentation was also not significant ($F < 1$). The main effect of Stimulus category was not significant either ($p > 0.05$). All of the interaction effects were not significant ($p > 0.05$). Mean and standard deviation recall score data for concrete and emotional word stimuli are shown in Table 20.

Table 19. ANOVA summary table of mean recall scores for concrete vs emotional word stimuli per ear of presentation among university male subjects

Source	DF	SS	MS	F	P
Familial sinistral.(A)	1	378.197	378.197	1.71	ns
SubWG	13	2879.719	221.517		
Ear of presentat.(B)	1	30.600	30.600	0.15	ns
AB	1	3.065	3.065	1.55	ns
B*SubWG	13	2557.703	196.746		
Stimulus category(C)	1	585.211	585.211	3.41	ns
AC	1	105.652	105.652	0.62	ns
C*SubWG	13	2230.703	171.593		
BC	1	238.500	238.500	2.74	ns
ABC	1	3.361	3.361	0.04	ns
BC*SubWG	13	1132.938	87.149		

Table 20. Mean (and standard deviation) recall scores for concrete vs emotional word stimuli for university males

	Concrete words		Emotional words	
	Left ear Mean score	Right ear Mean score	Left ear Mean score	Right ear Mean score
FS+	62.33(10.29)	56.83(8.11)	49.67(18.64)	51.33(12.32)
FS-	64.78(12.54)	59.22(7.79)	56.55(14.14)	60.11(16.05)

5.3.3. High school going female subjects

The ANOVA summary table appears overleaf as Table 21. The main effect of Familial sinistrality was not significant, as was the main effect of Ear of presentation ($p > 0.05$). The main effect of Stimulus category was not significant ($F < 1$). The Familial sinistrality by Ear of presentation by Stimulus category interaction effect was statistically significant ($F(1, 21) = 5.093, p < 0.05$), but all the other interaction effects were not significant ($p > 0.05$). Analysis of the Familial sinistrality by Ear of presentation by Stimulus category interaction effect only revealed that emotional word stimuli presented to the left ear are recalled significantly better than concrete word stimuli presented to the left ear ($F(1, 21) = 7.584, p < 0.025$). Mean and standard deviation recall score data are presented in Table 22.

Table 21. ANOVA summary table of mean recall scores for concrete vs emotional word stimuli per ear of presentation among high school female subjects

Source	DF	SS	MS	F	P
Familial sinistral.(A)	1	485.998	485.998	1.38	ns
SubWG	21	7392.438	352.021		
Ear of presentat.(B)	1	696.829	696.829	2.80	ns
AB	1	153.116	153.116	0.61	ns
B*SubWG	21	5225.438	248.830		
Stimulus category(C)	1	141.900	141.900	0.61	ns
AC	1	197.583	197.583	0.85	ns
C*SubWG	21	4895.969	233.141		
BC	1	76.017	76.017	0.39	ns
ABC	1	0.971	0.971	5.09	0.05
BC*SubWG	21	4005.781	190.751		

Table 22. Mean (and standard deviation) recall scores for concrete vs emotional word stimuli for high school females

	Concrete words		Emotional words	
	Left ear Mean score	Right ear Mean score	Left ear Mean score	Right ear Mean score
FS+	50.90(14.34)	55.90(15.75)	52.50(15.16)	53.40(23.26)
FS-	40.92(19.34)	50.69(17.81)	48.00(14.93)	54.53(15.73)

5.3.4. University going female subjects

The ANOVA summary table appears below as Table 23. The main effect of Familial sinistrality was not significant, as was the main effect of Ear of presentation ($p > 0.05$). The main effect of Stimulus category was not significant ($F < 1$). The Familial sinistrality by Stimulus category interaction effect was however significant ($F(1, 5) = 14.604$, $p < 0.025$), but all the other interaction effects were not significant ($p > 0.05$). Mean and standard deviation recall score data for concrete and emotional word stimuli appear in Table 24.

Table 23. ANOVA summary table for mean recall scores for concrete vs emotional word stimuli per ear of presentation for university subjects

Source	DF	SS	MS	F	P
Familial sinistral.(A)	1	165.089	165.089	1.22	ns
SubWG	5	674.125	134.825		
Ear of presentat.(B)	1	323.571	323.571	2.52	ns
AB	1	61.295	61.295	0.48	ns
B*SubWG	5	642.922	128.584		
Stimulus category(C)	1	24.598	24.598	0.29	ns
AC	1	1230.614	1230.614	14.60	0.025
C*SubWG	5	421.328	84.265		
BC	1	67.042	67.042	2.10	ns
ABC	1	3.873	3.873	0.12	ns
BC*SubWG	5	159.328	159.328		

Table 24. Mean (and standard deviation) recall scores for concrete vs emotional word stimuli for university females

	Concrete words		Emotional words	
	Left ear Mean score	Right ear Mean score	Left ear Mean score	Right ear Mean score
FS+	62.50(6.36)	71.00 (5.65)	50.00(11.31)	50.00(0.00)
FS-	40.00(7.17)	53.40(11.04)	55.20(12.60)	63.40(9.61)

Analysis of the Familial sinistrality by Stimulus category interaction effect revealed a significant simple effect of Ear of presentation on recall of concrete word stimuli in FS+ subjects ($F(1, 5)=8.387, p<0.05$). The simple effect of Ear of presentation was significant on recall of emotional word stimuli in FS- subjects ($F(1, 5)=7.805, p<0.05$). These data indicate that FS+ subjects recalled more concrete word stimuli presented to the right than the left ear. By contrast, FS- subjects recalled more emotional word stimuli presented to the right than the left ear.

5.4. Does recall of abstract word stimuli yield a right ear advantage (REA) or left ear advantage (LEA)?

Two Sex (male, female) by Familial sinistrality (FS+, FS-) ANOVA tests were performed to address this question. The dependent variables were the mean dichotic laterality and

index scores and the mean Z-laterality indices for abstract word stimuli. The ANOVA test results are presented in a summary form in Table 25 and Table 26 below.

Table 25. ANOVA results of dichotic laterality index scores for abstract word stimuli

Variable	Mean	StDev	DF	F	P
Sex:			1/58	0.02	0.891
Males	6.07	5.03			
Females	7.07	5.26			
Familial sinistrality:			1/58	0.33	0.565
FS+	4.46	5.55			
FS-	8.67	4.70			
Sex*Familial sinistrality:			1/58	2.72	0.104
FS+ Males	-2.04	7.54			
FS- Males	14.17	6.65			
FS+ Females	10.97	8.14			
FS- Females	3.17	6.65			

Table 26. ANOVA test results of Z-laterality indices for abstract word stimuli

Variable	Mean	StDev	DF	F	P
Sex:			1/58	0.04	0.851
Males	-0.14	1.02			
Females	0.14	1.07			
Familial sinistrality:			1/58	0.00	0.994
FS+	-0.01	1.13			
FS-	0.00	0.95			
Sex*Familial sinistrality:			1/58	3.13	0.082
FS+ Males	-1.46	1.53			
FS- Males	1.17	1.35			
FS+ Females	1.44	1.65			
FS- Females	-1.17	1.35			

On both ANOVA tests, the main effect of Sex was not significant ($F < 1$), as was the main effect of Familial sinistrality ($F < 1$). All of the interaction effects were not significant ($p > 0.05$). The answer to the fourth research question is as follows. The ANOVA test using mean laterality index scores as the dependent measures shows that both males and females exhibit an REA for abstract word stimuli, as do both FS+ and FS- subjects across sex group. This test shows that the REA exhibited by males and FS+ subjects is smaller than the REA exhibited by females and FS- subjects. By contrast, the ANOVA test employing the mean Z-laterality indices as the dependent measures shows that males and FS+ subjects exhibit an LEA, while females exhibit an REA. As a group, FS- subjects exhibit a no ear advantage (NEA).

5.5. Does recall of concrete word stimuli yield a left ear advantage (LEA) or right ear advantage?

Two Sex (male, female) by Familial sinistrality (FS+, FS-) ANOVA tests were performed to address this question. The dependent variables were the mean dichotic laterality index scores and the mean Z-laterality indices for concrete word stimuli. The ANOVA test results are presented in a summary form in Table 27 and Table 28 overleaf. On both tests, the main effect of Sex was significant ($F(1, 58) = 6.06, p = 0.017$

and $F(1, 58)=6.16, p=0.016$), indicating that males exhibited a larger LEA, while females exhibited a larger REA.

Table 27. ANOVA results of dichotic laterality index scores for concrete word stimuli

Variable	Mean	StDev	DF	F	P
Sex:			1/58	6.06	0.017
Males	-3.36	2.90			
Females	6.98	3.04			
Familial sinistrality:			1/58	0.00	0.956
FS+	1.92	3.20			
FS-	1.69	2.71			
Sex*Familial sinistrality:			1/58	1.25	0.269
FS+ Males	-0.90	4.35			
FS- Males	-5.82	3.84			
FS+ Females	4.75	4.70			
FS- Females	9.21	3.84			

Table 28. ANOVA test results of Z-laterality indices for concrete word stimuli

Variable	Mean	StDev	DF	F	P
Sex:			1/58	6.16	0.016
Males	-1.82	1.01			
Females	1.80	1.05			
Familial sinistrality:			1/58	0.00	0.989
FS+	-0.00	1.11			
FS-	-0.02	0.94			
Sex*Familial sinistrality:			1/58	1.64	0.206
FS+ Males	-0.88	1.51			
FS- Males	-2.77	1.33			
FS+ Females	0.87	1.63			
FS- Females	2.72	1.33			

On both ANOVA tests, the main effect of Familial sinistrality was not significant ($F=0$), and all of the interaction effects failed to reach statistical significance ($p>0.05$). The answer to the fifth research questions is as follows. Male subjects as a group consistently exhibit an LEA for concrete word stimuli. On the other hand, female subjects as a group consistently exhibit an REA for concrete word stimuli. The ANOVA test employing mean dichotic laterality indices as the dependent measures shows that on average both FS+ and FS- subjects exhibit an REA for concrete word stimuli. By contrast, the ANOVA test using mean Z-laterality indices as the dependent measures shows that on average both FS+ and FS- subjects exhibit an LEA for concrete word stimuli. In the former test the overall REA is due to the larger REA among females, and in the latter test the overall LEA is due to the larger LEA among males.

5.6. Does recall of emotional word stimuli yield a left ear advantage (LEA) or right ear advantage (REA)?

Two Sex (male, female) by Familial sinistrality (FS+, FS-) ANOVA tests were performed to address this question. The dependent variables were the mean dichotic laterality index scores and the mean Z-laterality indices for emotional word

stimuli. The ANOVA test results are presented in a summary form in Table 29 and Table 30 below.

Table 29. ANOVA results of dichotic laterality index scores for emotional word stimuli

Variable	Mean	StDev	DF	F	P
Sex:			1/58	0.44	0.510
Males	-0.25	3.55			
Females	2.86	3.72			
Familial sinistrality:			1/58	1.84	0.180
FS+	-2.18	3.92			
FS-	4.80	3.33			
Sex*Familial sinistrality:			1/58	0.00	0.980
FS+ Males	-3.68	5.33			
FS- Males	3.18	4.70			
FS+ Females	-0.69	5.76			
FS- Females	6.42	4.70			

Table 30. ANOVA test results of Z-laterality indices for emotional word stimuli

Variable	Mean	StDev	DF	F	P
Sex:			1/58	0.12	0.733
Males	-0.23	0.98			
Females	0.25	1.02			
Familial sinistrality:			1/58	0.01	0.917
FS+	-0.06	1.08			
FS-	0.08	0.92			
Sex*Familial sinistrality:			1/58	0.05	0.829
FS+ Males	-0.46	1.47			
FS- Males	-0.00	1.29			
FS+ Females	0.33	1.58			
FS- Females	0.17	1.29			

On both ANOVA tests the main effect of Sex was not significant ($F < 1$), as was the main effect of Familial sinistrality ($p > 0.05$), and the interaction effects failed to reach statistical significance ($F < 1$) on both ANOVA tests. The answer to the sixth research questions is as follows. Male subjects as a group exhibit an LEA for emotional word stimuli, as do FS+ subjects as a group. By contrast, females as a group exhibit an REA for emotional word stimuli, as do FS- males as a group when separated from FS+ males.

5.7. Summary of the present results

The present recall score data show that abstract word stimuli are recalled significantly more poorly than concrete and emotional word stimuli across ear of presentation. These data show that no significant difference exists between recall of concrete word stimuli and recall of emotional word stimuli overall. They also show that among high school and university going females, FS+ individuals recalled significantly more abstract and concrete word stimuli than did FS- individuals. On average, female subjects recalled more abstract, concrete and emotional word stimuli presented to the right than the left ear, while male subjects recalled more abstract, concrete and emotional word stimuli presented to the left than the right ear. The present laterality index score data show that recall of abstract word stimuli yields

a general REA, with females exhibiting a slightly stronger REA compared with the REA exhibited by males.

Table 31. Percent distribution of LEA's and REA's among male and female FS+ subjects per stimulus word category

Stimulus word category	FS+ Males		FS+ Females	
	LEA	REA	LEA	REA
Abstract	10(71%)	4(29%)	5(42%)	7(58%)
Concrete	9(64%)	5(36%)	5(42%)	7(58%)
Emotional	9(64%)	5(36%)	4(33%)	8(67%)

Table 32. Percent distribution of LEA's and REA's among male and female FS- subjects per stimulus word category

Stimulus word category	FS- Males		FS- Females	
	LEA	REA	LEA	REA
Abstract	6(33%)	12(67%)	13(72%)	5(28%)
Concrete	15(83%)	3(17%)	8(44%)	10(56%)
Emotional	5(28%)	13(72%)	8(44%)	10(56%)

These data show that recall of concrete word stimuli yields a larger LEA among males and a larger REA among females. They also show that recall of emotional word stimuli yields an LEA among males as a group, but that FS- males exhibit a smaller REA. Among females as a group, recall of emotional word stimuli yields a larger REA. FS+ females show a smaller LEA on recall of emotional word stimuli as determined by their mean dichotic laterality index score but not by their mean Z-laterality index scores. Percent distribution of left ear advantages and right ear advantages for FS+ and FS- subjects appear in Tables 31 and 32 respectively.

Data presented in Table 31 indicate that the majority of FS+ males exhibit a consistent LEA for both abstract, concrete and emotional word stimuli. By contrast, the majority of FS+ females exhibit a consistent REA for both abstract, concrete and emotional word stimuli. Data presented in Table 32 indicate that the majority of FS- males exhibit an REA for abstract and emotional word stimuli, while most of them exhibit an LEA for concrete word stimuli. Data for FS- females show a different picture. The majority of FS- exhibit an REA for concrete and emotional word stimuli, but an LEA for abstract word stimuli. Most of them were high school going FS- females, while most of those who exhibited an REA were university going FS- females. The main effect of Institution and the Sex by Institution interaction effect were not significant on their mean laterality index scores (Tables 7-9, Appendix D).

CHAPTER 6

DISCUSSION OF THE PRESENT FINDINGS

The present dichotic listening experiment investigated recall memory and cerebral laterality indices of abstract, concrete and emotional Zulu word stimuli among Zulu-speaking male and female dextrals, consisting of individuals with sinistral blood relatives (FS+) and individuals with no sinistral blood relatives (FS-). The main findings of the present experiment are as follows: (1) Abstract word stimuli are recalled significantly more poorly than both concrete and emotional word stimuli, (2) no difference exists between recall of concrete word stimuli and that of emotional word stimuli overall, (3) recall of abstract word stimuli yields a general right ear advantage (REA), (4) recall of concrete word stimuli yields a significantly larger left ear advantage (LEA) among males, while among females it yields a significantly larger REA, (5) among males recall of emotional word stimuli yields an LEA overall, while among females it yields an REA overall, (6) female FS+ subjects appear to possess better recall memory abilities than female FS- subjects for both abstract and concrete but not emotional word stimuli across ear of presentation, (7) FS+ subjects with a male sinistral relative (such as a father or brother) appear to possess better recall memory abilities

for abstract, concrete and emotional word stimuli compared with FS+ subjects with a female sinistral relatives, namely a sister, (8) males exhibit a higher incidence of an LEA across stimulus word category, while females exhibit a higher incidence of an REA across stimulus word category. This chapter discusses the observed recall memory and cerebral laterality index score data and their implications.

6.1. Recall of abstract vs concrete word stimuli

The present finding of superior recall of concrete word stimuli compared with that of abstract word stimuli could be interpreted in terms of the concreteness effect hypothesis (Eviatar et al., 1988). In terms of this hypothesis it could be argued that subjects performed better with concrete word stimuli due to their being represented in their brains by both the verbal and the imaginal code. These word stimuli refer to specific actions or objects which the subjects were able to visualize or imagine in their minds' eyes. It appears that such imageability of referents of these concrete word stimuli facilitated verbal processing and retention in the semantic memory storage system (McFarland et al., 1978; Reber, 1985). This resulted in these concrete word stimuli being recalled better than abstract word stimuli. By contrast, the observed poor recall of abstract word stimuli could be attributed to representation of these

word stimuli in the brains of these individuals by their semantic properties (verbal code) only. However, possible representation of abstract word stimuli by their verbal code only is not the only factor which make them more difficult to memorize. There are a few other factors which are likely to influence memory performance with abstract Zulu word stimuli. One such factor is the size of the vocabulary of abstract words in an average speaker of the language. Among most Zulu-speaking people, younger individuals are less likely to use abstract words in their everyday verbal communication compared with older individuals. This may be related to the fact that during childhood the acquisition of abstract words begins much later than that of concrete words, and it continues through to adulthood. It follows that an average speaker of the language aged 27 years or younger, as was the case with these individuals, is likely to have relatively fewer abstract words in his or her mental lexicon compared with an average speaker aged 50 years or older. But this does not necessarily mean that all younger speakers of isiZulu would perform more poorly with abstract words, nor does it mean that all older speakers of the language would perform better with abstract words in a task like this dichotic listening experiment.

Recall memory of these imageable concrete word stimuli is likely to have been influenced by past experiences or knowledge of their referents. In this case, subjects are likely to have performed better with concrete word stimuli

which refer to actions they have engaged in, objects they have seen or situations they have experienced once or more in their lives. Another factor most likely to have positively influenced performance with concrete word stimuli is the size of the vocabulary of concrete words. The first words an individual learns as a toddler are predominantly concrete words. Toddlers and young children are generally less able to grasp abstract words, so their parents or caretakers teach them words which refer to things they can see or touch and words that refer to practical actions. By the time Zulu-speaking children reach the age of five, they have a fairly large vocabulary of concrete words. As they grow older they acquire more and more concrete words, and as adults their vocabulary of concrete words is much larger than that of abstract words. The observed better recall memory of concrete word stimuli could thus be seen as having been positively influenced by the fact that concrete word stimuli were part of the mental lexicon in the subjects.

Table 1. Average percent recall score data for abstract, concrete and emotional word stimuli among FS+ males per sinistral blood relative

Sinistral relative	Abstract	Concrete	Emotional	Overall
Father	45.80%	52.05%	37.50%	45.12%
Brother	31.51%	55.33%	50.56%	45.80%
Sister	21.64%	52.73%	41.62%	38.02%

The present recall score data indicate that FS+ females recalled significantly more abstract and concrete word stimuli overall compared with FS- females. By contrast, there was virtually no difference between male FS+ and FS- subjects on recall of abstract and concrete word stimuli overall. The observed better recall scores among FS+ females compared with FS- females could be interpreted as suggesting that the former have better recall memory abilities, particularly for abstract and concrete word stimuli. This finding contrasts the findings of such investigators as Bradshaw et al. (1981) and Springer and Searleman (1978) among English-speaking male and female subjects. These investigators have observed that on average, FS+ subjects performed more poorly than FS- subjects on certain verbal cognitive tasks. This has led some authors (Beaumont, 1983; Bradshaw & Nettleton, 1983) to speculate that familial sinistrality among dextrals may be associated with poor verbal abilities, and that sinistrals possess somewhat poorer verbal abilities.

The present recall score data suggest that the influence of familial sinistrality is positive rather than negative. There are a few reasons why these data are not consistent with data obtained among English-speaking subjects by such investigators as Bradshaw et al. (1981). One such reason concerns the fact that native speakers of English and those of isiZulu share little in common, and their languages are very different. It follows that the processing of English

verbal stimuli in the brain of its native speaker may be different from the processing of Zulu word stimuli in the brain of its native speaker.

The present recall score data suggest that the extent to which positive familial sinistrality influenced performance with abstract and concrete word stimuli was related to whether the sinistral relative was a parent or sibling, and whether such a relative was male or female. Recall score data shown in Table 1 above indicate that male FS+ subjects with a sinistral father or brother outperformed male FS+ subjects with a sinistral sister. Similarly, recall score data shown in Table 2 below indicate that FS+ females with a sinistral father, maternal uncle or brother outperformed FS+ females with a sinistral sister. It is pertinent to state that none of the FS+ subjects reported having a sinistral mother or grandmother.

Data on Tables 1 and 2 together indicate that among these FS+ subjects having a sinistral father was associated with better verbal memory abilities, but that having a sinistral sister was associated with poorer verbal memory abilities. Recall score data presented in Table 3 below show that overall FS- males recalled more abstract and concrete word stimuli than did FS- females. Again, the present data are not consistent with some of the published findings from verbal studies among English-speaking individuals, showing better performance among females compared with males (Bradshaw & Nettleton, 1983; Piazza, 1980). The present

recall score data for abstract and concrete word stimuli do however indicate that FS+ females with a sinistral father or paternal grandfather performed better than males and other female subjects. So the present finding suggests that verbal recall memory abilities in females may to some extent be influenced by paternal sinistrality, rather than merely the biological sex of these female individuals. These data must however be seen as very tentative in view of the small number of dextral FS+ subjects involved.

In summary, the present recall score data show that abstract word stimuli are recalled more poorly than concrete word stimuli among all the subject groups. They also indicate that performance with abstract word stimuli is positively influenced by having a male sinistral blood relative, especially a father. However, this positive influence of paternal sinistrality on abstract and concrete verbal memory abilities may well not be true of other dextral individuals with sinistral fathers. This may be particularly true of individuals whose native language is not isiZulu, and it may also not be true of Zulu-speakers from different educational or geographical backgrounds.

6.2. Recall of abstract vs emotional word stimuli

The present experiment found that emotional word stimuli are recalled significantly better than abstract (nonemotional)

word stimuli. This finding is consistent with the finding of Graves et al. (1981) among English-speaking male and female dextrals. Factors which are likely to have influenced recall of abstract word stimuli have already been discussed above, and need not be repeated here. There are a few factors which appear to have influenced recall of emotional word stimuli. These include the size of the vocabulary of emotional Zulu words and arousal factors, which are mediated in the limbic system (Joseph, 1992; Reuterskiold, 1991).

First, the meaning of all the emotional word stimuli used in this experiment is likely to have been known among all the subjects. It follows that better performance with emotional word stimuli was positively influenced by their being better understood, hence better retention in the semantic memory storage system. Generally, adult and teenage speakers of isiZulu appear to have a good vocabulary of positive and negative emotional words. However, the amount of emotional words in the mental lexicon of an average speaker of isiZulu is smaller than that of concrete words, due to the fact that the Zulu language has fewer emotional words compared with concrete words. The other factor which could have positively influenced recall of emotional word stimuli is the arousal processes which are controlled in the limbic system. According to Reuterskiold (1991) presentation of emotional verbal stimuli appear to facilitate verbal encoding and retention, resulting in better recall or recognition memory performance. It was mentioned in chapter

3 that the limbic structure which plays a crucial role in emotional verbal encoding and retention is the hippocampus.

Table 2. Average percent recall score data for abstract, concrete and emotional word stimuli among FS+ females per sinistral blood relative

Sinistral relative	Abstract	Concrete	Emotional	Overall
Father+	52.05%	70.80%	62.45%	61.71%
Brother	27.05%	55.43%	54.80%	45.76%
Sister	31.25%	41.65%	41.60%	38.16%
Uncle	50.00%	54.10%	64.55%	56.21%

+one subject has a sinistral paternal grandfather

The present recall score data for emotional word stimuli suggest that the hippocampi, and possibly other limbic structures, in these individuals were stimulated by the presentation of these word stimuli. This arousal resulted in these emotional word stimuli being recalled much better than abstract word stimuli. Arousal during the presentation of emotional word stimuli might have been influenced by the fact that these word stimuli have a relatively bigger network of associations. They are not as restricted in their association as do these abstract word stimuli.

The argument of a facilitatory effect of emotional word stimuli could be substantiated by comparing and contrasting overall recall of these word stimuli with that of abstract word stimuli. Recall score data shown in Table 3 indicate

that high school and university going FS- females as a group recalled only 19.85% of abstract word stimuli across ear of presentation. The same FS- females recalled as many as 53.20% of emotional word stimuli across ear of presentation. Recall score data for FS- males as a group indicate that they recalled 28.88% of abstract word stimuli across ear of presentation, while their recall score for emotional word stimuli across ear of presentation stood at 51.82%. Surely, the observed differences between recall of abstract word stimuli and that of emotional word stimuli do suggest some facilitatory effects of presentation of emotional word stimuli on verbal encoding and recall memory.

In summary, the present experiment found that emotional word stimuli are recalled significantly better than abstract word stimuli among all subjects, except FS+ males with a sinistral father. Better recall of emotional word stimuli is attributed to their ability to arouse facilitatory limbic processes (Joseph, 1992; Reuterskiold, 1991). The present data suggest that familial sinistrality may have little or no notable influence on recall of emotional word stimuli.

6.3. Recall of concrete vs emotional word stimuli

The present recall score data indicate that there is virtually no difference between recall of concrete word stimuli and that of emotional word stimuli across ear of

presentation. It has already been indicated above that better performance with concrete word stimuli is likely to be related to their being represented in the brains of subjects by both their verbal and imaginal codes, and by their constituting the largest proportion of the mental lexicon in adult and teenage speakers of isiZulu. It has also been indicated that better performance with emotional word stimuli may be related to their ability to facilitate verbal information encoding and retention.

Table 3. Average percent recall score data for abstract, concrete and emotional word stimuli among male and female FS- subjects

Sex group	Abstract	Concrete	Emotional	Overall
Males	28.88%	54.13%	51.82%	44.94%
Females	19.85%	47.14%	53.20%	40.06%

The observed (positive) effect of having a sinistral father or brother among male and female FS+ subjects was more pronounced on recall of concrete word stimuli than on recall of emotional word stimuli. Female FS+ subjects with a sinistral maternal uncle exhibited superior performance with concrete word stimuli overall compared with female FS+ subjects with a sinistral sister (see Table 2). The latter

exhibited inferior performance with concrete word stimuli compared with other FS+ subjects and FS- subjects.

The present recall score data for concrete word stimuli could be seen as suggesting that familial sinistrality has a positive effect on recall memory of these word stimuli. This positive effect is more pronounced among FS+ dextrals with a male than a female sinistral blood relative, more especially a biological father. This finding could thus be seen as introducing a new concept to neuropsychological research on verbal memory: the association of paternal sinistrality with better auditory verbal memory abilities.

6.4. Cerebral laterality of abstract word stimuli

The present laterality data for abstract word stimuli show that recall of these word stimuli yields a right ear advantage (REA) among both males and females. The observed REA is consistent with the dual coding model, as well as empirical evidence from many of the published studies on lateralized cerebral processing of abstract word stimuli (McFarland et al., 1978; Rastatler et al., 1987). In terms of the dual coding model the observed REA is a dichotic listening index of an underlying contralateral left brain laterality in the processing of these abstract word stimuli. This left brain laterality is likely to have been influenced by a number of factors. These could include

representation of these abstract word stimuli in the brains of the subjects by their verbal code only and a delayed maturation of the left brain.

The assumption that abstract word stimuli are represented in the brains of the subjects by their semantic properties is based on the dual coding model. In terms of this model the hypothesized left brain laterality could be due to the fact that the left brain uses verbally-based mechanisms in processing abstract word stimuli (Eviatar et al., 1990). These mechanisms are believed to be relatively efficient in the processing of abstract word stimuli.

It has been found that the left brain generally matures later than the right brain (Rothbart et al., 1989). This late left brain maturity is believed to allow the right brain in toddlers and younger children to play an active role in the processing of speech (Joseph, 1992), which is largely made up of concrete words. As the left brain matures, it tends to take over many linguistic functions. It appears that left brain maturity may be accompanied by an increase in the individual's vocabulary of abstract words. A substantial proportion of these newly learned abstract words appears to be stored in the verbal memory storage system, which is believed by many neuroscientists to be primarily controlled in the left temporal cortex (Jones, 1981; Joseph, 1992). It follows that the ability of the left brain to process more abstract word stimuli than does the right brain is related to its being the primary center in which

abstract, nonimageable words are stored. Furthermore, it is related to the fact that the left brain uses verbally-based mechanisms in processing abstract verbal stimuli. Several dichotic listening researchers working with dextral subjects have also observed left brain laterality in the processing of abstract (meaningless) nonsense syllabic stimuli, such as aba (Wexler & Halwes, 1985) and deb and geb (Obrzut, Conrad, Bryden & Boliek, 1988). However, this does not necessarily mean that the left brain is the sole or dominant processor of abstract verbal information in all human beings. The present data for FS+ males support this argument in that they show an LEA for abstract word stimuli (see Table 4).

Table 4. Average Z-laterality index scores for abstract, concrete and emotional word stimuli among FS+ males per sinistral blood relative

Sinistral relative	Abstract	Concrete	Emotional	Overall
Father	1.08(REA)	-4.86(LEA)*	2.27(REA)#	-2.02(LEA)*
Brother	-2.33(LEA)*	-0.40(LEA)	0.82(REA)	-0.64(LEA)
Sister	-1.25(LEA)	0.05(REA)	-1.52(LEA)	-0.91(LEA)

*statistically significant LEA

#statistically significant REA

The observed LEA among FS+ males could be seen as suggesting some right brain laterality in the processing of these abstract word stimuli. This finding is basically consistent with the assumption that right brain laterality in verbal

information processing is more likely among FS+ dextrals than among FS- dextrals (Bradshaw, 1980; Lokker & Morais, 1985). A possible explanation for a more active involvement of the right brain in speech processing among these individuals is that they possess some inherited trait of sinistrality which is associated with bilaterality or right brain laterality for speech function (Bryden & Steenhuis, 1991; Andrews, 1977). This argument is supported by the observation that among these FS+ males higher recall scores for abstract word stimuli across ear of presentation were associated with a larger LEA. It could thus be argued that in these male individuals the right brain played an active role in abstract stimulus word processing.

It is interesting to learn that FS+ females with a sinistral sister and FS- subjects also exhibited an LEA advantage for abstract word stimuli. Unlike FS+ males, these female subjects recalled fewer abstract word stimuli than their female and male counterparts. The present recall and laterality data show that among these female subjects smaller recall scores for abstract word stimuli across ear of presentation were associated with a larger LEA. The observed LEA is unlikely to be indicative of an underlying bilaterality or right brain laterality for speech processing. One of the plausible explanations for this LEA is that it is due to differences in cognitive strategies of the right and the left brain in processing lateralized

stimuli. It is believed that the right brain employs parallel strategies, while the left brain employs serial strategies in processing information which requires the division of attention (Cook, 1986; Jones, 1981). It appears that the right brain was in a better position to memorize, using its parallel-holistic strategies, as many abstract word stimuli as it could. By contrast, serial-sequential strategies of the left brain might have led to a situation where relatively fewer abstract word stimuli were ever encoded and stored in the memory storage sites.

In summary, the observed general REA is interpreted as an indicator of left brain laterality in the processing of these abstract word stimuli. The observed LEA among FS+ males is seen as an indicator of right brain laterality in the processing of these word stimuli. The Z-laterality index score data in Tables 4 and 5 show that FS+ males with a sinistral father exhibited a larger REA compared with FS+ subjects with a sinistral sister or brother. By contrast, FS+ females with a sinistral maternal uncle exhibited the largest REA for abstract word stimuli. The implication of these data is that among these dextral FS+ subjects, having a sinistral father or uncle is associated with a more active involvement of the left brain in abstract verbal processing. Inspection of data in Table 6 shows that whereas FS- males had an REA, FS- females had an LEA for these word stimuli. The observed REA among FS- males is considered an indicator of left brain laterality, but the observed LEA among FS-

females as an indicator of relative failure of the left brain to encode and memorize speedily these abstract word stimuli efficiently via its serial (encoding) strategies.

6.5. Cerebral laterality of concrete word stimuli

The present laterality data for concrete word stimuli show that recall of these word stimuli yielded a significantly larger LEA among males, while among females it yielded a significantly larger REA. The observed LEA among males could be interpreted as an indicator of right brain laterality in the processing of concrete word stimuli. On the other hand, the observed REA among females could be interpreted as an indicator of left brain laterality in the processing of concrete word stimuli. The present finding of an LEA among males is consistent with the dual coding model. It is also consistent with many of the published dichotic listening and tachistoscopic studies on lateralized cerebral processing of concrete English word stimuli among native English-speakers (McFarland et al., 1978; Rastatler et al., 1987).

The observed LEA suggests that among these males the right brain played a more active role than the left brain in processing concrete word stimuli via its imagery-based processing mechanisms. These mechanisms are believed to benefit from imageability properties of the referents of concrete word stimuli, resulting in more efficient encoding

and retention of concrete word stimuli presented to the left ear or left visual field (Duhamel & Poncet, 1986; Villardita et al., 1988). It is possible that in these males early acquisition of concrete words resulted in a situation where the right brain, which matures earlier than the left brain, developed better abilities to comprehend, process and store concrete verbal information in its semantic memory system. Such a situation might have caused the right brain to become a more active (but not sole) processor of concrete speech. It would thus be logical to expect higher recall scores for concrete word stimuli presented to the contralateral left ear among these males. Preliminary inferential analyses on mean recall score data (Table 3, Appendices B-D) did in fact show that male subjects performed significantly better with concrete word stimuli presented to the left than the right ear compared with female subjects.

The observed REA among females could be interpreted as indicating that in these individuals the left brain rather than the right brain played a more active role in the processing of concrete word stimuli. According to the dual coding model such left brain laterality is likely to have been mediated by verbally-based processing mechanisms (Paivio & Te Linde, 1982). This means that in these females the brain used less of the imaging processes in encoding and storing concrete verbal information in its semantic memory system. The recall score data for females do support this contention that the left brain appears to have played a more

active role in processing these word stimuli. In this case, better recall memory of concrete word stimuli overall was related to a larger REA for these word stimuli.

Table 5. Average Z-laterality index scores for abstract, concrete and emotional word stimuli among FS+ females per sinistral blood relative

Sinistral relative	Abstract	Concrete	Emotional	Overall
Father+	1.80(REA)	1.30(REA)	3.11(REA)#	2.07(REA)#
Brother	1.05(REA)	-1.80(LEA)	-0.95(LEA)	-0.36(LEA)
Sister	-1.93(LEA)	2.69(REA)#	-4.55(LEA)*	-1.26(LEA)
Uncle	5.60(REA)#	1.80(REA)	6.29(REA)#	4.56(REA)#

+one subject has a sinistral paternal grandfather

*statistically significant LEA

#statistically significant REA

It may be possible that in these females early acquisition of concrete words accompanied by relatively early maturity of the left brain (Springer & Deutsch, 1981) resulted in a situation where this brain developed better abilities to encode and store verbal information in its semantic memory system, regardless of the semantic properties of that information. Indeed this is not just a speculation, but a fact which has been discussed by several neuropsychological researchers and theorists (Bradshaw & Nettleton, 1983). It has long been argued that approximately 96% of dextrals and 66% of sinistrals have language functions represented in the left brain (Bryden & Steenhuis, 1991). However, the concept

of left brain as the only processor of language is now out of date (Benowitz, Moya & Levine, 1990). As already indicated, several studies have found the right brain to play a more active role in the processing of certain verbal stimuli, such as concrete words (Rastatler et al., 1987).

The Z-laterality data in Table 4 indicate that FS+ males with a sinistral father or brother exhibited a very large LEA, while FS+ males with a sinistral sister exhibited a smaller REA. Among these FS+ males poor recall memory of concrete word stimuli was associated with an REA, while better recall memory for these word stimuli was associated with a larger LEA. The Z-laterality data shown in Table 5 indicate that FS+ females with a sinistral sister exhibited a larger REA, while FS+ females with a sinistral brother exhibited a smaller LEA. These data demonstrate that having a sinistral sister was related to an REA and poorer performance with concrete word stimuli. The Z-laterality data in Table 6 show that FS- males exhibited a larger LEA, while FS- females exhibited a larger REA. In these males concrete verbal memory abilities seem to have been largely controlled in the right brain, while in females they seem to have been largely controlled in the left brain.

In summary, it is argued that in males processing of concrete word stimuli is largely controlled by the right brain via its imagery-based mechanisms. By contrast, in

females it is considered to have been largely controlled by the left brain via its verbally-based mechanisms.

6.6. Cerebral laterality of emotional word stimuli

The present experiment found that recall of emotional word stimuli yields a left ear advantage (LEA) among males, while among females it yields a right ear advantage (REA). The observed LEA among males suggests right brain laterality, and the observed REA among females suggests left brain laterality in the processing of emotional word stimuli. The present data are consistent with some of the few published dichotic listening and tachistoscopic studies on cerebral laterality in the processing of emotional English word stimuli among native speakers of English. The observed LEA among males is consistent with the finding of an LEA for emotional word stimuli among male and female dextrals (Wexler et al., 1992), and an LEA for emotional phrase stimuli among dextrals and sinistrals (Bryden et al., 1991). It is also consistent with the finding of a left visual field advantage (LVFA) for emotional word stimuli among male dextrals (Graves et al., 1981).

The observed larger REA among females is consistent with the finding of an REA for emotional word stimuli among male and female dextrals (Wexler et al., 1986). It is also consistent with the finding of a right visual field

advantage (RVFA) for emotional word stimuli among female dextrals (Graves et al., 1981). The present data suggest that males differed from their female counterparts with respect to lateralized cerebral processing of emotional word stimuli. This may be related to the fact that at least among Zulu-speakers, females appear to be more likely than males to express their emotional feelings verbally, such as discussing them with significant others. One of the implications of this sex difference is that in females emotional information processing may be largely conscious, while in males it may be largely unconscious. It has been established that the processing of emotional word stimuli in the left brain is predominantly conscious (Wexler et al., 1986), while in the right brain it is primarily unconscious (Wexler et al., 1992). These authors have found that in a dichotic listening situation, conscious emotional verbal processing yields an REA, and unconscious emotional verbal processing an LEA.

Table 6. Average Z-laterality index scores for abstract, concrete and emotional word stimuli among FS- subjects

Sex group	Abstract	Concrete	Emotional	Overall
Males	1.17(REA)	-2.77(LEA)*	-0.00(LEA)	-0.53(LEA)
Females	-1.17(LEA)	2.72(REA)#	0.17(REA)	0.57(REA)

*statistically significant LEA

#statistically significant REA

The Z-laterality index score data shown in Table 4 indicate that as a group FS+ males with a sinistral father exhibited a larger REA, suggesting some left brain laterality in the processing of emotional word stimuli. Taken together with the recall score data appearing in Table 1, the present data demonstrate that in these FS+ males a larger REA was related to poor recall memory of emotional word stimuli overall. It could thus be argued that in these male individuals it is the right rather than the left brain which played an active role in the processing of both emotional, concrete and abstract word stimuli. The Z-laterality index score data in Table 5 show that FS+ females with a sinistral sister exhibited a very large LEA, while FS+ females with a sinistral maternal uncle or father exhibited a very large REA. It is still premature to speculate about any influence of familial sinistrality on the direction and magnitude of a dichotic ear advantage in view of the small number of FS+ subjects involved in this experiment.

Taken together with recall score data in Table 2, the present laterality data indicate that among these FS+ females an LEA was related to poor recall memory, and that an REA was related to better recall memory of emotional word stimuli. It could thus be argued that in these FS+ females it is the left rather than the right brain which played an active role in the processing of emotional word stimuli, as well as concrete and abstract word stimuli. In summary, the observed LEA among males is interpreted as an indicator of

right brain laterality in the processing of these emotional word stimuli. It is speculated that right brain processing might have taken place somewhat unconsciously. The observed REA among females is interpreted as an indicator of left brain laterality in the processing of these emotional word stimuli. It is speculated that left brain processing might have taken place somewhat consciously.

6.7. Conclusion

The present dichotic listening experiment is the first basic neuropsychological study to investigate both recall memory and cerebral laterality of abstract, concrete and emotional Zulu word stimuli among brain-intact dextral native speakers of isiZulu. It is the first dichotic listening study to find that abstract word stimuli are recalled significantly more poorly than both concrete and emotional word stimuli, and to find a null difference between recall of concrete and emotional word stimuli across ear of presentation. It is also one of the few cognitive neuropsychological studies conducted to date to find convincing evidence of influence of familial sinistrality on dichotic listening performance among male and female FS+ dextrals. It shows that among these FS+ dextrals, having a male sinistral blood relative such as a father could serve as a good predictor of better recall memory of verbal stimuli. It also demonstrates that

having a sinistral sister could serve as a good predictor of poor recall memory of verbal stimulus materials.

The present experiment is one of the relatively few basic neuropsychological studies to find convincing evidence of sex differences on cerebral laterality in the processing of dichotically presented concrete word stimuli, as well as emotional word stimuli. It suggests that the processing of concrete word stimuli was primarily lateralized to the right brain in males, while in females it was primarily lateralized to the left brain. It also suggests that processing of emotional word stimuli was primarily lateralized to the right brain in males, while in females it was primarily lateralized to the left brain. In view of the small sample size, no firm statement could be made with regard to differences between male and female Zulu-speaking dextral individuals on lateralized cerebral processing of abstract, concrete and emotional speech.

The present data indicate that among males better recall memory is positively related to larger left ear advantages, while among females it is positively related to larger right ear advantages. The implication of this finding is that among males the right brain might have been more active than the left brain in the processing of these word stimuli. By contrast, among females the left brain might have been more active than the right brain in the processing of these stimuli. Whereas FS+ males exhibit an LEA across stimulus word category, FS+ females exhibit an REA across stimulus

word category. These data suggest that both sex and familial sinistrality influenced patterns of lateralized cerebral processing of the word stimuli among the subjects. No firm conclusions could be arrived at, primarily because the dichotic recall test used in the present experiment is a newly developed test which has not been used with any other sample of native Zulu-speakers. As such, its sensitivity as a cognitive neuropsychological measure for auditory verbal free-recall memory and cerebral speech laterality (empirical validity) is yet to be established, as also its consistency over repeated administration with the same individuals (retest reliability) (Reber, 1985; Springer, 1986).

It is suggested that more basic neuropsychological research be conducted amongst various samples of native speakers of isiZulu using this dichotic recall test. Future research should, where possible, involve both dextral and sinistral FS+ and FS- individuals. However, more neuropsychological tests for assessing patterns of verbal memory and cerebral laterality in the processing of Zulu verbal stimuli still need to be developed and empirically validated. Such tests could include auditory and visual stimulus-presentation tests. Finally, more abstract, concrete and emotional word stimuli, amongst other verbal stimuli, need to be developed for the purpose of cognitive neuropsychological research among both normal and brain-damaged individuals.

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APPENDIX A

Figure 1. Stem-and-leaf plot of recall scores for abstract word stimuli across ear of presentation (N=62)

Count	Stem	Leaves
3	0	0 4 4
7	0	8 8 8 8
11	1	2 3 3 3
17	1	7 7 7 7 7 7
21	2	1 1 1 1
(23)	2	5 5 5 5 5 5 5 5 5 9 9 9 9 9 9 9 9 9 9 9 9
18	3	3 3 3 3
14	3	8 8 8
11	4	2
10	4	6 6 6
7	5	0 0 4 4
3	5	
3	6	3 3 3

Figure 2. Stem-and-leaf plot of recall score for concrete word stimuli across ear of presentation (N=62)

Count	Stem	Leaves
1	2	5
4	3	3 3 3
9	3	8 8 8 8 8
14	4	2 2 2 2 2
22	4	6 6 6 6 6 6 6 6
(17)	5	0 0 0 0 0 0 0 0 4 4 4 4 4 4 4 4
23	5	8 8 8 8 8 8 8 8 8 8
12	6	2 3 3 3 3
7	6	7 7 7 7
3	7	1
2	7	5 5

APPENDIX A

Figure 3. Stem-and-leaf plot of recall scores for emotional word stimuli across ear of presentation (N=62)

Count	Stem	Leaves
1	2	1
2	2	9
7	3	1 1 2 3 3
23	3	5 5 5 5 5 6 6 6 6 8 8 8 8 9 9 9
(14)	4	0 0 2 2 2 2 2 2 3 3 3 4 4 4
25	4	6 6 6 6 6 9
19	5	0 0 0 1 1 1 1 1 1 1 1
8	5	6 7
6	6	0 1 1 3
2	6	7
1	7	4

Figure 4. Stem-and-leaf plot of dichotic laterality index scores for abstract word stimuli (N=62)

Count	Stem	Leaves
3	-4	9 9 9
7	-3	7 2 2 2
7	-2	
14	-1	9 9 3 3 3 0 0
24	-0	8 8 7 7 6 0 0 0 0 0
(13)	0	0 0 0 0 0 1 1 1 1 1 1 1 7
25	1	4 4 4 4 4 4 7
18	2	0 0 0 5 5 7
12	3	3 3 3 3
8	4	3 3 3
5	5	0
4	6	7 7
2	7	1 8

APPENDIX A

Figure 5. Stem-and-leaf plot of dichotic laterality index scores for concrete word stimuli (N=62)

Count	Stem	Leaves
1	-3	2
3	-2	7 6
6	-2	4 4 1
10	-1	9 9 9 6
14	-1	2 0 0 0
23	-0	9 9 7 7 7 6 6 6 5
30	-0	0 0 0 0 0 0 0
(7)	0	0 0 0 0 0 0 0
25	0	7 7 8 8 8
20	1	0 0 1 1 3 4 4 4
12	1	7 7 7
9	2	3
8	2	7 7 7
5	3	1 3 3 3
1	3	9

Figure 6. Stem-and-leaf plot of dichotic laterality index scores for emotional word stimuli (N=62)

Count	Stem	Leaves
2	-4	4 2
4	-3	9 9
5	-3	2
6	-2	8
7	-2	2
11	-1	9 9 7 6
16	-1	4 3 0 0 0
22	-0	9 9 7 7 6 6
26	-0	4 0 0 0
29	0	0 0 0
(8)	0	6 6 7 7 7 8 8 8
25	1	0 0 0 0 0 1 4
18	1	6 7
16	2	0 0 0 0 0 3 3
8	2	5 5 5 7 7 9
2	3	3
1	3	9

APPENDIX ADescriptive data

Table 1. Descriptive features of recall scores for left ear-presented dichotic word stimuli

Stimulus category	Mean	StDev	1st Quartile	Median	3rd Quartile
Abstract	24.58	17.31	8.00	25.00	33.00
Concrete	50.65	13.46	42.00	50.00	58.00
Emotional	49.68	14.20	42.00	50.00	58.00

Table 2. Descriptive features of recall scores for right ear-presented dichotic word stimuli

Stimulus category	Mean	StDev	1st Quartile	Median	3rd Quartile
Abstract	31.18	16.61	17.00	33.00	42.00
Concrete	53.06	13.79	42.00	58.00	67.00
Emotional	52.84	17.12	42.00	50.00	67.00

APPENDIX B Sex by Experimental group ANOVA tests

Table 1. ANOVA recall score data for abstract word stimuli presented to the left ear

Variable	Mean	StDev	DF	F	P
Sex:			1/58	1.13	0.292
Males	26.78	2.97			
Females	22.23	3.07			
Group:			1/58	3.09	0.084
Forward-Reversed	28.26	3.02			
Reversed-Foward	20.75	3.02			
Sex*Group:			1/58	2.55	0.116
FR Males	27.13	4.21			
RF Males	26.44	4.21			
FR Females	29.40	4.34			
RF Females	15.07	4.34			

Table 2. ANOVA recall score data for abstract word stimuli presented to the right ear

Variable	Mean	StDev	DF	F	P
Sex:			1/58	0.15	0.704
Males	31.97	2.97			
Females	30.33	3.07			
Group:			1/58	0.06	0.809
Forward-Reversed	30.63	3.02			
Reversed-Forward	31.67	3.02			
Sex*Group:			1/58	1.25	0.269
FR Males	29.06	4.21			
RF Males	34.87	4.21			
FR Females	32.20	4.34			
RF Females	28.47	4.34			

APPENDIX B

Table 3. ANOVA recall score data for concrete word
stimuli presented to the left ear

Variable	Mean	StDev	DF	F	P
Sex:			1/58	9.42	0.003
Males	55.44	2.24			
Females	45.53	2.32			
Group:			1/58	0.00	0.964
Forward-Reversed	50.41	2.28			
Reversed-Forward	50.56	2.28			
Sex*Group:			1/58	1.16	0.285
FR Males	53.63	3.17			
RF Males	57.25	3.17			
FR Females	47.20	3.28			
RF Females	43.87	3.28			

Table 4. ANOVA recall score data for concrete word
stimuli presented to the right ear

Variable	Mean	StDev	DF	F	P
Sex:			1/58	0.41	0.524
Males	51.97	2.46			
Females	54.23	2.54			
Group:			1/58	0.50	0.481
Forward-Reversed	54.35	2.50			
Reversed-Forward	51.85	2.50			
Sex*Group:			1/58	1.09	0.300
FR Males	51.38	3.48			
RF Males	52.56	3.48			
FR Females	57.33	3.59			
RF Females	51.13	3.59			

APPENDIX B

Table 5. ANOVA recall score data for emotional word stimuli presented to the left ear

Variable	Mean	StDev	DF	F	P
Sex:			1/58	0.37	0.545
Males	48.59	2.56			
Females	50.83	2.64			
Group:			1/58	0.20	0.657
Forward-Reversed	50.54	2.60			
Reversed-Forward	48.89	2.60			
Sex*Group:			1/58	0.08	0.778
FR Males	49.94	3.62			
RF Males	47.25	3.62			
FR Females	51.13	3.74			
RF Females	50.53	3.74			

Table 6. ANOVA recall score data for emotional word stimuli presented to the right ear

Variable	Mean	StDev	DF	F	P
Sex:			1/58	1.26	0.266
Males	50.50	2.99			
Females	55.33	3.09			
Group:			1/58	0.95	0.333
Forward-Reversed	55.02	3.04			
Reversed-Forward	50.81	3.04			
Sex*Group:			1/58	2.16	0.147
FR Males	49.44	4.23			
RF Males	51.56	4.23			
FR Females	60.60	4.37			
RF Females	50.07	4.37			

APPENDIX B

Table 7. ANOVA results of dichotic laterality index scores for abstract word stimuli

Variable	Mean	StDev	DF	F	P
Sex:			1/58	0.01	0.915
Males	7.08	5.11			
Females	6.29	5.27			
Group:			1/58	0.19	0.668
Forward-Reversed	4.65	5.19			
Reversed-Forward	8.72	5.19			
Sex*Group:			1/58	0.00	0.980
FR Males	5.14	7.22			
RF Males	9.02	7.22			
FR Females	4.16	7.46			
RF Females	8.41	7.46			

Table 8. ANOVA results of dichotic laterality index scores for concrete word stimuli

Variable	Mean	StDev	DF	F	P
Sex:			1/58	7.06	0.010
Males	-3.67	2.90			
Females	7.42	2.99			
Group:			1/58	0.28	0.600
Forward-Reversed	2.98	2.95			
Reversed-Forward	0.78	2.95			
Sex*Group:			1/58	0.03	0.863
FR Males	-2.93	4.11			
RF Males	-4.41	4.11			
FR Females	8.88	4.24			
RF Females	5.96	4.24			

APPENDIX B

Table 9. ANOVA results of dichotic laterality index scores for emotional word stimuli

Variable	Mean	StDev	DF	F	P
Sex:			1/58	0.46	0.502
Males	0.18	3.50			
Females	3.58	3.62			
Group:			1/58	0.19	0.668
Forward-Reversed	2.96	3.56			
Reversed-Forward	0.79	3.56			
Sex*Group:			1/58	2.62	0.111
FR Males	-2.81	4.95			
RF Males	3.16	4.95			
FR Females	8.73	5.11			
RF Females	-1.58	5.11			

Table 10. ANOVA recall score data for all the word stimuli combined across ear of presentation

Variable	Mean	StDev	DF	F	P
Sex:			1/58	0.07	0.786
Males	44.22	1.75			
Females	43.54	1.81			
Group:			1/58	0.67	0.415
Forward-Reversed	44.92	1.78			
Reversed-Forward	42.85	1.78			
Sex*Group:			1/58	2.06	0.156
FR Males	43.45	2.47			
RF Males	45.00	2.47			
FR Females	46.38	2.56			
RF Females	40.70	2.56			

APPENDIX C Sex by Familial sinistrality ANOVA tests

Table 1. ANOVA recall score data for abstract word stimuli presented to the left ear

Variable	Mean	StDev	DF	F	P
Sex:			1/58	0.59	0.445
Males	26.98	3.00			
Females	23.64	3.14			
Familial sinistrality:			1/58	3.94	0.052
FS+	29.62	3.31			
FS-	21.00	2.81			
Sex*Familial sinistrality:			1/58	1.57	0.216
FS+ Males	28.57	4.50			
FS- Males	25.39	3.97			
FS+ Females	30.67	4.86			
FS- Females	16.61	3.97			

Table 2. ANOVA recall score data for abstract word stimuli presented to the right ear

Variable	Mean	StDev	DF	F	P
Sex:			1/58	0.00	0.959
Males	31.92	2.81			
Females	32.12	2.94			
Familial sinistrality:			1/58	4.40	0.040
FS+	36.29	3.11			
FS-	27.75	2.63			
Sex*Familial sinistrality:			1/58	5.30	0.025
FS+ Males	31.50	4.22			
FS- Males	32.33	3.72			
FS+ Females	41.08	4.56			
FS- Females	23.17	3.72			

APPENDIX C

Table 3. ANOVA recall score data for concrete word stimuli presented to the left ear

Variable	Mean	StDev	DF	F	P
Sex:			1/58	7.48	0.008
Males	55.22	2.14			
Females	46.75	2.24			
Familial sinistrality:			1/58	1.98	0.165
FS+	53.17	2.36			
FS-	48.81	2.00			
Sex*Familial sinistrality:			1/58	6.35	0.015
FS+ Males	53.50	3.21			
FS- Males	56.94	2.83			
FS+ Females	52.83	3.47			
FS- Females	40.67	2.83			

Table 4. ANOVA recall score data for concrete word stimuli presented to the right ear

Variable	Mean	StDev	DF	F	P
Sex:			1/58	0.64	0.427
Males	52.07	2.47			
Females	54.93	2.58			
Familial sinistrality:			1/58	1.43	0.237
FS+	55.64	2.73			
FS-	51.36	2.31			
Sex*Familial sinistrality:			1/58	0.57	0.454
FS+ Males	52.86	3.71			
FS- Males	51.28	3.27			
FS+ Females	58.42	4.00			
FS- Females	51.44	3.27			

APPENDIX C

Table 5. ANOVA recall score data for emotional word stimuli presented to the left ear

Variable	Mean	StDev	DF	F	P
Sex:			1/58	0.53	0.470
Males	48.34	2.57			
Females	51.04	2.68			
Familial sinistrality:			1/58	0.07	0.787
FS+	49.18	2.84			
FS-	50.19	2.40			
Sex*Familial sinistrality:			1/58	0.69	0.409
FS+ Males	46.29	3.85			
FS- Males	50.39	3.40			
FS+ Females	52.08	4.16			
FS- Females	50.00	3.40			

Table 6. ANOVA recall score data for emotional word stimuli presented to the right ear

Variable	Mean	StDev	DF	F	P
Sex:			1/58	1.36	0.248
Males	49.84	3.01			
Females	54.92	3.14			
Familial sinistrality:			1/58	2.86	0.096
FS+	48.70	3.32			
FS-	56.06	2.81			
Sex*Familial sinistrality:			1/58	0.54	0.467
FS+ Males	44.57	4.51			
FS- Males	55.11	3.98			
FS+ Females	52.83	4.87			
FS- Females	57.00	3.97			

APPENDIX D Sex by Educational institution ANOVA tests

Table 1. ANOVA recall score data for abstract word stimuli presented to the left ear

Variable	Mean	StDev	DF	F	P
Sex:			1/58	0.44	0.510
Males	27.13	3.01			
Females	23.99	3.66			
Institution:			1/58	3.52	0.066
High school	21.11	2.72			
University	30.01	3.88			
Sex*Institution:			1/58	0.24	0.628
School Males	21.53	4.12			
Varsity Males	32.73	4.38			
School Females	20.70	3.54			
Varsity Females	27.29	6.42			

Table 2. ANOVA recall score data for abstract word stimuli presented to the right ear

Variable	Mean	StDev	DF	F	P
Sex:			1/58	0.02	0.883
Males	32.11	2.99			
Females	31.41	3.65			
Institution:			1/58	0.81	0.372
High school	29.64	2.70			
University	33.88	3.86			
Sex*Institution:			1/58	0.00	0.965
School Males	29.88	4.09			
Varsity Males	34.33	4.36			
School Females	29.39	3.52			
Varsity Females	33.43	6.38			

APPENDIX D

Table 3. ANOVA recall score data for concrete word stimuli presented to the left ear

Variable	Mean	StDev	DF	F	P
Sex:			1/58	10.02	0.002
Males	55.93	2.02			
Females	45.84	2.46			
Institution:			1/58	7.04	0.010
High school	46.66	1.82			
University	55.11	2.61			
Sex*Institution:			1/58	5.23	0.026
School Males	48.06	2.77			
Varsity Males	63.80	2.95			
School Female	45.26	2.38			
Varsity Females	46.43	4.31			

Table 4. ANOVA recall score data for concrete word stimuli presented to the right ear

Variable	Mean	StDev	DF	F	P
Sex:			1/58	0.82	0.370
Males	52.34	2.35			
Females	55.69	2.87			
Institution:			1/58	5.45	0.023
High school	49.68	2.12			
University	58.35	3.04			
Sex*Institution:			1/58	0.74	0.393
School Males	46.41	3.22			
Varsity Males	58.27	3.43			
School Females	52.96	2.77			
Varsity Females	58.43	5.02			

APPENDIX D

Table 5. ANOVA recall score data for emotional word stimuli presented to the left ear

Variable	Mean	StDev	DF	F	P
Sex:			1/58	0.56	0.456
Males	48.90	2.48			
Females	51.84	3.02			
Institution:			1/58	3.00	0.088
High school	46.98	2.24			
University	53.76	3.21			
Sex*Institution:			1/58	0.60	0.443
School Males	44.00	3.39			
Varsity Males	53.80	3.62			
School Females	49.96	2.92			
Varsity Females	53.71	5.29			

Table 6. ANOVA recall score data for emotional word stimuli presented to the right ear

Variable	Mean	StDev	DF	F	P
Sex:			1/58	1.62	0.209
Males	50.86	2.97			
Females	56.81	3.62			
Institution:			1/58	3.30	0.074
High school	49.58	2.68			
University	58.09	3.84			
Sex*Institution:			1/58	0.40	0.527
School Males	45.12	4.06			
Varsity Males	56.60	4.33			
School Females	54.04	3.49			
Varsity Females	59.57	6.33			

APPENDIX D

Table 7. ANOVA results of dichotic laterality index scores for abstract word stimuli

Variable	Mean	StDev	DF	F	P
Sex:			1/58	0.01	0.931
Males	6.78	5.09			
Females	6.09	6.21			
Institution:			1/58	0.40	0.528
High school	8.98	4.60			
University	3.89	6.58			
Sex*Institution:			1/58	0.29	0.591
School Males	11.51	6.97			
Varsity Males	2.07	7.43			
School Females	6.46	5.99			
Varsity Females	5.71	10.87			

Table 8. ANOVA results of dichotic laterality index scores for concrete word stimuli

Variable	Mean	StDev	DF	F	P
Sex:			1/58	7.58	0.008
Males	-3.76	2.89			
Females	8.81	3.53			
Institution:			1/58	0.05	0.818
High school	1.99	2.61			
University	3.05	3.74			
Sex*Institution:			1/58	0.82	0.370
School Males	-2.23	3.96			
Varsity Males	-5.30	4.22			
School Females	6.21	3.41			
Varsity Females	11.40	6.18			

APPENDIX D

Table 9. ANOVA results of dichotic laterality index scores for emotional word stimuli

Variable	Mean	StDev	DF	F	P
Sex:			1/58	0.54	0.466
Males	0.27	3.58			
Females	4.41	4.36			
Institution:			1/58	0.30	0.586
High school	0.79	3.23			
University	3.89	4.63			
Sex*Institution:			1/58	0.00	0.993
School Males	-1.25	4.90			
Varsity Males	1.79	5.22			
School Females	2.84	4.22			
Varsity Females	5.98	7.64			

Table 10. ANOVA recall score data for all the word stimuli combined across ear of presentation

Variable	Mean	StDev	DF	F	P
Sex:			1/58	0.00	0.989
Males	44.56	1.64			
Females	44.52	1.99			
Institution:			1/58	7.87	0.007
High school	40.92	1.48			
University	48.16	2.11			
Sex*Institution:			1/58	1.89	0.175
School Males	39.17	2.24			
Varsity Males	49.95	2.38			
School Females	42.68	1.93			
Varsity Females	46.37	3.49			

APPENDIX E

Table 1. ANOVA results of abstract stimulus words average recall among FS+ subjects per sex of their sinistral blood relatives

Variable	Mean	StDev	DF	F	P
Sex:			1/22	0.88	0.359
Males	28.16	4.56			
Females	33.94	6.34			
Sinistral relative's sex:			1/22	0.56	0.463
Male	35.66	3.76			
Female	26.44	6.85			
Sex*Sinistral relative's sex:			1/22	0.02	0.881
Males*male sin relative	34.69	5.45			
Males*feml sin relative	21.64	7.32			
Females*male sin relati	36.64	5.17			
Females*feml sin relati	31.25	11.57			

Table 2. ANOVA results of concrete stimulus words average recall among FS+ subjects per sex of their sinistral blood relatives

Variable	Mean	StDev	DF	F	P
Sex:			1/22	0.11	0.743
Males	52.70	2.68			
Females	49.94	3.73			
Sinistral relative's sex:			1/22	1.82	0.191
Male	56.42	2.21			
Female	46.22	4.03			
Sex*Sinistral relative's sex:			1/22	0.57	0.458
Males*male sin relative	54.60	3.21			
Males*feml sin relative	50.80	4.30			
Females*male sin relati	58.24	3.04			
Females*feml sin relati	41.65	6.81			

APPENDIX E

Table 3. ANOVA results of emotional stimulus words average recall among FS+ subjects per sex of their sinistral blood relatives

Variable	Mean	StDev	DF	F	P
Sex:			1/22	0.29	0.597
Males	44.64	3.50			
Females	47.86	4.87			
Sinistral relative's sex:			1/22	2.39	0.139
Male	50.89	2.89			
Female	41.61	5.26			
Sex*Sinistral relative's sex:			1/22	0.29	0.594
Males*male sin relative	47.66	4.19			
Males*feml sin relative	41.62	5.62			
Females*male sin relati	54.12	3.97			
Females*feml sin relati	41.60	8.89			

Table 4. ANOVA results of Z-laterality index scores for abstract word stimuli among FS+ subjects per sex of their sinistral blood relatives

Variable	Mean	StDev	DF	F	P
Sex:			1/22	0.45	0.508
Males	-1.40	1.30			
Females	0.09	1.80			
Sinistral relative's sex:			1/22	0.70	0.411
Male	0.28	1.07			
Female	-1.59	1.95			
Sex*Sinistral relative's sex:			1/22	0.96	0.339
Males*male sin relative	-1.56	1.55			
Males*feml sin relative	-1.25	2.08			
Females*male sin relati	2.11	1.47			
Females*feml sin relati	-1.93	3.29			

APPENDIX E

Table 5. ANOVA results of Z-laterality index scores for concrete word stimuli among FS+ subjects per sex of their sinistral blood relatives

Variable	Mean	StDev	DF	F	P
Sex:			1/22	0.88	0.359
Males	-0.67	1.42			
Females	1.60	1.97			
Sinistral relative's sex:			1/22	0.56	0.463
Male	-0.44	1.17			
Female	1.37	2.13			
Sex*Sinistral relative's sex:			1/22	0.02	0.881
Males*male sin relative	-1.39	1.69			
Males*feml sin relative	0.05	2.27			
Females*male sin relati	0.51	1.61			
Females*feml sin relati	2.69	3.59			

Table 6. ANOVA results of Z-laterality index scores for emotional word stimuli among FS+ subjects per sex of their sinistral blood relatives

Variable	Mean	StDev	DF	F	P
Sex:			1/22	0.11	0.743
Males	-0.69	1.63			
Females	-1.62	2.26			
Sinistral relative's sex:			1/22	1.82	0.191
Male	0.72	1.34			
Female	-3.03	2.44			
Sex*Sinistral relative's sex:			1/22	0.57	0.458
Males*male sin relative	0.13	1.94			
Males*feml sin relative	-1.52	2.61			
Females*male sin relati	1.31	1.84			
Females*feml sin relati	-4.55	4.13			

APPENDIX F

Table 1. Percent distribution of significant LEA's and REA's among FS+ subjects per stimulus word category as computed from Z-laterality indices

Stimulus category	FS+ Males		FS+ Females	
	LEA	REA	LEA	REA
Abstract	6(60%)	2(50%)	3(60%)	5(71%)
Concrete	5(56%)	3(60%)	3(60%)	6(86%)
Emotional	7(78%)	5(100%)	3(75%)	7(87%)

Table 2. Percent distribution of significant LEA's and REA's among FS- subjects per stimulus word category as computed from Z-laterality indices

Stimulus category	FS- Males		FS- Females	
	LEA	REA	LEA	REA
Abstract	6(100%)	7(58%)	6(46%)	4(80%)
Concrete	11(73%)	2(67%)	4(50%)	9(90%)
Emotional	5(100%)	5(39%)	6(75%)	6(60%)

APPENDIX G

The pilot raters were administered the following 120 Zulu words to rank three times each: once for abstractness, once for concreteness, and once for emotionality. They were given detailed oral and written instructions on how to rate each of the target words.

They were informed that in this context, a highly abstract word could be taken as a word that is difficult to clearly understand, the least concrete word or a word which was not concrete at all, a word with no reference to known material objects, or a word that referred to characteristics of concrete objects or situations. Practical illustrations were given using appropriate abstract words which were not part of the 120 target words (as a way to avoid influencing their ratings of the target words), as follows. For example, they were given clues that words such as 'lumbo' (from 'i-lumbo' which refers to what is regarded as a very strange form of affliction by some supernatural forces), 'sambane' (from 'i-sambane' which is an imagery underground animal, whose sight is believed by some to be associated with misfortune), 'ncane' (from 'e-ncane' which means small), and 'khalipha' (from 'uku-khalipha' which refers to a state of being clever) could be regarded as abstract.

By contrast, a highly concrete word was defined as a word which referred to practical actions which could be carried out (such as 'gijima' from 'uku-gijima' which means to run),

specific objects which could be seen, touched or imagined in the mind's eyes (such as 'isihlahla' which refers to a tree, or 'itshe' which refers to a stone). They were also told that concrete words could be regarded as words that referred to things, events or situations that could be perceived by any of the sense organs.

With regard to rating the target words for emotionality, the raters were informed that in the present context a very emotional word could be regarded as a word which arouses emotions, such as a feeling of joy, anger, guilt or sadness, a word with an emotional connotation, or a word that referred to an emotional situation. Examples included words like 'i-ntokozo' which means happiness, 'uku-thukuthela' which means to be in a state of extreme anger (a synonym of 'uku-dinwa'), 'umu-thakathi' which refers to someone who practises witchcraft, destructive magic spells or sorcery. Examples of words referring to emotional-laden situations included words such as 'ukwe-swela' (a state of destitution) and 'uku-zingelwa' which means to be pursued or hunted by one or more individuals, who may be one's enemies.

In summary, the raters were told that abstract was the opposite of concrete. Hence none of the target words could rate high on both abstractness and concreteness levels. They were asked to begin rating the target words by simply entering a numerical code on the dotted line under the appropriate stimulus word category. The rating procedure used was unidimensional or unipolar in that raters indicated

whether in their opinion the target word was not abstract (alibukhuni), slightly abstract (libukhuni kancane), moderately abstract (libukhuni kakhudlwana), or highly abstract (libukhuni kakhulu). The same procedure was applied with the concreteness and emotionality rating. Raters were asked to indicate if they did not understand the meaning of the word, rather than just leaving a blank space. Target words included in the final lists are words whose meanings or semantic properties were known to most of the raters. The ratings used are as follows:

- 0 = not abstract/concrete/emotional
- 1 = slightly abstract/concrete/emotional
- 2 = moderately abstract/concrete/emotional
- 3 = highly abstract/concrete/very emotional

The target 120 words are given below, and include those that were not included in the final stimulus word lists.

IGAMA (WORD)	OKUBUKHUNI (ABSTRACT)	OKUBONWAYO (CONCRETE)	OKUNEMIZWA (EMOTIONAL)
1. hleka
2. mbodla
3. hlinza
4. bamba
5. ngozi
6. nginga

	ABSTRACT	CONCRETE	EMOTIONAL
7. liba
8. phupha
9. dladla
10. dinga
11. nhlungu
12. khamo
13. gquma
14. nkuna
15. bola
16. khalo
17. lamba
18. thomba
19. mufi
20. dlelo
21. futha
22. hleba
23. bhozo
24. dunga
25. minza
26. mopho
27. vala
28. phika
29. geja
30. phinga
31. dinwa
32. chama
33. ntunja
34. gqubu
35. bhema
36. ndlondlo
37. bhimbi
38. phunza
39. phuza
40. bhuqa
41. thinta

	ABSTRACT	CONCRETE	EMOTIONAL
42. ntonga
43. khonza
44. lembe
45. khala
46. futho
47. finya
48. bhonga
49. hloba
50. bonga
51. sutha
52. nhlwathi
53. shona
54. vuza
55. nungu
56. zindla
57. guga
58. nqina
59. feba
60. guqa
61. mpatho
62. thuka
63. mfoma
64. mfene
65. njinga
66. jabha
67. thanda
68. zotha
69. nkambo
70. nana
71. lutha
72. chitha
73. lala
74. gwaza
75. nzilo
76. siza

	ABSTRACT	CONCRETE	EMOTIONAL
77. ntshontsho
78. mongo
79. ndonsa
80. songa
81. bhubha
82. ntshontsha
83. cula
84. mfumfu
85. ndlanzi
86. nuku
87. bhunga
88. hloma
89. ndlala
90. mvunge
91. notha
92. shaya
93. mbube
94. njongo
95. zila
96. gwedla
97. thenga
98. nhlonhlo
99. zaca
100. ndondo
101. lunda
102. zonda
103. mbulu
104. bopha
105. gula
106. nkasa
107. gazi
108. nkonzo
109. bila
110. ngcwele
111. nyoka

	ABSTRACT	CONCRETE	EMOTIONAL
112. ngcwaba
113. bumba
114. ngcwenga
115. nhlupho
116. mfumbe
117. beka
118. thutha
119. jova
120. khakha

The 24 concrete words were then rated for imageability after the completion of the primary statistical analyses. They were rated on a 7-point bipolar rating scale, ranging from very low imageability/highly nonimageable in the mind's eyes (akubonakali nhlobonhlobo emehlweni engqondo) to very high imageability/highly imageable in the mind's eyes (okubonakala kakhulu emehlweni engqondo). It is pertinent to state that abstract words were also rated on a 7-point scale for familiarity, ranging from highly unfamiliar (akwazeki nhlobo) to highly familiar (kuyaziwa kakhulu). The final list of 24 abstract words was made up of 12 unfamiliar and 12 familiar disyllabic words. However, since familiarity and abstractness are different concepts, familiarity data did not have to be used in this thesis. Finally, the emotional words list (n=24) included both positive and negative emotional words as in most previous studies (see Chapter 3).