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A study of the effects of time-of-day on hemispheric processing in adults using two dichotic listening tasks.

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A STUDY OF THE EFFECTS OF TIME-OF-DAY ON

HEMISPHERIC PROCESSING IN ADULTS USING TWO

DICHOTIC LISTENING TASKS

By

Margaret J. Wojtowicz

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ABSTRACT

Sixty-four adults, (32 males and 32 females), were
tested on two dichotic listening tasks, consonant-
vowels (CVs) and musical melodies, during two sessions,
one in the morning and one in the afternoon. The study
was set up to examine two time-of-day hypotheses:
Colquhoun's (1971) hypothesis that performance follows
circadian body rhythms and would increase later in the
day; and Folkard's (1979) hypothesis that a cognitive
shift in processing occurs in the course of the day,
such that performance on some tasks would improve while
performance on other tasks would deteriorate. Neither
Colquhoun's nor Folkard's hypothesis was wholly
supported. The only significant effect was an improved
right ear report for males in the afternoon on the
Music task. It is suggested that further investigation
into the transference of information between the
hemispheres is warranted when considering the time-of-
day effect.

ACKNOWLEDGEMENTS

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CHAPTER I

INTRODUCTION

In examining the time-of-day literature, an
extensive computer search revealed many studies in the
area. A number of the studies available dealt with the
effect of shift work on performance. Of particular
interest were the studies linking performance and time-
of-day in the educational setting. One study, which
investigated performance in the language area,
specifically acoustic and semantic processing (Folkard,
1979), presented two possible explanations for a time-
of-day effect. The first possible explanation was
related to arousal. This explanation came out of the
shift work related literature (Colquhoun, 1971).
Colquhoun noted that body temperature over the course
of the day increased. He suggested that the rise in
temperature was indicative of increased arousal over
the course of the day. Colquhoun further related
increased performance to increased arousal. The second
possible explanation set forth was related to a
cognitive shift in processing. Folkard suggested that

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there appeared to be a shift from acoustic (left hemisphere) processing in the morning to semantic (right hemisphere) processing in the afternoon. It was these two possible explanations which formed the basis for the present study.

Given Folkard's second possible explanation (i.e. a cognitive shift explanation) it was necessary to consider hemispheric processing and the specialized functions of the left and right sides of the brain. Investigations into hemispheric processing, using the dichotic listening task, have shown linguistic tasks tend to be housed in the left hemisphere (Kimura, 1961) and non linguistic tasks in the right hemisphere (Kimura, 1964, Knox & Kimura,1970).

Dichotic listening is a technique employed to explore differences in the function of the two hemispheres. This is done by the simultaneous presentation of competing information to the left and right ears. The pairs of stimuli to be presented are played on a stereo tape deck and heard by the subject over stereo headphones. Information, which is presented to the left ear appears to be channelled first to the right hemisphere, whereas, information

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presented to the right ear appears to be channelled to the left hemisphere first. The results of the dichotic listening task are considered indicative of the hemisphere one tends to use to process the information presented.

The purpose of this study was to investigate the effects of time-of-day on hemispheric processing in adults. This was accomplished by using two dichotic listening tasks. A consonant-vowel task was selected as representative of language, since Kimura had found that dichotically presented linguistic stimuli could be linked to left hemisphere processing. The other task was a Music discrimination task, which Kimura (1964) had found could be linked to right hemisphere processing.

A glossary of technical words is presented in Appendix I to assist the reader.

Review of Literature

The following review examines various issues relevant to the present study. Specifically examined are (a) the time-of-day phenomenon, (b) the dichotic listening task, which includes how the process works,

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and its relationship to specific hemispheric processes
and (c) factors which may affect lateralization.

Based on the review of the literature, this
chapter concludes with a conceptual framework and
working hypotheses for the present study.

Time-of Day-Effects

Lavie (1980) in his review of early studies of
time-of-day effects, referred to Dressler's (1892)
report that the speed of Morse code tapping fluctuated
during the day, increasing to late morning, dropping
off in early afternoon and then increasing again until
about 6:00 p.m.. Lavie (1980) also described
Kleitman's (1933) work with tasks such as: sorting
cards, mirror drawing, copying, coding, and
multiplying. Kleitman found diurnal rhythms in both
speed of performance and accuracy with the minimum
occurring in early morning and late at night, and a
maximum occurring at midday.

Baddeley, Hatter, Scott, and Snashall (1970)
examined subjects on two occasions, one in the morning
and the other in the afternoon. The tasks included one
for immediate recall of sequences of nine digits. The

other task, designed to test long term memory, involved a repeated item technique devised by Hebb (1961), in which one nine-digit sequence is surreptitiously repeated. Each of the repetitions was separated by two non-repeated sequences. Baddeley et al. found that immediate memory for digits was better in the morning than in the afternoon. The second task (i.e. Hebb's technique) was more accurately repeated than the non-repeated digits, but, there was no time-of-day effect noted.

Blake (1967) tested adults, using eight tasks, to determine the effect of time-of-day on the performance. Subjects were tested five times a day between 8 a.m. and 9 p.m.. Tasks included novel laboratory tests (five-choice serial reaction, vigilance, time estimates, digit span and reaction time) and practised familiar skills (card sorting, letter cancellations, and calculations). Results fell into three categories. Five tasks (five-choice serial reaction, vigilance, card sorting, letter cancellation and calculations) showed a consistent tendency to improve throughout the course of the day. Time estimation and simple reaction time did not show any significant change in performance

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over the day. Performance, on one task (digit span), deteriorated. Blake's results showed a diurnal variation in performance for the five tasks which improved in efficiency through the course of the day.

Folkard and Monk, (1978) examined the effects of time-of-day on memory for information presented in natural contexts. In the first experiment, 36 subjects were required to read a 1500 word article in three minutes. Subjects were instructed to read for comprehension. As well subjects were directed to read as much as they reasonably could in the time allowed. They were then given ten multiple choice questions to test for comprehension which was an immediate memory task. An instance generation task followed to test long term memory. Subjects were to list as many instances as possible from two categories printed at the top of the page. The six pairs of categories were matched in terms of the number of common instances. Results indicated that there was no significant improvement in reading speed over the course of the day. For immediate memory, there was a time-of-day effect with best results occurring at 8:00 a.m. and poorest results occurring at 8:00 p.m.. There was no

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time-of-day effect for long-term/semantic memory as indicated by the ability to retrieve information required for the category instance task.

In Folkard and Monk's (1978) second experiment 4 groups of school children listened to a tape recording of a story at either 9:00 a.m. or 3:00 p.m.. A multiple choice questionnaire was given on the story's contents. Two groups received the questionnaire immediately following the story and two groups received it seven days later. In the immediate memory group, results were better following the 9:00 a.m. presentation than following the 3:00 p.m. presentation. In the delayed recall situation (seven days later), the 3:00 p.m. presentation resulted in better results than the 9:00 a.m. presentation. Thus, immediate memory was better for material learned in the morning, whereas, long term memory was better for material learned in the afternoon.

In the third experiment, 50 nurses were shown a film at 8:30 p.m. and 4:00 a.m. on either the first or second night of a span of successive night shifts. The retention was tested immediately and after 28 days. Questions were structured in single answer, short

answer and multiple-choice formats. There was inferior

delayed retention following the 4:00 a.m. presentation.

There was an overall 4:00 a.m. superiority in immediate

memory. Thus, immediate memory was better for material

that was learned in the morning, whereas, delayed (long

term) memory was better for material that was learned

in the afternoon.

Morton and Kershner (1985) studied time-of-day

effects on incidental visual memory for words and

ability to solve analogies. Thirty-six normal,

learning disabled and educable retarded children were

randomly assigned to either a morning group or an

afternoon group. Results indicated that both normal

and learning impaired children showed an increased

ability in the afternoon to recognize words that were

processed incidentally. Children tested in the

afternoon on the word memory test showed superior

performance compared to those tested in the morning.

In addition, the educable retarded children did not do

as well as other subjects on the verbal analogies in

the afternoon.

Colquhoun (1971) studied the effects of body

temperature and time-of-day. He recorded body

temperatures of 70 young men (Naval ratings) during the course of a 24 hour period. These temperatures were recorded hourly during waking hours and at two hour intervals during sleep. Colquhoun found that the peak temperature reading occurred at 8:00 p.m., and the minimum temperature occurred at 5:00 a.m..

He found that the fall in temperature took place over an approximately nine hour time period, whereas the rise took almost twice as long. The fall was approximately linear for the most part. The rise was not so, for 60% of it occurred from 5:00 a.m. to 10:00 a.m.. The remainder of the rise occurred at a much slower rate from 10:00 a.m. to 8:00 p.m. (see Figure 1).

In recognizing the variation in body temperature throughout the day, Colquhoun wondered to what extent this variation would affect performance. In three experiments where Naval personnel simulated shiftwork, results indicated an increase in performance for both a vigilance task and a calculations test as body temperature increased.

In the first experiment Colquhoun (1971) found that the circadian rhythm of temperature persisted

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Circadian Rhythm of Temperature.
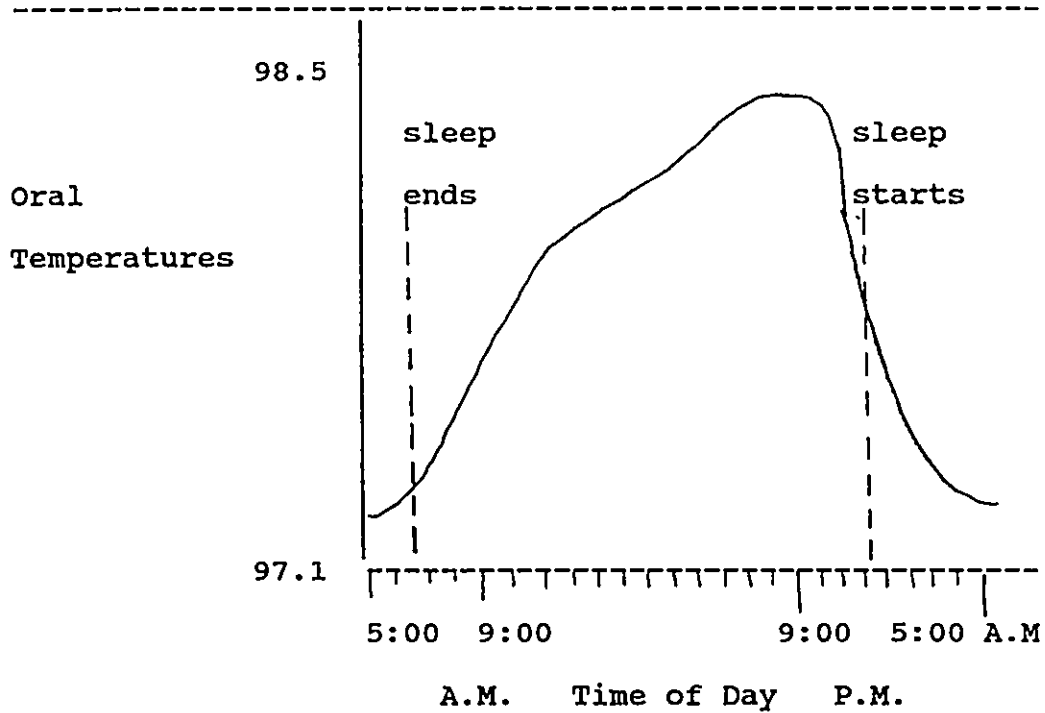
Figure 1. The relationship between the time-of-day and body temperature showing an increase in temperature from 5:00 a.m. to 9:00 p.m. and a decrease in temperature from 9:00 p.m. to 5:00 p.m..

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unchanged throughout the experiment. The experiment
compared rotating versus stabilized split-shift
systems. Subjects were required to perform a vigilance
(auditory discrimination) task during the first work
period and a calculations test during the second work
period. Colquhoun found that the efficiency of mental
tasks was quite closely related to the circadian rhythm
of temperature, in that there was a one-to-one
correspondence between changes in calculation output
and changes in temperature, and a one-to-one
correspondence between changes in detection rate
(vigilance task) and changes in temperature. Colquhoun
observed interesting adaptational shifts in the
circadian rhythm as the temperature during the night
shift gradually rose from the sixth to the eighth day
of a twelve day shift. A parallel rise in performance
was noted as well. The rise in temperature and
performance dropped off at the end of the shifts as
rest was anticipated.

The second experiment dealt with split four hour
shifts with an eight hour rest period between, while
the third experiment studied twelve hour shifts. Both
these experiments found similar results to the first.

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There was a rise in temperature throughout the shift. Performance on the vigilance and calculation tests paralleled the rise, until nearing the conclusion of the shift when a drop-off effect was noted.

Colquhoun demonstrated, as a result of his experiments, that during the course of the day, performance increased as body temperature rose. Colquhoun suggested that the increase in temperature was indicative of an increase in arousal. It was this increased arousal which led to increased performance.

The problem is that performance on some tasks improves while performance on other tasks deteriorates (Blake, 1967, Folkard, 1979). Thus, Folkard (1979), unlike Colquhoun (1971) suggested that a cognitive shift in processing might be the cause of time-of-day effects rather than arousal. Folkard suggested that individuals might spontaneously engage in a shift in the type or level of processing which they adopted over the day. Folkard, in his three experiments studied the effects of time of day on acoustic similarity and semantic similarity. The first experiment was set up to test acoustic similarity effects on short term memory. One hundred and fifty-six subjects were

assigned to six groups of 26 that were approximately matched with respect to both age and the proportion of males and females. Three of the groups were tested at 10:00 a.m. and three were tested at 7:00 p.m.. Acoustically similar words and a list of control words were presented to each group at three different rates of presentation. Control words included: cow, day, bar, few, hot, pen, sup, hit. Acoustically similar words included: mad, man, mat, map, cad, can, cat, cap. From these lists, five words were randomly drawn to represent the control or the acoustically similar lists. After hearing the lists the subjects would be given 15 sec. to make a correctly ordered written recall. Subjects showed superior performance on the control lists both in the morning and in the afternoon. However, subjects showed some improvement in the acoustically similar lists in the afternoon. The acoustic similarity effect was greater at 10:00 a.m. than at 7:00 p.m. and reduced with the slowing down of the presentation rate at both times. Thus, subjects, in the morning, engaged in more maintenance processing based on the physical characteristics of the item.

The second experiment was designed to test the

effect of semantic similarity on memory. One hundred
and twenty-eight of the subjects from experiment one
took part in this study. This time they were divided
into four groups approximately matched for age and the
proportion of males and females. Two of the groups
were tested at 10:30 a.m. and two at 7:30 p.m.. At
each time of day one group learned the semantically
similar list while the other learned the control list.
The semantically similar list consisted of: great,
large, big, huge, broad long, tall, fat, wide, high.
The control list consisted of: good, huge, hot, safe,
thin, deep, strong, foul, old, late. The lists were
shown four times, and after each presentation the
subjects were required to perform a digit span task
involving the memory of six auditorially presented
sequences of nine random digits. After the six
sequences of digits the subjects were given one minute
to write down the list of words in its correct order in
a column. The results were scored in terms of the
number of words written in the correct location for
each successive recall. There was a substantial
semantic similarity effect in the evening. The greater
semantic similarity effect in the evening was due in

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part to greater variation between the performance on the control words which increased somewhat in the evening and a worsening of the performance on the semantically similar list. Though neither of these differences were found to be significant the results suggested that subjects did better in semantic processing in the evening.

Ninety-six subjects were involved in experiment three. They were divided into four groups of 24 subjects each approximately matched for age and the proportion of males and females. Two of the groups were tested at 10:30 a.m. and two at 7:30 p.m.. All four groups learned the same high-frequency monosyllabic concrete nouns. One group at each time of day was required to engage in the digit sequence task between each recall and the subsequent presentation of the word list. The results indicated that the digit sequence task had a greater detrimental effect on performance at 10:30 a.m. than at 7:30 p.m..

Folkard suggested that the results of these experiments indicated that subjects engaged in more maintenance processing based on the physical characteristics (acoustical properties) of the items in

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the morning. The greater semantic similarity effects found in the evening, Folkard indicated, might be due to an increased use of elaborative processing based on the meaning of items.

Folkard suggested that his findings might reflect a cognitive shift in processing. In support of the cognitive shift suggestion, Folkard referred to Martin's (1978) work. Martin found that memory for physically encoded words was superior when presented to the left hemisphere. But, there was no hemispheric difference observed for semantically encoded words. In Folkard's experiment, the acoustically similar words could be compared to Martin's physically encoded words, which produced superior results when presented to the left hemisphere. Therefore, reduced left hemispheric dominance in the course of the day could account for a reduced acoustic similarity effect at 7:00 p.m.. As a result, Folkard suggested that acoustic processing, which was more effective in the morning might be indicative of a left hemisphere process. Semantic processing, which was more effective in the afternoon might be indicative of a right hemisphere process.

Research has developed a number of ways to study

hemispheric processing. Visual half-field techniques, dichhaptic tasks, electrical patterns as recorded by an electroencephalograph, the amount of blood flowing into various regions of the brain, the dichotic listening task, and more recently magnetic resonance imaging are measures which have been used to examine brain lateralization in normals. The dichotic listening task will be the focus of the present study.

Dichotic Listening Task

Dichotic listening is a non-invasive technique employed to assess differences in the function of the two hemispheres. This is done by the simultaneous presentation of competing information to the left and right ears. The pairs of stimuli to be tested are aligned on two tracks of a magnetic tape such that the beginning and end of one stimulus coincide exactly with the beginning and end of the other stimulus. The intensity of the stimulus is balanced. The tape is played over stereo headphones, such that the subject hears one stimulus in one ear and the other stimulus in the other ear. Broadbent (1954) first used the procedure in his selective attention studies. But, it

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was largely the work of Kimura, which gave rise to the popularity of dichotic listening as a tool for investigating hemispheric asymmetry (Beaton, 1985).

Kimura (1961a) showed that temporal lobectomy resulted in deficits in the recall of digits presented to the ear opposite the side of surgical removal. She saw that her findings were consistent with clinical evidence (Rosenweig, 1951) that there are more neural connectors in the contralateral pathways (the right ear with the left hemisphere and the left ear with the right hemisphere) than the same side or ipsalateral pathways. The same side connections were found to be less effective (the right ear with the right hemisphere and the left ear with the left hemisphere) for the transmitting of auditory information.

The dichotic listening procedure presents simultaneously two different messages - one to each ear. The subject is directed by the tester to report on the different information which was simultaneously presented to each ear. The subject may be required to report on what was heard by the left ear only, the right ear only or both ears.

From the data the following information can be

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gathered:

1) laterality (the ear with the higher report)

2) short-term memory capacity (total report)

3) attentional stratcgies

4) selective attending (the ability to attend as instructed to left or right ear)

5) attentional bias (the influence of the non-attended ear in the for. of intrusion errors)

6) priming effects (the effect of the ear attended first upon subsequent processing) (Morton, unpublished manuscript).

Dichotic listening task - reliability. The reliability of the dichotic test has been studied by Blumstein, Goodglass, and Tartter (1975). In a test-retest setting, 29 percent of subjects reversed ear advantage for consonants, 19 percent reversed for music, and 46 percent for vowels. However, the Pearson product moment correlations between $(R - L)/(R + L)$ ear scores on the first and second tests were significant for consonants ($r = .74$) and for music ($r = .46$). The results would indicate reliability, but caution is warranted given the number of reversals of ear advantage reported.

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Adequate reliability and validity for dichotic
procedures were reported by Kraft, Hsia, Roberts &
Hallum (1987) and by Strauss, Gaddes, and Wada (1987).
Thus, research would suggest that dichotic listening
could be considered fairly reliable, but because of the
inconsistency in ear preferences (Blumstein et al.,
1975) caution needs to be exercised.

The directed-report paradigm would appear to
eliminate some of the problems, which might arise with
the free-report paradigm. With the free-report
paradigm there are no controls for individual
strategies in that subjects might vary their strategy
from the test to the retest situation. On the first
sitting subjects may attend to all the stimuli at once,
while on the second sitting decide to attend to a
specific ear first. These changing strategies could
lead to unstable ear advantage scores, which would
affect the test-retest reliability score. In the
directed-report condition, the subject is instructed to
attend to a specific ear. The tester is able to
control the strategy employed by the subject. Thus,
the directed-report paradigm would appear to be the
preferable design strategy to employ (Bryden, 1967).

Dichotic listening task and contralateral

dominance. Kimura (1961 a & b), in studying patients

with lesions of the left temporal lobe, found that the

left temporal lobe had a critical function in the

perception of spoken material, which the right temporal

lobe didn't share. In studying these patients, as well

as normal subjects using dichotic listening tasks,

Kimura found that the scores on the dichotic digit

tests were higher for the ear opposite the dominant

hemisphere. Kimura, based on the work of Rosenweig

(1951), explained this right ear advantage (REA) in

structural terms, in that anatomically, there are more

neural connectors between the right ear and the left

hemisphere than there are between the right ear and the

right hemisphere. Similarly, there are more neural

connectors between the left ear and the right

hemisphere than there are between the left ear and the

left hemisphere. Since the left hemisphere has been

found to be dominant for language, Kimura suggested

that the right ear advantage (REA), which she found on

the dichotic test, might be indicative of language

processing in the left hemisphere. Similarly, the

right hemisphere has been found to be dominant for

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music and therefore, a left ear advantage (LEA) might

be indicative of musical processing (Kimura, 1964) by

the right hemisphere. Kimura, in fact has reported a

right ear preference or right ear advantage for verbal

stimuli (Kimura, 1961 a & b) and a left ear advantage

for music (Kimura, 1964).

Kimura's (1961 a & b) studies showed that

patients, whose dominant hemisphere for language was

known, as the result of the Wada test, displayed a

right ear advantage when the left hemisphere was

dominant. They showed a left ear advantage when the

right hemisphere was dominant for language.

Kimura (1961a), tested 71 patients, suffering from

epileptic seizures using the digit dichotic listening

task. Fifty-five of the patients underwent surgery for

the removal of epileptogenic tissue which required the

removal of the temporal-lobe or frontal-lobe. Kimura

in testing subjects following surgery found that the

patients with lesions of the left temporal-lobe had

poorer digit span results than those with lesions of

the right. The left temporal removal group though

impaired on verbal auditory tasks achieved good results

on non-verbal auditory tasks. The right temporal

removal group experienced opposite results. Such
results led Kimura to believe that the left temporal-
lobe was specialized for the recognition of verbal
material at least in the auditory mode by which she was
testing the patients.

Kimura (1961a) found that temporal-lobe excision,
whether left- or right-sided had an effect on the
perception of digits arriving at the contralateral ear.
This contralateral ear effect was not found in patients
who underwent frontal-lobe excision.

Kimura (1961a) found that unilateral temporal
lobectomies impaired the recognition of digits arriving
at the ear contralateral to the removal. As well, she
found that the number of correctly identified digits
was lower for the left temporal lobectomy than for the
right. Patients with lesions of the left temporal-lobe
produced inferior results before and after surgery
compared to those with lesions of the right temporal
lobe.

Kimura (1961a) concluded that the crossed auditory
pathways were more effective than the uncrossed. She
also saw that the left temporal-lobe played a more
important role in the perception of spoken material

than the right.

Kimura (1961a) found that the preoperative digit score was higher for the right ear for all subjects regardless of the site of the lesion. Since the right ear is more strongly connected to the left temporal-lobe, she suggested that verbal material would be more reliably transmitted to the left hemisphere which was dominant for speech representation.

In a second study, Kimura (1961b) chose to investigate cerebral dominance by examining 120 patients suffering from epileptogenic lesions. Cerebral dominance was determined by the injection of sodium amytal into the internal carotid artery. Temporary dysphasia developed when the dominant hemisphere was injected. One hundred and seven patients demonstrated left hemisphere dominance while only thirteen exhibited right hemisphere dominance.

Using the digit dichotic listening task, Kimura found that when speech was represented in the left hemisphere, the right ear was more efficient. Conversely, she found when speech was represented in the right hemisphere, the left ear was more efficient. Kimura found that for subjects with left hemisphere

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dominance for speech that they primarily exhibited right handedness. More subjects with right hemisphere dominance exhibited left handedness.

Even when subjects were studied for handedness in relationship to hemispheric dominance for language the ear advantage remained the same. Patients, who demonstrated a left hemisphere dominance, showed a right ear advantage. Patients, who demonstrated a right hemisphere dominance, showed a left ear advantage.

In further investigating REA, Kimura (1963) studied children age five and subsequently age four. She found that these children showed a right ear advantage even at those early ages. Kimura concluded that a REA at ages four and five suggested the left hemisphere was prepotent for speech at a very early age.

To test right hemisphere processing for melodies, Kimura (1964) employed a dichotic melodies task, which used a multiple-choice recognition technique. Two different melodies were presented dichotically. Then these melodies had to be selected from a group of four melodies, two of which had not been presented. The

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melodies were not familiar to the subjects. The
melodic test showed a significantly greater number of
accurate identifications for left ear than right ear.
This suggested a right hemisphere processing bias.
These same subjects had a higher score for the right
ear on the digit test.

Kimura (1964) suggested that these tests showed a
clear dissociation of auditory asymmetries depending on
the type of stimulus presented. She saw these
asymmetries reflecting differences between the
functions of the left and right hemispheres.

As a result of Kimura's work, dichotic listening
tasks have been used to determine hemispheric
processing. A right ear advantage (REA) suggests left
hemispheric processing and a left ear advantage (LEA)
suggests right hemispheric processing.

Dichotic listening and hemispheric processing.
Kimura's (1961 a & b) work with the dichotic listening
task encouraged other research into the linguistic
abilities of the left hemisphere (Zurif & Sait, 1970;
Heeschen & Jurgens, 1977). The dichotic listening task
has also been used to explore the linguistic abilities
of the right hemisphere. Some of the right hemisphere

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language abilities fall into the areas of intonation,
emotional inflection, and syntactic structure
(Blumstein & Cooper, 1974; Heeschen & Jurgens, 1977;
McFarland, McFarland, Bain, & Ashton, 1978). The right
hemisphere exhibits superior skill in copying designs
or matching visually presented designs to felt
templates (Nebes, 1974). Nonlinguistic tasks, such as
the identification of non verbal sounds like crying,
shrieking (Knox & Kimura, 1970; King & Kimura, 1972;
Carmon & Nachshon, 1973) and the processing of music
(Kimura, 1964, Zatorre, 1979) appear to be effectively
handled by the right hemisphere.

Factors Which May Affect Lateralization

Segalowitz (1984) has suggested that a number of
variables may contribute variance to lateralization
scores.

Sex differences and lateralization. Women on
average have been found to be superior on verbal and
linguistic skills and men on spatial ability (Harris,
1978). McGlone (1980) suggested that females appeared
to be superior to males in a number of skills which
require the use of language, such as fluency, speed of
articulation and grammar. Whereas, males demonstrated

superior performance in tasks that were spatial in nature, such as maze performance, picture assembly, block design, mental rotation and mechanical skills (McGee, 1979). The question of differences in brain lateralization for males and females appears to have grown out of the ability of different sexes to do well at a particular task. McGlone (1980) in a review of sex differences in human brain asymmetry found a growing base of literature supporting sex differences in lateralization. She found that there was greater left hemisphere dominance in right-handed adult males than in right-handed adult females in dichotic listening and tachistoscopic studies.

Handedness. The pattern of brain lateralization usually described is based on the typical right-handed person, despite 5-12% of the population being left-handed. In dichotic listening tasks and other lateralization measures, left handedness, doesn't appear to follow the usual right side of the body (left hemisphere) bias for speech related tasks (Kimura,1967; Zurif & Bryden,1969; Bryden,1970). Research on other lateralized skills has indicated that right-handers showed a right hemisphere bias when making judgments

about the pitch and loudness of words, while left-
handers did not (Nachshon,1978).

Since gender and handedness may have an influence
on lateralization, an attempt was made to control for
these variables in the present study.

<div align="center">The Present Study</div>

The research question

Folkard in his 1979 study investigated the effects
of time-of-day on acoustic and semantic processing. In
the discussion of his results, Folkard suggested two
possible explanations for the time-of-day effect. One
explanation presented was an improvement due to
increased arousal which followed an increase in
circadian temperature rhythms over the day (Colquhoun,
1971). The other explanation Folkard suggested was
that a shift in the degree of cerebral dominance
occurred over the course of the day, such that the left
hemisphere became less dominant and the right
hemisphere became more dominant as the day progressed.

In view of these two explanations for time-of-
day effects, the question asked in the present study
is: Is there any difference in hemispheric processing

in terms of time-of-day?

To address this question the present study evaluated the performance of adult subjects on two dichotic listening tasks, one for consonant-vowels (CVs), which tested for left hemisphere processing, and the other for music, which tested for right hemisphere processing.

In an effort to consider these research questions, morning and afternoon dichotic scores were collected and later compared for the CV task and for the Music task. Skin temperatures, taken at each of the testing sessions, were compared in order to confirm physiological changes in arousal as indicated by changes in skin temperature.

Hypotheses

Folkard suggested two possible explanations for performance changes related to time-of-day. One explanation presented was an improvement due to an increase in arousal over the day (Colquhoun, 1971). The other explanation Folkard suggested was a shift in the degree of cerebral dominance over the course of the day, such that the left hemisphere became less dominant and the right hemisphere became more dominant as the

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day progressed.

This thesis involved a test of Folkard's two possible explanations of the results of his 1979 study, by examining two dichotic tasks, CVs and Music, which are considered to be representative of left hemisphere processing and representative of right hemisphere processing, respectively. The time-of-day effect was examined by testing performance or CVs and Music in both the morning and the afternoon.

More specifically two hypotheses were tested:

1) Colquhoun's hypothesis that there would be a gradual increase in performance on all tasks from the morning session to the afternoon session which would be paralleled by an increase in temperature from the morning session to the afternoon session; and

2) Folkard's hypothesis that there would be a cognitive shift in processing, whereby the left hemisphere would become less dominant during the course of the day.

Support for Colquhoun's hypothesis would be seen in increases in the verbal (CVs) and Music dichotic scores, as well as increases in temperature from the

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morning testing to the afternoon testing (see Figure 2). Support for Folkard's hypothesis would be seen in verbal (CVs) dichotic scores being higher in the morning session than in the afternoon session, and Music dichotic scores being higher in the afternoon than in the morning (see Figure 3).

Hypothesis 1. reflects Colquhoun's hypothesis that there would be a gradual increase in performance from the morning session to the afternoon session which would be paralleled by an increase in temperature.
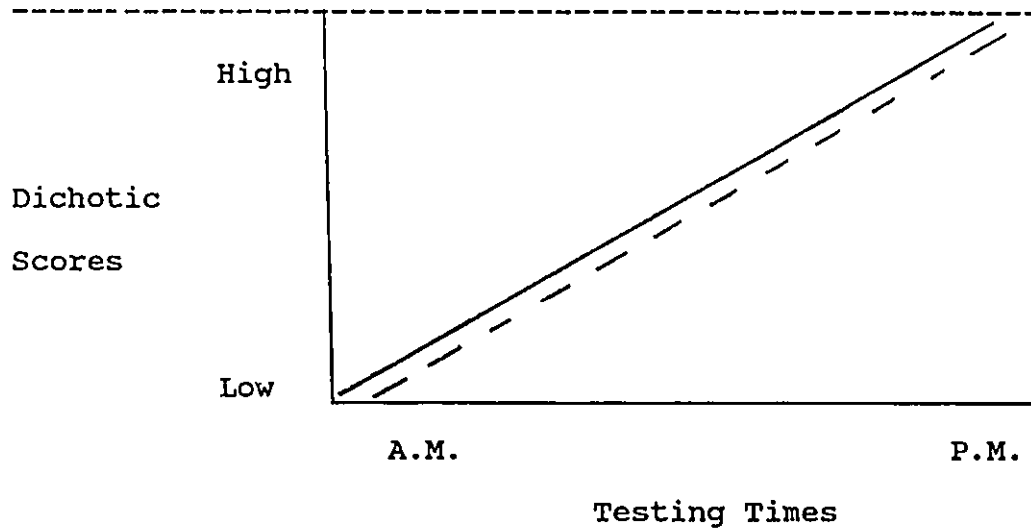
Note. CVs _____

        Music------------------

Figure 2. Conceptual diagram of hypothesis 1, based on Colquhoun's (1971) findings. The diagram shows lower dichotic scores for both CVs and Music in the morning, when skin temperature is lower and increased dichotic scores for both CVs and Music in the afternoon when skin temperature has increased.

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Hypothesis 2. reflects Folkard's hypothesis that there would be a cognitive shift in processing, whereby the left hemisphere would become less dominant during the course of the day.
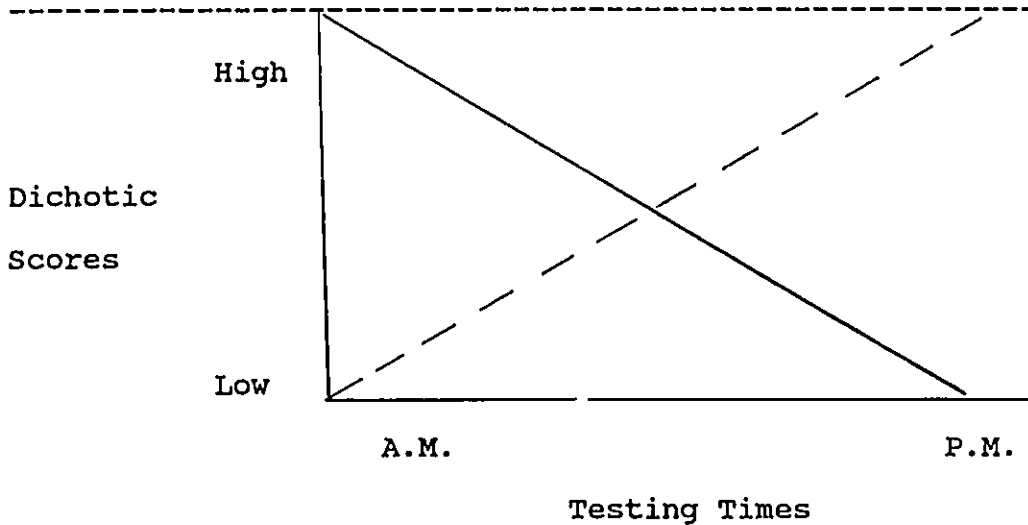
Figure 3. Conceptual diagram of hypothesis 2, based on Folkard's (1979) hypothesis. The diagram shows a cognitive shift in processing which occurs from the morning to the afternoon as indicated by CV (left hemisphere) scores being higher in the morning than in the afternoon and Music (right hemisphere) scores being lower in the morning than in the afternoon.

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CHAPTER II

METHODOLOGY

<u>Subjects</u>

Subjects were university students and recent
graduates, in the age range 20 - 55 years. There were
32 males (27 right handed, 5 left handed) and 32
females (26 right handed, 6 left handed).

Subjects were found to fall within the high
average to the above average range on the WAIS-R
vocabulary subtest (scaled scores mean = 13.38, $\underline{SD}$ =
2.79; males mean = 13.50, $\underline{SD}$ = 2.79; and females mean =
13.25, $\underline{SD}$ = 3.03), and on the WAIS-R block design
(scaled scores mean = 12.97, $\underline{SD}$ = 2.23; males mean =
13.31, $\underline{SD}$ = 2.16, and females mean = 12.63, $\underline{SD}$ = 2.28).

Presentations were made in 5 classrooms during the
summer session in order to encourage participation in
the experiment. Students, from one undergraduate
psychology class received 2% for their participation.
Other subjects came as a result of personal contact or
by the recommendation of a subject.

The original intent was to test only right handers
but as a result of the class reward system, 11 of the

subjects tested were left handers.

Classification of subjects. In the month of July, subjects were required to come to the Faculty of Education on two occasions for testing, once in the morning (between 7:00 a.m. and 10:00 a.m.) and once in the afternoon (between 3:00 p.m. and 6:00 p.m.). Half the subjects (N=16 males and N=16 females) were required to be tested first in the morning while the other half were required to be tested first in the afternoon.

Besides the morning first-afternoon first designation, subjects also were divided into those, who were to attend to the left ear first and those who were to attend to the right ear first. Thus, within the morning-first section (N=32), there were 16 directed left first and 16 directed right first with 8 being male and 8 being female in each segment. This was repeated for the afternoon first group as well. Subjects were further classified by whether they received consonant-vowels (CV) or music task first. The classification of subjects is illustrated in Table 1.

Table 1

Classification of Males and Females as to Time of First Presentation, Stimulus Presented First, and Direction Attended First.

Males

Morning First				Afternoon First			
16 subjects				16 subjects			
Music First		CV First		Music First		CV First	
8 subjects		8 subjects		8 subjects		8 subjects	
DRF	DLF	DRF	DLF	DRF	DLF	DRF	DLF
4	4	4	4	4	4	4	4

Females

Morning First				Afternoon First			
16 subjects				16 subjects			
Music First		CV First		Music First		CV First	
8 subjects		8 subjects		8 subjects		8 subjects	
DRF	DLF	DRF	DLF	DRF	DLF	DRF	DLF
4	4	4	4	4	4	4	4

Note. DRF=direct right first   DLF=direct left first

CV=consonant-vowels

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Testing Instruments

Subject's hearing was tested with a Beltone Model 119 Audiometer, set at 25db. The CV dichotic tape was supplied by Dr. L. Morton. It was produced by Auditec of St. Louis and was identified as Rand H - No Delay. The music dichotic tape was supplied by Dr. John Kershner. The tapes were presented on a Realistic Stereo Dual Cassette Tape Deck SCT-74 which was hooked up to a Realistic Digital Synthesized Stereo Receiver STA-2150. Subjects listened to the tapes with Realistic Pro-60 stereo headphones. Skin temperature was recorded on a Temp SC201T digital skin temperature monitor, which was supplied by Dr. N. Williams.

The assessment and analysis of handedness: The Edinburgh Inventory (Oldfield, 1971) (see Appendix B) was used to determine subject's hand preference. The vocabulary and block design subtests of The Wechsler Adult Intelligence Scale - Revised (WAIS-R) (Wechsler, 1981) were used to determine that the subject's verbal and performance abilities fell within the normal range.

Procedure

An ordered report focused-attention paradigm was

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used. Counterbalancing was implemented for stimulus presented first (CVs first, Music first), for time of first presentation (morning first, afternoon first), and for direction attended first (directed left first, directed right first). This was done to control for practice effects and order effects.

The entire experiment, including two sessions of the two dichotic tasks, hearing test, skin temperature, WAIS-R vocabulary and block design subtest, and 2 questionnaires took a total of 90 minutes. It was determined that to facilitate class and work schedules, 3 divisions of time would be made available to the subjects.

1) session 1: 45 minutes   session 2: 45 minutes

2) session 1: 60 minutes   session 2: 30 minutes

3) session 1: 30 minutes   session 2: 60 minutes

It was determined that in session 1 all subjects would receive the hearing test and the demographic and handedness questionnaires, along with the two dichotic tasks and the measurement of their skin temperature. The WAIS-R subtests would begin the second session unless otherwise requested by the subject.

On arrival at the lab facilities supplied by the

Faculty of Education, subjects were required to fill
out the demographics (see Appendix A) and handedness
questionnaire (see Appendix B).

Subject's hearing was then screened at 25db, on
the advice of a speech pathologist. Only subjects, who
were in the normal range for 1000Hz - 8000Hz were
selected for this study.

Following these procedures, the subject and
experimenter moved to another part of the lab where the
dichotic listening equipment was located. At this time
the subject received oral instructions as to the
dichotic listening task and was instructed to put on
the stereo earphones. All subjects were directed to
attend to the left earphone. When subjects were
directed to attend left, the left earphone would be on
the left ear. When subjects were directed to attend
right, the left earphone would be on the right ear.
Three samples of each task were given on the first
occasion prior to beginning the task. Throughout the
samples and at the beginning of the actual task the
researcher reminded the subject of the direction to
which attention was to be given. The two listening
tasks were heard consecutively, with only a short pause

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to change tapes and give instructions for the second task.

For the CV task, a sheet displaying the CV monosyllables (ba, da, ga, ka, pa, and ta) was provided for the subjects' reference. The CV task consisted of 30 pairs of monosyllables that were spaced seven seconds apart. Subjects were required to direct attention to one ear for 30 trials, then switch earphones and direct attention to the other ear for 30 trials, as instructed by the researcher.

The tester wore the earphones during the test situations, so that she could monitor the results and determine whether any test items were omitted.

For the dichotic music task, 10 target melodies, five seconds in duration, were employed with a different melody on each channel. Following a four second delay, four melodies were played, which were made up of the melody heard in the right ear and the melody heard in the left ear and two extra melodies. These melodies were played in succession with the same melody heard in each ear. Each of these melodies were separated by a two second gap. Subjects were required to direct attention to one ear, then match the melody,

heard in that ear, with one of the four melodies which
followed. Subjects were to direct attention to one ear
for 10 trials. Earphones were then switched and they
were to direct attention to the other ear for 10
trials.

During the first of the music dichotic tasks, the
velcro band with the attached temperature probe was
affixed to the subject's left index finger. The music
task (approximately 10 minutes in duration - each side)
provided ample opportunity for the skin temperature to
stabilize. The temperature was recorded prior to
switching earphones and attending to the other ear.
This normally concluded the first session unless the
subject requested a longer first session to accommodate
scheduling. If such was the case the researcher would
administer the WAIS-R vocabulary and block design
subtests. These subtests usually began the second
session of testing.

The subject's vocabulary answers were recorded by
the tester to facilitate for later examination and
scoring of the subtest. Subjects, in particular
females, expressed anxiety and uncertainty about the
block design subtest. So a few minutes were taken to

demonstrate the components of the blocks: two red sides, two white sides and two sides that were split, half red and half white. Subjects were then shown how the blocks could be matched to make triangles and stripes. This was done in addition to discussing the timed nature and the exact duplication process. The reduction of anxiety was of prime concern to the tester.

The second session would normally begin with the WAIS-R vocabulary and block design subtests. Following these, the subject would complete the dichotic listening tasks in the same manner as they had been directed in the first session. The second skin temperature would be taken during the first directed attention condition of the second session music task.

In appreciation for the subject's willingness to take part in the experiment a summary of the results would be forwarded to them at the conclusion of the study.

The subject's dichotic listening results and information on questionnaires were hand coded by the researcher and entered into a data file on a computer programme after each session.

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The results were analyzed using two-way ANOVAS for CV and Music laterality indices $((R_c - L_c/R_c + L_c)*100$ (Marshall, Caplan, & Holmes, 1975). In this index R_c = right ear correct report, L_c = left ear correct report. In addition, correct report scores for CVs and Music on the left ear and on the right ear were analyzed. Because the sample included left handers ($\underline{N}$=11), oneway ANOVAs were computed to compare left and right handed subjects on all dependent variables. There were no differences between the two handedness groups.

Results are presented in 5 sections: skin temperature; laterality for CVs; laterality for Music; correct report scores for CVs; and correct report scores for Music.

Skin temperature. A t-test revealed that the afternoon temperature ($\underline{M}$ = 32.46, $\underline{SD}$ = 4.46) was significantly higher than the morning temperature ($\underline{M}$ = 31.64, $\underline{SD}$ = 4.49), $\underline{t}$ (1,62) = 2.95, $\underline{p}$ < .01.

Laterality Index for CVs. A two-way ANOVA (Sex by

Time) was computed for the Laterality Index $((R_c - L_c/R_c + L_c) * 100)$ for CVs. Using this index, positive numbers indicate lateralization to the right and negative numbers indicate lateralization to the left. Sex (male, female) was a between-subjects variable and Time (morning, afternoon) was a within-subjects variable.

There were no main effects, or interactions. Means and standard deviations for the Laterality Index for Cvs are reported in Table 2. The ANOVA table for the laterality index for CVs is presented in Appendix C.

Laterality Index for Music. A similar two-way ANOVA was computed for the Laterality Index $((R_c - L_c/R_c + L_c) * 100)$ for Music. Again, using this index, positive numbers indicate lateralization to the right and negative numbers indicate lateralization to the left. Sex (male, female) was a between-subjects variable and Time (morning, afternoon) was a within-subjects variable.

There were no main effects, or interactions. Means and standard deviations for the Laterality Index for Music are reported in Table 3. The ANOVA table for

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Table 2

Means and Standard Deviations for the Laterality Index

$((R_c - L_c/R_c + L_c)*100)$ for CVs for Males and Females

When Tested in the Morning and When Tested in the

Afternoon.

	Male	Female
Morning		
$\underline{N}$	32	32
Mean	17.36	08.28
$\underline{SD}$	30.18	16.83
Afternoon		
$\underline{N}$	32	32
Mean	15.31	12.56
$\underline{SD}$	22.70	18.21

Note. A positive number equals a right ear advantage

(REA) and a negative number equals a left ear advantage

(LEA).

Table 3

Means and Standard Deviations for the Laterality Index

$((R_c - L_c/R_c + L_c)*100)$ for Music for Males and Females

When Tested in the Morning and When Tested in the

Afternoon.

	Males	Females
Morning		
$\underline{N}$	32	32
Mean	-03.96	-00.09
$\underline{SD}$	16.63	08.77
Afternoon		
$\underline{N}$	32	32
Mean	-00.09	-01.36
$\underline{SD}$	08.66	10.88

Note. A positive number equals a right ear advantage
(REA) and a negative number equals a left ear advantage
(LEA).

the laterality index for Music is presented in Appendix
D.

    <u>Correct Report Scores for CVs</u>. A two-way ANOVA
was computed for the Correct Report Scores for CVs, for
the left ear report. The independent variables were
Sex and Time. Sex (male, female) was a between-
subjects variable and Time (morning, afternoon) was a
within-subjects variable.

    There were no main effects or interactions.
However, there was a trend toward significance for Sex,
F (1,62) = 3.49, p < .07. Females (M = 12.67) tended
to achieve better scores for CVs with the left ear than
males (M = 10.84). Means and standard deviations for
the Correct Report Scores for CVs, for the left ear are
reported in Table 4. The ANOVA table for correct
report scores for CVs, for the directed left condition
presented in Appendix E.

    A two-way ANOVA was computed for the Correct
Report Scores for CVs, for the right ear. The
independent variables were Sex (male, female), and
Time. Sex (male, female) was the between-subjects
variable and Time (morning, afternoon) was the within-
subjects variable.

Table 4

Means and Standard Deviations for Correct Report Scores

for CVs for the Left Ear for Males and Females When

Tested in the Morning and When Tested in the Afternoon.

	Males	Females
Morning		
N	32	32
Mean	10.34	12.88
SD	04.99	03.81
Afternoon		
N	32	32
Mean	11.34	12.47
SD	04.94	04.50

Note. Maximum possible score = 30.

There were no main effects, or interactions. Means and standard deviations for the Correct Report Scores for Cvs, for the right ear are reported in Table 5. The ANOVA table for the correct report scores for CVs for the directed right condition is presented in Appendix F.

Correct Report Scores for Music. A two-way ANOVA was computed for the Correct Report Scores for Music, for the lef. ear. The independent variables were Sex and Time. Sex (male, female) was a between-subjects variable and Time (morning, afternoon was a within-subjects variable).

There were no main effects, or interactions. Means and standard deviations for the Correct Report Scores for Cvs, for the right ear are reported in Table 6. The ANOVA table for the correct report score for Music, for the directed left condition is presented in Appendix G.

A two-way ANOVA was computed for the Correct Report Scores for Music, for the right ear. The independent variables were Sex and Time. Sex (male, female) was a between-subjects variable and Time (morning, afternoon) was a within-subjects variable.

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Table 5

Means and Standard Deviations for Correct Report Scores
for CVs for the Right Ear for Males and Females When
Tested in the Morning and When Tested in the Afternoon.

	Males	Females

Morning

$\underline{N}$	32	32
Mean	14.88	15.22
$\underline{SD}$	06.02	04.13

Afternoon

$\underline{N}$	32	32
Mean	15.22	16.00
$\underline{SD}$	05.28	04.43

Note. Maximum possible score = 30.

Table 6

Means and Standard Deviations for Correct Report Scores
for Music for the Left Ear for Males and Females When
Tested in the Morning and When Tested in the Afternoon.

	Males	Females
Morning		
N	32	32
Mean	07.78	08.50
SD	01.85	01.44
Afternoon		
N	32	32
Mean	08.22	08.53
SD	01.39	01.24

Note. Maximum possible score = 10.

The ANOVA revealed no main effects, but there was a significant interaction (Sex by Time), F (1,62) = 3.94, $p <. 05$. Tests for simple effects revealed that males achieved poorer music scores in the morning with the right ear, t (1,31) = 2.03, $p < .05$, than they did in the afternoon. Means and standard deviations for the Correct Report Scores for Cvs, for the right ear are reported in Table 7. The ANOVA table for the correct report scores for Music for the directed right condition is presented in Appendix H.

Table 7

Means and Standard Deviations for Correct Report Scores
for Music for the Right Ear for Males and Females When
Tested in the Morning and When Tested in the Afternoon.

	Males	Females
Morning		
N	32	32
Mean	07.56	08.50
SD	02.37	01.52
Afternoon		
N	32	32
Mean	08.28	08.34
SD	01.61	01.43

Note. Maximum possible score = 10.

CHAPTER IV

DISCUSSION

The research question for this thesis was based on the two possible explanations for the time-of-day effect found in Folkard's 1979 study. The first explanation emerged from Colquhoun's (1971) notion that improvement in performance was due to increased arousal, which paralleled an increase in temperature over the course of the day. In terms of the actual testing, this first hypothesis leads to the prediction that there would be lower dichotic scores for both CVs and Music in the morning, when skin temperature was lower, and that there would be an increase in the dichotic scores for both CVs and Music in the afternoon when skin temperature, and therefore, arousal, had increased.

The second explanation was based on Folkard's suggestion that a shift in the degree of cerebral dominance occurred over the course of the day. More specifically, Folkard suggested that the left hemisphere became less dominant and the right.

hemisphere became more dominant as the day progressed.
Such a cognitive shift from left hemisphere in the
morning to right hemisphere in the afternoon, would be
characterized by high CV scores in the morning and low
CV scores in the afternoon(since CVs are processed
primarily by the left hemisphere), and by low Music
scores in the morning and high Music scores in the
afternoon (since Music is processed primarily by the
right hemisphere).

The first hypothesis (Colquhoun's) was not supported
by the performance on the CVs, even though skin
temperature was significantly higher in the afternoon
than in the morning. However, there was an increase in
Music performance for males in the afternoon, which
partially supported Colquhoun. But, the support was
restricted to Music, to males and to the right ear.
Thus, Colquhoun's (1971) hypothesis, that overall
performance would increase as body temperature
increased was not fully substantiated.

Such a differential performance increase would
appear to be supportive of Folkard's hypothesis. This
second hypothesis stated that were would be a cognitive
shift in processing, whereby the left hemisphere would

become less dominant during the course of the day. As discussed earlier, CVs were considered to be representative of language and left hemisphere processing, whereas, Music was considered to be representative of right hemisphere processing. Higher CV scores in the morning than in the afternoon would be indicative of more left hemisphere processing in the morning. Higher music scores in the afternoon than in the morning would be indicative of more right hemisphere processing in the afternoon. The increased Music score in the afternoon, would therefore be indicative of a shift in processing. But, this improved afternoon score was achieved only on the right ear, and only for males. Thus, the support for a simple cognitive shift is somewhat limited.

The time-of-day effect was restricted to males in the Music stimulus setting and for the right ear only. This time-of-day finding might reflect improved right hemisphere processing in the afternoon. However, the fact that the improvement occurred on the right ear only and for males only would suggest caution be taken in such an interpretation. On the laterality index, a LEA was maintained in both the morning and afternoon

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results for the Music. Thus, there was no clear shift in laterality.

A second possible explanation, for the improved right ear Music score for males in the afternoon would be the simple inability to concentrate on such a complex task as the Music, in the morning, perhaps due to low arousal (Colquhoun,1971). The left ear report may not have been affected by the reduced arousal because of the benefit of the connection to the right hemisphere, which appears to be programmed to process music. The right ear, on the other hand, did not have this same advantage, as the ipsalateral connections (right ear - right hemisphere) are not as strong as the contralateral connections (left ear - right hemisphere) (Rosenweig, 1951). Thus, in a state of low arousal the right ear was further restricted in its ability to effectively access the help of the right hemisphere in processing the Music. Thus, the right ear may have been at a disadvantage because of lack of sufficient arousal as well as its weaker connection to the right hemisphere.

A third possible interpretation, might be linked to the transference of information across the corpus

callosum. In this case, males might have experienced an improved ability in the afternoon to transfer musical information from the right ear to the left hemisphere and across the corpus callosum to the right hemisphere for processing. In effect the transfer of information from the left hemisphere to the right hemisphere might be more efficient in the afternoon.

Anomalous information transfer has been reported with certain populations. For example, Obrzut, Obrzut, Hynd, & Pirozzolo (1981) studied the effect of directed attention on cerebral asymmetries in normal and learning-disabled children. They suggested that a deficit in callosal functioning might have been responsible for an inability of these learning-disabled children to demonstrate a REA when attention was directed to the left ear. Normal children had been able to produce a REA despite the directed attention conditions. Obrzut et al. (1981) suggested that the inefficiency of the corpus callosum to transfer information across the hemispheres blocked the right ear from displaying its advantage. In other words, the left hemisphere should have controlled the processing of information. In the present study, in the morning,

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the right hemisphere maintained its dominance for processing the music task. The lower right ear report would be consistent with Obrzut et al.'s (1981) findings for normals, in that it was indicative of an ability to block the left hemisphere from processing the information. However, in the afternoon, there was an improved music report for males on the right ear. Using Obrzut et al.'s (1981) rationale, this increased performance on the right ear might be indicative of a reduced ability to block the left hemisphere and therefore a time-of-day induced difference in corpus callosal transference.

The linkage of Colquhoun's (1971) arousal theory and corpus callosum transference might suggest that males were less aroused in the morning and so could not effectively activate the transfer of information across the corpus callosum. In the afternoon, males were sufficiently aroused for the corpus callosum to function more effectively as seen in the increased Music score for the right ear in the afternoon. This increased right ear score might be indicative of a greater ability for males to attend bilaterally in the afternoon on the Music task.

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In recent years, the role of the corpus callosum in interhemispheric transfer has been the subject of increasing study. De Lacoste-Utamsing and Holloway (1982), in their post-mortem examination of 14 normal brains (males = 9, females = 5), observed a sex difference in the shape of the splenium, which is the posterior portion of the corpus callosum. They found that the female splenium was more bulbous and larger than the male splenium. They suggested that a larger splenium implied a larger number of fibres interconnecting cortical areas. De Lacoste-Utamsing and Holloway (1982) suggested that the number of interhemispheric fibres correlated inversely with lateralization. They suggested that their results supported the hypothesis that the female brain, was less lateralized and exhibited less hemispheric specialization than the male brain for visuospatial functions (Harris, 1979, McGlone, 1980). The results of de Lacoste-Utamsing and Holloway (1982) were supported by the research of Potter and Graves (1988).

Potter and Graves (1988) tested 48 adults to assess interhemispheric transfer. Subjects were required to compare five tasks: two motor, two tactile and one

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visual task, which were presented simultaneously on both sides of the body midline. The first four tasks the subjects were required to perform blindfolded. The first motor task was to draw with the left and right hand simultaneously, a straight vertical line down the page. The second motor task was to create a straight diagonal line on an "Etch-a-Sketch" ™ toy (Kelton Corporation Ltd.) by turning both knobs simultaneously. The first tactile task required each subject to determine if each palm of their hands had been touched at the same or different loci. The second tactile test required subjects to determine whether cards, touched with the left or right hand were covered in the same or different materials (sandpaper, felt, satin, etc.). A tachistoscope was used for the visual task. The subject was required to state whether the figures in the left and right visual field differed. Potter and Graves found that right-handed males appeared to be disadvantaged on the tested hemispheric transfer tasks. They indicated that their results suggested that more lateralization may be associated with less hemispheric transfer.

All recent findings are not supportive of the sex

related differences in interhemispheric transfer.
Whitelson (1985) in her study of 42 subjects, using
magnetic resonance imaging (MRI) found that no size
difference by sex occurred for the corpus callosum.
However, Whitelson did find that the corpus callosum
was larger by 0.75 square centimeters, or 11 percent,
in left-handed and ambidextrous people than in those
with consistent right-hand preference. The difference
was present in both the anterior and posterior halves,
but not in the region of the splenium itself.
Whitelson suggested that the greater bihemispheric
representation of cognitive functions in left- and
mixed-handers might be associated with the size of the
corpus callosum. Kertesz, Polk, Howell and Black
(1987) found no significant sex or handedness
differences in 104 subjects, when area of the corpus
callosum was measured by MRI. They found that the
ratings of the bulbousness of the splenium as defined
by De Lacoste-Utamsing and Holloway correctly
classified the sex of the subject in only 56% of the
cases, which was not significant on a chi square test.
They did not find the callosal areas correlated with
brain size or for measures of lateralization for hand

performance, dichotic listening or visual field
preference.

The research into hemispheric transfer leaves many
questions unanswered, but it would suggest that
bilateral ability to attend may be related to greater
ability to transfer information from one hemisphere to
the other (Potter & Graves, 1988; de Lacoste-Utamsing &
Holloway, 1982). The results of this study would
suggest that for males, the ability to attend
bilaterally may be affected by the time-of-day and the
type of processing involved. This would appear to be
the case for males, when tested with the Music stimuli
in the afternoon.

The results of this study would suggest that for
adult students, and in particular male students, the
courses which demand a lot of information transfer or
bilateral involvement might be better taken in the
afternoon. Thus, the time-of-day when courses occur
might influence individual performance. When courses
are available at different times of the day, courses
that are cognitively complex might be better taken
later in the day (Folkard, 1979; Folkard & Monk, 1978).
In music schools, afternoon sessions for listening and

performance related courses might prove to provide better results.

A REA existed for morning and afternoon laterality scores for CVs (Kimura, 1967). A LEA existed for morning and afternoon laterality scores for Music, for both males and females (Kimura, 1964, Zatorre, 1979).

The CV result is consistent with previous research (Kimura, 1961 a & b). The music result was more open to debate because of the musician-nonmusician controversy (Bever & Chiarello, 1974; Johnson, 1977; Johnson et al., 1977; Zatorre, 1979). There is some research to indicate that musical background and experience affect the way music is processed. Zatorre (1979) like Kimura (1964) found a LEA for dichotic melodies and a REA for dichotic CVs in his examination of 24 musicians and 24 nonmusicians. He did not find that musicians used left hemisphere processing for musical melodies.

Johnson (1977) found in an examination of 64 adults, 32 musicians and 32 nonmusicians that the musicians, on a dichotic music task, demonstrated a right ear superiority, while nonmusicians performed better with the left ear. Johnson (1977) suggested that as a

person became more musically adept that he would
increasingly make use of left hemisphere processing.
Johnson, Bowers, Gamble, Lyons, Presprey and Vetter
(1977) found in their study of musicians, that
individuals, who were most musically sophisticated more
effectively processed music by the left hemisphere as
indicated by a REA, on a melody discrimination task.
Johnson et al. had subjects identify the two melodies,
which were heard dichotically, from the four melodies
that followed. Johnson et al. (1977) found that the
ability to transcribe music, which is an advanced
skill, was associated with subjects, who processed
music better with the right ear (left hemisphere).

Research of Bever and Chiarello, (1974) also
supported the notion that nonmusicians used the right
hemisphere to process musical stimuli, while musicians
used the left hemisphere. Such a difference appeared
to be the result of musical experience. The research
didn't appear to suggest that the subjects have
differently organized brains but rather, that the
strategies applied to the task were different.
Musically trained subjects, who were adept at analyzing
a melody would favour an analytic strategy in order to

get the correct response. Bever and Chiarello (1974) found that subjects, who were musically adept and used an analytic strategy, processed the information with the left hemisphere. Nonmusicians, on the other hand, tended to approach the task in a more holistic fashion. Bever and Chiarello found that subjects, who used this holistic strategy, processed the music task with the right hemisphere.

Only two subjects, in the present study had sufficient theoretical training to be able to transcribe music (Johnson et al.,1977). Thus, it would appear that the subjects of this study would fall primarily into the nonmusician category. Consequently, the results of this study are consistent with the research reporting a LEA for non musicians (Bever and Chiarello, 1974; Johnson, 1977; Johnson et al., 1977).

For correct report scores for CVs, a trend to significance arose for females. They tended to achieve better scores for the left ear than males. This tendency might be linked to lateralization differences. It has been suggested that females are less lateralized for CVs than males? McGlone (1980) in a review of sex differences in human brain asymmetry found a

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growing base of literature supporting sex differences in lateralization. She found that there was greater left hemisphere dominance in right-handed adult males than in right-handed adult females in dichotic listening and tachistoscopic studies. Reduced lateralization in females might suggest an ability to attend both left and right effectively. Such an ability to attend left and right might also be explained by the effectiveness of the corpus callosum as a vehicle to transfer information from one hemisphere to the other, than it does to overall lateralization. De Lacoste-Utamsing and Holloway (1982) found that the female splenium was more bulbous and larger than the male splenium, which they suggested implied a larger number of fibres interconnecting cortical areas. De Lacoste-Utamsing and Holloway (1982) suggested that females, because of larger corpus callosums were less lateralized than males. As a result, females were considered better able to transfer information bilaterally.

Limitations of present study

There were several technical difficulties, which

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arose in the course of the testing, and might have had some effect on the results. The dichotic listening task has been criticized for being remote from real life and exclusive to the laboratory setting (Noffsinger, 1985). The laboratory setting was not as controlled as perhaps it should have been. During some of the very hot summer days, the room temperature and humidity were quite high and may have affected the subject's performance. A climate controlled room would have eliminated variations in temperature. During the course of the testing, there were occasional times, when hall noise was prohibitive. At those times, the subject was asked to wait until conditions became quieter and less distractive. A sound proofed room would have controlled for noise distracters.

At one time during the testing period, subjects indicated difficulty hearing the dichotic tapes. The tester increased the volume to provide an immediate solution to the problem. The volume was increased equally on both channels. Further investigation into the problem, revealed a faulty earphone connection and the difficulty was remedied.

The time span of the testing might be narrowed from

a three hour time span in the morning and a three hour time span in the afternoon to a more limited time period. Colquhoun's (1971) research has indicated that the greatest rise in temperature occurred in the morning. Thus, the three hour time span between 7 a.m. and 10 a.m. could result in differences in morning performance. Since the continued rise in temperature is slowed in the afternoon, the time difference from 3:00 p.m. to 6:00 p.m. might not be as critical.

Suggestions for further research

The present findings would argue for more research into the hemispheric processing of males and females. The tendency for a higher left ear result for CVs by females might be supported if a larger sample of subjects were used.

The results of the Music task would suggest additional study into the functioning of the corpus callosum would be warranted. In particular, the effects of time-of-day on males and females in the transference of information across the corpus callosum, should be explored.

The present study into the effects of time-of-day on

hemispheric processing was focused on the adult

population. A comparison study of results in courses

that are offered at different times of the day might

provide interesting time-of-day data. Even the study

of professional musicians and their preferred time of

rehearsal might add additional light to the time-of-day

question and in particular the preference for right

hemisphere processing later in the day.

The fact that males improved their performance in

the afternoon would suggest that time-of-day had an

effect on performance. This improved performance would

appear to be sufficient evidence to pursue a similar

study with children.

If time-of-day is a relevant factor, as these

results suggest, then the manipulation of various times

of presenting curriculum in an effort to see if some

courses produce better results when taught at a

particular time-of-day, might prove very insightful.

In such a study, sex preferences would be of special

interest. Male children's performance on school

related tasks appears to be poorer in the early grades

than female children. The time-of-day, courses are

scheduled, may make a difference in the performance of

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males, as early as elementary school.

The present study would suggest that gender differences for tasks and time-of-day exist. Would the same results emerge if other left hemisphere designated tasks such as dichotic digits (Kimura, 1961) or right hemisphere designated tasks such as emotions (Ley,1980) were employed?

Conclusions

The results of this study weakly support a time-of-day effect. Neither Colquhoun 's (1971) hypothesis nor Folkard's (1979) hypothesis fully explain the results. Further research into the effective transmission of information bilaterally would appear to be warranted, since it seems to present a possible explanation for the improved music performance for males in the afternoon.

APPENDIX A

Part 1. General Information

Please provide information about yourself and your
musical background.

    (Please check ✓ appropriate response.)

1. Age   ___ Under 20   ___ 20-24   ___ 25-29

            ___ 30-34   ___ 35-39   ___ 40-44

            ___ 45-49   ___ 50-54   ___ 55-59

            ___ 60+

2. Sex   ___ Male   ___ Female

3. Ethnic origin

    ___ Anglo-Saxon

    ___ French

    ___ Native Canadian

    ___ Other (Please specify):_____

4. Was English your first language learned?

    ___ Yes   ___ No

5. Are you bilingual?

___ Yes   ___ No

If so, in which languages are you fluent?

_____   _____

If so, at what age did you become bilingual?

___ Under 5 ___ 5-13 ___ 14-18 ___ 19-25 ___ 26+

6. The level of education in which you are presently enroled.

___ Preliminary year

___ 1st year

___ 2nd year

___ 3rd year

___ 4th year

___ Masters

___ Doctorate

What is your area of interest?

___ Science   ___ Music

___ Mathematics   ___ Fine Arts

___ Psychology   ___ Languages

___ Other (Please indicate) _____

7. Have you had private music instruction?

____ Yes ____ No

8. If yes, please indicate the instrument and the length of time you studied it. Consider voice to be an instrument.

Instrument	Length of time of instruction
a)_____	_____
b)_____	_____
c)_____	_____
d)_____	_____
e)_____	_____
f)_____	_____

9. If yes, are you presently taking music lessons?

____ Yes ____ No

10. If no, how long ago did you terminate instruction?

____ Under 2 years ____ 2-5 years ____ 5-10 years

____ 10+ years

11. Do you play your instrument regularly for your own enjoyment?

____ Yes ____ No

12. Do you perform with your musical instrument regularly?

___ Yes   ___ No

If yes, please indicate how often?

___ daily   ___ weekly   ___ monthly

___ quarterly ___ twice a year ___ yearly

If yes, please indicate the style of performance. (Please check   appropriate response.)

___ solo   ___ duet   ___ trio

___ quartet   ___ orchestra   ___ Jazz band

___ Rock band ___ band   ___ choir

___ Other (Please specify):_____

13. Have you received any theoretical musical instruction? (Please check   appropriate response.)

___ Rudiments (basic theory)

___ Harmony

___ Counterpoint

___ Composition

___ Other (Please specify):_____

Part 2. The Assessment and Analysis of Handedness

Please indicate your preference for handedness.

(Please check ✓ appropriate response.)

1. Have you ever had a tendency to left-handedness?

___ Yes   ___ No

2. Are/Were either of your parents left-handed?

___ Yes   ___ No If yes, please indicate whom.

___ Father   ___ Mother

3. Are/Were any of your brothers or sisters left-handed?

___ Yes   ___ No   If yes, please indicate whom.

___ brother(s) (Please specify number):___

___ sister(s) (Please specify number):___

The Edinburgh Inventory

Please indicate your preference in the use of hands in the following activities by putting + in the appropriate column. Where the preference is so strong that you would never try to use the other hand unless absolutely forced to, put ++. If in any case you are

really indifferent put + in both columns.

Some activities require both hands. In these cases the part of the task, or object, for which hand preference is wanted is indicated in brackets.

Please try to answer all questions, and only leave a blank if you have no experience at all of the object or task.

		R	L
1.	Writing		
2.	Drawing		
3.	Throwing		
4.	Scissors		
5.	Comb		
6.	Toothbrush		
7.	Knife (without fork)		
8.	Spoon		
9.	Hammer		
10.	Screwdriver		
11.	Tennis Racket		
12.	Knife (with fork)		
13.	Cricket bat (lower hand)		
14.	Golf Club (lower hand)		

		R	L
15.	Broom (upper hand)		
16.	Rake (upper hand)		
17.	Striking match (match)		
18.	Opening box (lid)		
19.	Dealing cards (card being dealt)		
20.	Threading needle (needle or thread		
	according to which is moved)		

APPENDIX C

ANOVA Table for the Laterality Index $((R_c - L_c/R_c + L_c)*100)$ for CVs.

	df	MS	F	p
Sex	1	1120.83	1.49	.23
Time	1	39.87	.15	.70
Sex by Time	1	319.83	1.19	.28
Error	62	267.93		

APPENDIX D

ANOVA Table for the Laterality Index ((R_c $-$ L_c/R_c + L_c)*100) for Music.

	df	MS	F	p
Sex	1	53.94	.32	.57
Time	1	54.37	.51	.48
Sex by Time	1	211.97	2.01	.16
Error	62	105.69		

APPENDIX E

ANOVA Table for the Correct Report Scores for CVs, for the Directed Left Condition.

	df	MS	F	p
Sex	1	106.95	3.49	.07
Time	1	2.82	.25	.62
Sex by Time	1	15.82	1.39	.24
Error	62	11.38		

APPENDIX F

ANOVA Table for the Correct Report Scores for CVs, for the Directed Right Condition.

	df	MS	F	p
Sex	1	10.12	.24	.62
Time	1	10.13	1.13	.29
Sex by Time	1	1.53	.17	.68
Error	62	8.99		

APPENDIX G

ANOVA Table for the Correct Report Scores for Music,

for the Directed Left Condition.

	df	MS	F	p
Sex	1	8.51	2.53	.12
Time	1	1.76	1.59	.21
Sex by Time	1	1.32	1.20	.28
Error	62	1.10		

APPENDIX H

ANOVA Table for the Correct Report Scores for Music,

for th Directed Right Condition.

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	df	MS	F	p
Sex	1	8.00	1.69	.20
Time	1	2.53	1.63	.21
Sex by Time	1	6.13	3.94	.05
Error	62	1.55		

APPENDIX I

Glossary

Corpus callosum - The largest of the commissures

        joining the two cerebral hemispheres.

Dichhaptictask - A task assessing hemisphere

        specialization by having the subject identify

        by touch two objects, one to each hand,

        presented simultaneously.

Dichotic listening - A task designed to assess

        hemispheric specialization by sending

        simultaneous input to the two ears.

Dominant hemisphere - The tendency for one hemisphere

        to control the processing of information in a

        particular task. Often used to refer to the

        hemisphere controlling speech.

EEG - An electroencephalogram is a recording of

        brain wave patterns taken from electrodes

        placed on the scalp.

Frontal lobe - The anterior portion of the cerebrum.

Nondominant hemisphere - The hemisphere not dominant

        for speech.

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Sinistrality - Left-handedness.

Sodium Amytal - The drug used in the Wada test.

Splenium - The posterior portion of the corpus
callosum.

Temporal lobe - The portion of the cerebrum below the
parietal lobe.

Visual half-field - A field of vision to one side of
the point of fixation.

Wada test - A test given to neurological patients
presurgically to determine the effects,
primarily on speech, of the loss of one
hemisphere. A barbiturate, sodium
amobarbitol (sodium amytal) is injected into
the artery leading to one hemisphere.

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VITA AUCTORIS

Margaret Jane Wojtowicz was born on August 21, 1948, in Windsor, Ontario. She graduated from the Hon. W. C. Kennedy Collegiate Institute in 1967. She continued her post secondary education at the University of Windsor, where she received a Bachelor of Music in 1971 and a Bachelor of Education in 1972.

Following two years of teaching with the Windsor Board of Education, Margaret took up a new career as a full-time Mother. During the past sixteen years, she became increasingly involved in ministry to women and in May 1990 received the Phyllis Mitchell Christian Writing Award.

Upon graduation, Margaret intends to broaden her ministry to include special needs children and their parents.