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**LA THÈSE A ÉTÉ
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A LINGUISTIC DEFICIT RESULTING FROM RIGHT HEMISPHERE DAMAGE

by

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This thesis is dedicated to my mother,
Ethel Victoria Saddy.

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i Abstract

This thesis reports on research undertaken by the author to determine if damage to the right hemisphere of the human brain results in a significant linguistic deficit.

The research involves the presentation of tasks designed to test both general cognitive performance and linguistic ability. The results of these tests clearly indicate that damage to the right hemisphere of the brain results in a circumscribed linguistic deficit that cannot be attributed to general cognitive effects resulting from brain damage.

In interpreting the results of this study the author takes the theoretical framework described in Chomsky, Lectures on Government and Binding (1981), and recent work in that framework, to represent a reasonable approximation of the abstract organization of grammar in the brain. This approach allows the deficit in performance exhibited by the right hemisphere damaged individuals on the experimental tasks to be explained in terms of a single underlying impairment affecting a particular level of the grammar. In addition, empirical support is provided for particular aspects of the theory of grammar.

1.0 Introduction

1.1 Present state of knowledge

Investigation of brain damaged patients is a major form of research into the functional and structural characteristics of the human brain. The association of specific symptoms and syndromes with local, unilateral pathology forms the basis of support for current concepts of hemispheric specialization. The research described here lies within this investigative tradition. Its aim is to elucidate the role of the right hemisphere in language processing and to relate this to existing theories of language.

Studies of left hemisphere damaged individuals have resulted in the association of a range of aphasic syndromes with specific lesion sites and have convincingly demonstrated left hemisphere dominance for language¹ (Broca 1865, see Albert and Hecaen 1978 for comprehensive bibliography). Indeed, linguistic abilities are generally regarded as the most highly lateralized of cognitive functions. Similarly, right hemisphere dominance for visuo-spatial information processing has been demonstrated (Gazzaniga 1970) and a range of syndromes has been associated with right hemisphere damage. These include neglect, some agnosias, and dressing apraxia.

Consideration of the specialized abilities of the hemispheres has led to the characterization of their general operating strategies, with the left hemisphere seen as sequential and analytic and the right hemisphere as simultaneous and holistic (Sperry et al. 1969). The widely held view that the right hemisphere plays little or no role in language functions

derives both from the interpretation of language as a highly sequential and analytic operation as well as from the fact that damage to the right hemisphere does not result in a readily perceived language impairment.

However, two approaches to the assessment of right hemisphere linguistic abilities have produced evidence of a right hemisphere contribution to language. In the first, the ability of the right hemisphere to assume linguistic functions in compensation for a damaged left hemisphere is evaluated. Data from commissurotomized (split-brain) subjects (Gazzaniga and Sperry 1967, Zaidel 1977), left hemispherectomized subjects (Smith 1966, Kohn and Dennis 1974, Hillier 1954) and subjects with extensive left hemisphere damage (Cummings et al. 1979) show that the right hemisphere is capable of considerable verbal comprehension. Its expressive ability in adults is, nevertheless, quite limited (Searlemann 1977). In the second approach, the verbal ability of the left hemisphere is evaluated after right hemisphere damage. Administration of aphasia test batteries, designed to evaluate language disturbance after left hemisphere damage, have occasionally revealed language disturbances after right hemisphere damage (Marcie et al. 1965, Citterio 1974). These occurrences are exceptional, however, and right hemisphere subjects generally score within the normal range on aphasia test batteries (Boller 1968).

It should be noted that the above cited work evaluates right hemisphere linguistic abilities in terms of primary linguistic functions (syntax, semantics and phonology) already established

as left lateralized. A third approach to the assessment of right hemisphere abilities takes into account the differences between right and left hemisphere processing and attempts to evaluate language disturbances in terms of right hemisphere processing characteristics. Research within this framework include tests of supra-segmental aspects of language, such as sensitivity to intonation contours, as well as discourse related tasks. Results of such studies have suggested right hemisphere roles that complement rather than mirror those of the left.

For example, while the speech of right hemisphere damaged subjects may seem quite normal initially, under careful examination it has been noted that their speech may have a flat tonal quality and that they may be insensitive to tonal, emotional and affective cues in discourse (Gardner 1975, Geschwind 1976, Ciccione et al. 1980, Gianotti 1972, Ross and Mesulam 1979). Right hemisphere dominance for intonation contours and affective stress has been previously noted (Blumstein and Cooper 1974, Kimura 1973). Thus, such deficits can be interpreted as resulting from damage compromising those areas of the right cortex responsible for processing intonation. By contrast, such deficits are not observed in left brain damaged subjects. Although left brain damaged subjects do have difficulties following discourse, this is due to a more fundamental aphasic impairment (Lesser 1974).

In addition, right hemisphere subjects appear to have another deficit only recently observed. This is an apparent inability to derive and maintain a sense of context. In recent studies, Wapner, Hamby and Gardner (1981) and Delis, Wapner,

Gardner and Moses (in press) tested a group of right hemisphere damaged patients on a battery devised to examine complex linguistic functioning in the right hemisphere. To determine the ability of right hemisphere damaged subjects to organize story elements into a narrative, Wapner et al. and Delis et al. used a "Story Arrangement Test". In this test, randomly ordered sentences composing a simple story were presented to the subjects whose task was to order these sentences into a coherent story. Wapner et al. and Delis et al. found their subjects to be significantly impaired on this task. These subjects seemed to be unable to recognize the relationships between key points of a narrative or story. While left hemisphere damaged subjects are also impaired on this task, their diagnosed aphasic impairments would account for this performance.

Recent investigations in Italy reveal a similar deficit existing at a more basic linguistic level. Research conducted by Cavalli (1980) has shown right hemisphere subjects to be impaired on the performance of a sentence anagram test (Cavalli 1980, Cavalli et al. 1981). In this test, words comprising a sentence are written on separate cards and presented to the patient in random order, the task being to order the cards to form a grammatical sentence. The story arrangement task requires that sentences be composed into a coherent story, while the sentence anagram task requires that words be composed into a grammatical sentence. The similarity between the two tasks suggests a related deficit. This is particularly so in the light of Cavalli's (1980) results in which the nature of the errors made on the

sentence anagram test appear to reflect a pragmatic rather than a syntactic impairment.

Linguistic theory takes the sentence as its object of description (Chomsky 1957, 1965, 1976, 1981). Aphasiological research has supported the theoretical claim that the primary linguistic processes (syntax, semantics and phonology) form an autonomous cognitive system operating at the sentence level. The organization of sentences into a coherent narrative is believed to require the operation of discourse and pragmatic processes. These processes, which call upon world view, societal convention, emotional tone, context and other types of non-verbal information, fall outside the realm of primary linguistic functioning. Right hemisphere processing strategies seem ideal for dealing with discourse and pragmatic processes which require the simultaneous consideration of such various levels and types of information. It is, therefore, not surprising that a right hemisphere lesion leads to the disruption of these processes. However, the organization of words into a sentence fits the description of linguistic functioning. It is not clear that discourse or pragmatic processes are necessarily involved in the association of words into a grammatical statement. Semantic and syntactic constraints appear to be the guiding principles of the task. Yet Cavalli's (1980) results seem to suggest a pragmatic role operating at the sentence level. If it is true that primary linguistic functions make up an autonomous cognitive component, then the analysis of speech or text must proceed from linguistic information derived at the sentence level to pragmatic and discourse processes which are fed, in part, by such linguistic

information. The inability to perform both the story arrangement and the sentence anagram tasks may indicate a disruption of the projection of information from the sentence to discourse levels.

1.2 Objectives)

The research reported here was undertaken to clarify the nature of the seemingly related deficits reported by Cavalli (1980) and Wapner et al. (1981) and Delis et al. (in press). The demonstration of a linguistically related deficit resulting from a focal right brain lesion would be an important addition to our understanding of human neuropsychology. It would also have important consequences for our understanding of linguistic processes. To demonstrate such a deficit it will be necessary to answer two questions:

1. Can the inability of right hemisphere damaged subjects to perform the sentence anagram and story arrangement tests be duplicated?
2. If the subjects are impaired on the story arrangement and sentence anagram tasks, what is the linguistic nature of the deficit?

¹ Right hemisphere dominance for language is known to occur in a very small percentage of the population. However, the research described here is concerned with the analysis of the effect of right hemisphere damage on individuals who are clearly left lateralized for language.

2.0 THE STUDY

2.1 Experimental Tasks

This research addresses the two questions stated above and investigates the role of the right cerebral hemisphere in language processing. It involves the presentation of three experimental tasks designed by the author to probe a range of language skills requiring interaction of linguistic and pragmatic information. The tasks are also designed to present a variety of linguistic constructions. Two of the experimental tasks are based on the sentence anagram test and the story arrangement test described above. The third, the insertion test, is described below.

- A. The sentence anagram test, based on Cavalli (1980), requires that single words be composed into a sentence. This task makes demands on syntactic and semantic ability. It also requires the ability to apply pragmatic knowledge to the composition of syntactic-semantic constructions (phrases) which will in turn create a reasonable sentence. At many stages in the the solution of an anagram sentence the subject will have to formulate new potential propositions and decide from among them on the most reasonable course to pursue.
- B. The insertion test (Saddy et al. 1981) differs from the anagram test in the syntactic and semantic demands it makes. The insertion test requires that a word or a phrase be inserted grammatically and appropriately into a presented sentence. For example, the sentence 'The dog

lay on the mat may be presented to the subject who will then be asked where the word 'lazy' could be inserted into the sentence. This task, while similar to the anagram task, does not require the generation of many changing propositions. The basic proposition is given. The subject's task is to show how the sentence, or phrases within the sentence, can be modified and reparsed in a reasonable way. All the decisions made in the insertion test are made within, at most, the framework of a single pre-established sentence. Thus, unlike the sentence anagram test, the subject need not keep in mind a global representation of a potential sentence while working within the boundaries of a sub-component (phrase) of that sentence.

- C. The story arrangement test, based on Wapner et al. (1981) and Delis et al. (in press), requires sentences to be composed into a coherent narrative. This necessitates the understanding of the propositions expressed by each complete sentence and the recognition of the potential relationships between those propositions.

Together, these three tests examine the interaction of pragmatic information with linguistic information at three levels; the phrasal level in the insertion test, the global sentence level in the sentence anagram test and the supra-sentential level in the story arrangement test.

2.2 Evaluative measures

The study also includes two evaluative measures intended to assess brain damaged subjects' degree of general verbal and cognitive impairment.

- A. The similarities test is an extended version of the Similarities sub-component of the Weschler Adult Intelligence Scale, which is known to correlate highly with verbal I.Q. (Weschler 1954). Its purpose in this study is to evaluate general cognitive and verbal abilities in brain damaged subjects and controls.
- B. The verbal fluency test requires subjects to produce as many words beginning with a given letter (p,l,f) as possible in sixty seconds. This common test is included as an additional general measure of verbal ability.

2.3 Selectional Measures

Visuo-spatial deficits can result from right hemisphere damage. Thus, impairment on the experimental tasks may be due to a diminished ability to rearrange or sequentially order objects in the visal field, rather than a disruption of language processing.

A test sensitive to these aspects of visuo-spatial processing was reported in Veroff (1978). In her picture arrangement test, a sequential event is represented pictorially on a series of cards. The cards are presented to the subject in a random order and must be reordered to represent the event

portrayed. Veroff showed that right brain damaged subjects were capable of the reordering and sequencing required by this task. Defective performance was noted only when determination of the sequence of the cards relied on a visuo-spatial analysis of the contents of a single card. This strongly suggests that poor performance by right brain damaged subjects on the sentence anagram, story arrangement and insertion tests would not be the result of a visuo-spatial problem.

A picture arrangement task, modelled after Veroff's, is included as a screening test to control for the subjects ability to handle the visuo-spatial aspects of the experimental tasks. An individual unable to perform the picture arrangement task will not be tested further.

Contralateral visual field neglect after brain injury is also a common problem, particularly in right brain damaged individuals. A line crossing test is used as a screen for individuals suffering from visual neglect.

Handedness must also be taken into consideration, as a small percentage of left handed individuals, and an even smaller percentage of right handed individuals, are known to be right hemisphere lateralized for language. All brain damaged individuals are evaluated on the Edinburgh Handedness Inventory (Oldfield, 1971). No subject determined to be left handed will be tested further.

2.4 Subjects

The study includes a right brain damaged experimental group and two control groups. The first control group consists of non-brain damaged individuals matched as closely as possible to the experimental group for age, sex and education. The second control group is made up of left brain damaged individuals who exhibit no aphasic symptomatology or are judged to be very minimally impaired.

2.5 Hypotheses

It is assumed that brain damage will result in some degree of reduction in an individual's cognitive abilities. Both brain damaged groups are therefore expected to exhibit poorer performance than non-brain damaged controls on the Similarities Test. However, based on the results of Wapner et al. (1981) and Cavalli (1980), it is predicted that only the right brain damaged group will be significantly impaired on the three experimental measures. By comparing the performance of both brain damaged groups on the Similarities Test with their performances on the three experimental measures it may be possible to demonstrate the independence of performance on the experimental measures from the general cognitive effects of brain damage. The performance of the right hemisphere damaged group could thus be attributed to a specific language deficit.

The hypotheses for this study are:

1. Both brain damaged groups will be impaired with respect to normals on the Evaluative measures.
2. Right brain damaged subjects will be significantly impaired with respect to both control groups on all three experimental measures.

3. Method

3.1 Subject Selection

Right and left hemisphere damaged subjects were chosen with the cooperation of the neurological service of the Ottawa Civic Hospital, the Montreal Neurological Hospital and the Jewish Convalescent Hospital in Laval, Quebec. Non-brain damaged controls were selected from the rehabilitation service of the Ottawa Civic Hospital.

All brain damaged subjects had undergone recent neurologic assessment and pertinent medical history was noted by the experimenter. Potential brain damaged subjects were screened for the presence of visual field neglect, visuo-spatial impairments and handedness. This was done by the administration of the line crossing test, the picture arrangement task and the Edinburgh Handedness Inventory. All subjects were right handed. Left hemisphere damaged subjects had been evaluated by the Speech and Communications group at the Ottawa Civic Hospital. All brain damaged subjects were diagnosed as having suffered a cardio-vascular accident.

3.2 Selectional Measures

Line crossing test. A sheet of paper on which short lines are drawn randomly is presented to the subject. The task is to draw a mark through all of the lines on the page. A right brain damaged person suffering from neglect will ignore the lines left of the mid-line of the page. In a small number of cases, left brain damaged individuals will ignore lines right of the mid-line.

Picture arrangement test. This test is modelled after Veroff (1978) and the picture arrangement sub-component of the Weschler Adult Intelligence Scale (Weschler 1954). The subject is presented with four 3" x 4" cards bearing cartoon representations of events that compose a simple story or sequence of events. The cards are presented in a random order and the subject must rearrange them to reflect the story. The test consists of a practice trial plus ten actual items.

Handedness. The Edinburgh Handedness Inventory (Oldfield 1971) was used to assess handedness. Individuals scoring nine out of ten were considered right handed.

3.3 Evaluative Measures

Similarities. This test was modelled after the Similarities sub-test of the Weschler Adult Intelligence Scale (Weschler 1954). The subject is told he will hear a pair of words and must respond by indicating what these words have in common. Scoring is based on recognition of superordinate category membership in the response. For example, in response to 'apple-pear', fruit would receive two points, 'both have

skins' one point, and 'can eat them' no points. The test is composed of fifteen pairs ranging in difficulty from 'apple-pear' to 'crime-punishment'.

Verbal Fluency. In this test, the subject is asked to produce as many words starting with a given letter as he can in a 60 second time period. The subject is asked to avoid using proper names and productive affixes such as in 'fruit, fruitful, fruitfulness'. Three letters, P, L and F, are tested. The letter 's' is used as a practice item. The subject's score is the sum of the unique words produced for the letters P, L and F during the allotted time periods.

3.4 Experimental Tasks

A. Sentence anagram test. The words composing a grammatical sentence are each printed on 1/4" high, bold face, gothic capitals on individual 3/4" high cards. The length of each card varies with the length of the word printed on it. The cards are presented to the subject in random order. The subject's task is to form a grammatical sentence using all of the words. The subject is asked to read the words aloud before starting the task. There are three practice trials and sixteen test items. There is no time limit set for the trials. The subject is instructed to tell the investigator when he has produced a good sentence. The subject is timed from when he finishes reading the words aloud until he declares he has finished. One point is awarded for a grammatically correct sentence.

B. Insertion test. The subject is presented with a complete grammatical sentence, printed in 1/4" high, bold face, gothic capitals, on a 3/4" high card. The length of the card varies with the length of the sentence. The subject is first asked to read the sentence aloud. He is then presented with a 3/4" high card bearing a word or a phrase printed in 1/4" high, bold face, gothic capitals. His task is to show where the word or phrase can be inserted into the sentence. He must then read the new sentence aloud. The test consists of three practice trials and twelve test sentences. There are three or four non-cumulative insertions per sentence. The insertions for each sentence are done sequentially. The time for the subject to complete all of the insertions for a sentence is recorded. One point is awarded for each grammatically correct insertion.

C. Story arrangement test. Four or five sentences composing a simple story are each printed in 1/4" high, bold face, gothic capitals on individual 3/4" high cards. The length of the cards varies with the length of the sentences. These cards are presented to the subject in random order. The subject is asked to read the sentences aloud and is then asked to form a coherent story using all of the sentences presented. The test consists of three practice trials and ten items. Testing begins after the subject has read the sentences aloud and ends when he declares that the story is completed. The scoring is as follows: 3 points if the paragraph produced matches the paragraph in the protocol, 2 points if the paragraph produced is well-formed but

3

differs from that given in the protocol, 1 point if the paragraph produced is marginal and 0 points for a paragraph that makes no sense.

3.5 Procedures

Initial screening of potential subjects was done through examination of medical charts and discussion with nurses and neurologists. A bedside interview with the patient was conducted in which the nature of the study was explained. Each subject was told that his cooperation in the study was strictly voluntary and that the study was not in any way connected with his treatment or eventual recovery. Once an individual was determined to be a suitable and willing candidate for the study, a testing session was arranged.

All testing was done in two sessions. The first session lasted approximately ninety minutes. The second, usually conducted a day later, lasted an hour. The composition of the sessions was as follows:

Session I

Screening tests

Line crossing test

Picture arrangement test

Handedness

Evaluative Measures

Similarities

Verbal Fluency

Experimental Measures

Story Arrangement Test

Sentence Anagram Test (The first 8 items only)

Session II

Experimental Measures

Sentence Anagram Test (The last eight items)

Insertion Test

The order of presentation of the items within each experimental measure was randomized throughout the population.

3.6 Experimental Population

The experimental population consisted of 5 right hemisphere damaged individuals, 4 non-aphasic left hemisphere damaged individuals and 6 non-brain damaged individuals. All brain damaged subjects were diagnosed as cardio-vascular accidents involving the middle cerebral artery distribution. Tables 1 and 2 give background information on the experimental population. RBD indicates right hemisphere damaged subjects, LBD indicates left hemisphere damaged subjects and NBD indicates non-brain damaged subjects.

TABLE 1. Background Information on Experimental Population

	NAME	AGE	SEX	EDUCATION (yrs)	TIME SINCE ONSET
RBD	LD	69	F	12	7 mo.
	IB	60	F	18	3 wks.
	GP	67	F	10	4 mo.
	YB	27	M	14	5 yrs.
	JS	59	M	7	5 mo.
LBD	AD	69	F	19	2 wks.
	LF	75	M	18	22 mo.
	EH	71	F	13	9 wks.
	SL	30	M	15	5 yrs.
NBD	SR	30	M	20	
	MN	61	F	12	
	BD	74	F	12	
	RC	60	M	9	
	RG	60	M	13	
	SS	29	F	13	

TABLE 2. Mean Age and Education of Population

	AGE	EDUCATION
RBD	56.40 (s.d.=16.99)	12.20 (s.d.=4.14)
LBD	61.25 (s.d.=20.98)	16.25 (s.d.=2.75)
NBD	52.33 (s.d.=18.47)	13.71 (s.d.=3.66)

4. RESULTS

The results reported in tables 3 through 6 represent the individual subjects' scores on each of the measures. See appendix I for complete protocol, including individual test items. See appendix II for subjects' raw scores on individual test items.

TABLE 3. Individual Scores on the Evaluative Measures Arranged by Group

	NAME	SIMILARITIES	VERBAL FLUENCY
RBD	LD	21/30	41
	IB	25/30	30
	GP	18/30	27
	YB	19/30	26
	JS	18/30	17
LBD	AD	25/30	44
	LF	20/30	15
	EH	22/30	37
	SL	22/30	29
NBD	SR	26/30	43
	MN	28/30	26
	BD	24/30	49
	RC	21/30	30
	RG	28/30	43
	SS	29/30	72

TABLE 4. Group Performance Means for Evaluative Measures

	SIMILARITIES	VERBAL FLUENCY
RBD	20.20 (s.d.=2.95)	28.20 (s.d.=8.64)
LBD	22.25 (s.d.=2.06)	31.25 (s.d.=12.45)
NBD	26.00 (s.d.=3.03)	43.83 (s.d.=16.31)

TABLE 5. Individual Scores on Experimental Measures
Arranged by Group

	NAME	STORY	SENTENCE	INSERTION
RBD	LD	23/30	12/16	34/40
	IB	27/30	14/16	36/40
	GP	26/30	12/16	35/40
	YB	14/30	11/16	36/40
	JS	6/30	9/16	34/40
LBD	AD	29/30	16/16	38/40
	LF	18/30	15/16	37/40
	EH	25/30	15/16	38/40
	SL	26/30	15/16	39/40
NBD	SR	22/30	16/16	40/40
	MN	27/30	16/16	38/40
	BD	20/30	16/16	38/40
	RC	19/30	14/16	39/40
	RG	20/30	16/16	39/40
	SS	25/30	16/16	40/40

TABLE 6. Group Performance Means for Experimental Measures

	STORY	SENTENCE	INSERTION
RBD	19.20 (s.d.=8.98)	11.60 (s.d.=1.82)	35.00 (s.d.=1.00)
LBD	24.50 (s.d.=4.65)	15.25 (s.d.=0.50)	38.00 (s.d.=0.82)
NBD	22.17 (s.d.=3.19)	15.67 (s.d.=0.82)	39.00 (s.d.=0.89)

Simple one tailed t-tests were applied to the results reported above in order to determine if there was a significant impairment demonstrated on any of the measures by the brain damaged groups with respect to each other or with respect to the performance of the non-brain damaged group (see Table 7).

TABLE 7.

T-Test Results and Corresponding Significance Levels for Brain Damaged Groups Compared to Non-Brain Damaged Group on Evaluative Measures

	SIMILARITIES	VERBAL FLUENCY
RBD vs. NBD	t= -4.40 df= 4 p < .01	t= -4.05 df= 4 p < .01
LBD vs. NBD	t= -3.64 df= 3 p < .025	t= -2.02 df= 3 ns

Table 7 shows that both brain damaged groups are impaired on the evaluative measures in comparison to the non-brain damaged controls. There was no significant difference between the performance of the two brain damaged groups on the evaluative measures. These results support hypothesis 1 which predicted that both brain damaged groups would be impaired on the evaluative measures compared to the non-brain damaged group.

T-tests were also applied to the performance of the three subject groups on the experimental measures. Table 8 shows the results of the comparison of the performance of the right hemisphere damaged group against the left hemisphere damaged group and the non-brain damaged group.

TABLE 8.

T-Test Results and Corresponding Significance Level
for Right Brain Damaged Group Compared to Non-Brain Damaged
and Left Brain Damaged Groups on Experimental Measures

	STORY	SENTENCE	INSERTION
RBD vs. NBD	t= -.74 df= 4 ns	t= -5.00 df= 4 p < .005	t= -8.94 df= 4 p < .0005
RBD vs. LBD	t= -1.32 df= 4 ns	t= -4.48 df= 4 p < .01	t= -6.71 df= 4 p < .005

From Table 8, it can be seen that right hemisphere damaged subjects were significantly impaired on the sentence anagram and insertion tests with respect to both the left brain damaged and the non-brain damaged groups. There was, however, no significant difference between the performance of the right brain damaged group and either the left brain damaged group or the non-brain damaged group on the story arrangement test.

These results partially support hypothesis 2, which predicted that the right hemisphere damaged group would be significantly impaired on the experimental measures with respect to both the non-brain damaged and left brain damaged groups. Furthermore, the left brain damaged group showed no significant decrement in their performance on any of the experimental measures with respect to the non-brain damaged group (see table 9).

TABLE 9.

T-Test Results and Corresponding Significance Levels
for Left Brain Damaged Group Compared to Non-Brain Damaged Group
on Experimental Measures

	STORY	SENTENCE	INSERTION
LBD vs. NBD	t= 1.00 df= 3 ns	t= -1.68 df= 3 ns	t= -2.44 df= 3 ns

5.0 Discussion

From Table 7 above it can be seen that hypothesis 1 of the study has been born out. Both groups of brain damaged subjects are similarly impaired on the evaluative measures with respect to the non-brain damaged subjects. In fact, there was no significant difference between the performance of the two brain damaged groups on the evaluative measures (see Table 7). As predicted, only the right hemisphere damaged group was significantly impaired on the sentence anagram and insertion tests (see Tables 8 and 9). This pattern of results clearly indicates that the general effect of brain damage is not a sufficient explanation for the diminished performance of the right hemisphere damaged subjects on the experimental measures. Thus, hypothesis 2 and its underlying assumptions are partially supported.

Although hypothesis 2 was born out in the case of the sentence anagram and insertion tests, this was not the case for the story arrangement test. With the exception of one subject, JS, the right hemisphere damaged subjects in this study had little problem producing reasonable paragraphs. This is surprising, as the story arrangement test was based on the results reported in Wapner et al. (1981) and Delis et al. (in press). They found that right hemisphere damaged subjects could not perform the story arrangement task. The failure of the present study to reproduce Wapner et al.'s and Delis et al.'s results appears to be due to a basic methodological difference. In these two previous studies, the subject was first presented with a theme sentence that summarized the theme and events to be represented in the target paragraph. Only then was the subject

presented with the sentences he was to use to construct the paragraph. In the study reported here, no such theme sentence was employed. The subjects were simply presented with the randomly ordered sentences and asked to produce any reasonable paragraph employing those sentences.

Although one would presume that the presence of a theme sentence would improve performance on the story arrangement test, a comparison of the Wapner et al.'s and Delis et al.'s results with the results of the present study would indicate the reverse is true. Furthermore, given the right hemisphere damaged subjects' ability to perform the story arrangement task in the present study, it is clear that the impairment demonstrated by the right hemisphere damaged subjects in the previous studies is not due to difficulty in respecting or generating either text or discourse structures. Rather, it will be argued later that the impairment is due to the presence of the theme sentence and is in accord with a linguistic analysis of errors made by the right hemisphere damaged subjects on the sentence anagram and insertion tests.

5.1 The Nature of the Linguistic Deficit

5.1.1 The Insertion Test

The right hemisphere damaged group was significantly impaired on the insertion test with respect to both the non-brain damaged group ($p < .0005$) and the left hemisphere damaged group ($p < .005$). The robustness of these effects may be due to a subset of items which consistently proved difficult for the right hemisphere damaged subjects. The analysis that follows will consider those items of the insertion test that 2 or more right brain damaged subjects performed incorrectly (see appendix II for raw scores).

The following insertions proved problematic for the right brain damaged group (# incorrect indicates the number of right hemisphere subjects who performed the item incorrectly):

<u>Item</u>	<u>Insertion</u>	<u>#Incorrect</u>
1.2 the cat the dog chased scratched him	after	2
1.4 " " " "	that	2
4.2 if sally comes she will bring salad	then	2
5.1 the boy that is missing is sick	among the	2
7.1 cindy saw her take his drink	daughter	2
7.2 " " " "	Howard	4
9.2 the store is open for business	hours only	4
10.4 everybody appears concerned about him	not	2

The errors made by the right hemisphere damaged subjects in the above insertions were of two sorts. Either the subject simply claimed he could not find a suitable place to put the item to be inserted or the subject treated the item as some kind of

modifying agent, generally a sentential adverb. In the latter case the subjects sometimes stated that their insertion seemed odd. The errors made by the right hemisphere damaged subjects on three insertions (1.4, 4.2 and 10.4) do not correspond to this pattern and are treated here individually.

In insertion 1.4:

the cat the dog chased scratched him that
the error was to put the 'that' in a potential complementiser position in the embedded S:

the cat the dog chased that scratched him

Two subjects made this error. In at least one case this error can be attributed to the subject believing that the empty comp position in the base sentence was filled. In reading the sentence aloud, the subject read:

the cat that the dog chased that scratched him

In insertion 4.2:

if Sally comes she will bring salad then

the sentences produced were:

then if Sally comes she will bring salad and

if Sally comes she will bring salad then

These constructions using 'then' as a temporal adverb were also produced by two of the left hemisphere damaged subjects and two of the non-brain damaged subjects. Although such constructions are not ungrammatical, they are marked here in the absence of supporting context. Given the performance of the other subject groups on 4.2, the performance of the right hemisphere damaged subjects on this item cannot be interpreted as indicating a

particular deficit in performance.

In insertion 10.4:

everybody appears concerned about him not

the sentence produced was:

everybody appears not concerned about him

In general, negation was not a problem for the right hemisphere damaged group. Insertion 9.3, which required the insertion of 'not' into the sentence 'the store is open for business', caused no trouble. What is interesting about insertion 10.4 is that the incorrect insertion made by the subjects is incorrect not on structural grounds but, rather, on morpho-lexical grounds. For the negation to appear where they have placed it, the sentence would have to read 'everybody appears unconcerned about him'. These subjects have respected the general principles of negation but have failed to respect a lexical, word formation rule that requires the incorporation of the negative. This error was also made by three of the non-brain damaged subjects and therefore, cannot be attributed to a particular deficit. It is, nevertheless, interesting, in view of the subsequent analyses.

It will be seen that the remaining errors can be accounted for in terms of a single deficit.

The insertion of 'Howard' in 7.2 requires that the subcategorization of the verb 'take' in the base sentence be changed from a single argument to two arguments;

take [(his drink)] ---> take [(Howard)(his drink)]

This change could be the source of the subjects' trouble with this particular insertion. However, this explanation does not

generalize to the other errors made by these subjects. Furthermore, insertion 7.3, which requires 'from him' to be inserted into the same base sentence, requires the identical reassignment of the status of the verb 'take' in the embedded sentence;

take [(his drink)] ---> take [(his drink)(from him)]

This insertion proved to be non-problematic. No brain damaged subject made an error on insertion 7.3. Thus, it is not the shift from a single argument structure to a two argument structure that is the source of the problem in 7.2.

It is interesting to note that while insertion 7.3 was performed properly by all subjects, the right hemisphere damaged subjects were incapable of insertion 7.2. Insertion 7.2 is, in fact, the dative equivalent of 7.3

V[np1][p[np2]] ---> V[np2][np1]

This failure to deal with a particular structure indicates that the underlying deficit affecting the performance of these subjects is linguistic in nature. If their problem was of a more general cognitive nature, such as a general problem solving deficit affecting their ability to manipulate the elements of a problem or argument, then surely 7.3 and 7.2 should be of equal difficulty.

Another possible analysis of the problem in 7.2 concerns Case assignment. In 7.2, the inserted element 'Howard' must be assigned Case by the verb 'take', requiring the already present NP 'his drink' to have its Case reassigned. Thus the insertion of 'Howard' into 'take his drink' results in a disturbance of the

Case relations already established in the sentence. In insertion 7.3, the prepositional phrase brings its own Case with it. Its inclusion in the base sentence does not disturb the established Case relations. Although a disturbance in Case assignment appears to explain the right hemisphere damaged subjects' difficulty with 7.2, this analysis will not generalize to the other common errors made by the right hemisphere damaged subjects.

Like insertion 7.2, which we will return to later, insertion 9.2 was a problem for 4 of the 5 right hemisphere damaged subjects. This insertion requires that 'hours only' be incorporated into the adjectival phrase 'open for business' in the base sentence 'The store is open for business.'

[[open][[for][[business]]]]
 AP Adj PP P NP N

[[open][[for][[business][hours]]]] [only]
 AP Adj PP P NP Adj N Adv

Here the basic structure of the adjectival phrase is maintained and the preposition still assigns Case directly to its complement of ~~which~~ 'business' is still the first element. Thus, the manipulation of Case relations is not required and cannot be the source of the problem in 9.2. Nor can the attachment of the adverb 'only' be considered to be a source of trouble. Insertions 1.3, 2.3, 3.2, 4.1, 4.3, 5.4, 6.3, 10.2 and 11.2 all required the insertion of adverbials into various structures and none of these insertions caused the right hemisphere damaged group any trouble. What is required in insertion 9.2 is the lexical re-analysis of

re-analysis. One example is insertion 11.1:

I opened the book on the table which was

[[I] [opened] [the book] [on the table]]
S NP VP V NP PP

[[I] [opened] [the book] [[which] [e] [was] [on the
S NP VP V NP S Comp NP VP V PP
table]]]]

In insertion 11.1 it should be noted that while the task requires the re-analysis of the sentence structure from a simple S to an embedded S, no lexical reassignment is required.

It may also be argued that the difficulties in 9.2 and 5.1 stems more from the fact that the items to be inserted ('hours only' and 'among the') are not members of any natural constituent category. This does not substantially change the nature of the analysis of the performance of the right hemisphere damaged subjects. The problem in this case becomes one of constituent analysis as well as lexical re-analysis.

However, this observation is countered by the fact that insertion 8.3:

it is strange that Christine left more than

--- it is more than strange that Christine left

posed no problem for the right hemisphere damaged subjects. In this insertion, 'more than' parallels 'among the' and 'hours only'. Its lack of membership in a natural category should have also caused problems. In this insertion however, no lexical re-analysis takes place. 'more than' is incorporated directly into the adjectival phrase 'strange' and 'strange' keeps its original lexical identity.

It centers around how Case can be assigned to the second NP in such structures without violating the principle of strict adjacency. In the government and binding framework a verb assigns Case to its complement (Chomsky 1981). In the above sentence 'his drink' is the original complement of the verb and receives its Case from the adjacent verb 'take'. In double object structures such as 'take Howard his drink', 'Howard' is the adjacent element receiving Case and Case must be transmitted either over or through 'Howard' to the second NP 'his drink', thus requiring a modification of the adjacency condition to account for Case assignment to the second NP in double object structures (see Chomsky 1981:94).

While presenting a theory of a category-neutral base component, Stowell (1981) argues for the retention of the strict-adjacency rule for Case assignment. Stowell demonstrates that maintaining this requirement of strict-adjacency allows the order of constituents in a phrase to be derived from the theory of Case. Adhering to the principle of strict-adjacency, Stowell argues, requires the existence of a verb incorporation rule (see Stowell 1981: chap.5). He proposes a word formation rule that operates in double object constructions to produce a complex verb (see Stowell 1981:301) such as:

[[[take]-[Howard]][his drink]]
 VP V V N NP,

Adopting such an analysis overcomes the problem of adjacency for Case assignment in such structures. As is argued in Stowell (1981), incorporation of the first NP into the verb in double object structures allows Case to be assigned to the direct object

under adjacency. The incorporated object is treated as having the status of a clitic.

Stowell extends his application of a complex verb word formation rule to verb-particle constructions as well. He argues that structures such as 'turn on the light' should be analysed as:

[[[turn]-[on]] [the light]]
 VP V V Prt NP

(see Stowell, 1981, pg.301.)

Given Stowell's treatment of verb-particle constructions, the analysis of the deficit portrayed by right hemisphere damaged subjects presented here would predict that these subjects would have trouble with verb-particle constructions as well. In fact, the last problematic insertion left to be considered corresponds to just this structure.

Insertion 1.2:

the cat the dog chased scratched him after
 ----- the cat the dog chased after scratched him

A standard analysis would treat 'after' in this structure as a preposition. Insertions 4.4, 7.3, 8.1, 10.1 and 12.1 all involved prepositional structures and posed no problem for the right hemisphere damaged subjects. Thus, under a standard analysis of structure, the problem the right brain damaged subjects had with the insertion of 'after' in 1.2 is mysterious.

[[chased][e]] --->[[chased][[after][e]]
 VP V NP VP V PP P NP

However, Stowell predicts that the complex verb word formation rule should apply in this structure. Adopting this treatment

changes the task from the insertion of a preposition into the VP to a lexical re-analysis task similar to 7.2 and all the other problematic insertions.

[[chased] ---> [[[chased]-[after]]
VP V VP V V Particle

The data from the performance of the right hemisphere damaged subjects on the insertion test provides independent support for Stowell's analysis of these double object and verb particle constructions. Adopting an analysis that invokes a word formation rule which generates complex verbs in double object and verb-particle constructions allows the difficulties experienced by the right hemisphere damaged subjects to be characterized by a single deficit. The right hemisphere cortical damage suffered by these subjects has resulted in an inability to reassign lexical category membership when manipulating sentential components (insertions 4.2, 5.1, 7.1, 9.2) and an inability to respect the operation of word formation rules triggered by the manipulation of sentential components (insertions 1.2, 7.2, 10.4). These two observations indicate that the deficit expressed by these right hemisphere damaged subjects affects the level of the lexicon in their grammars. In particular, the deficit seems to impair the application of word formation rules to individual lexical entries once a lexical item has been projected to the other components of the grammar.

The theory of grammar adopted here is that of Chomsky (1981). In this theory the components of the grammar are as

follows:

1. the lexicon
2. the syntax
 - the categorial component
 - the transformational component
3. the phonetic form component
4. the logical form component

The lexicon is composed of lexical items each specified for categorial features, contextual features and morpho-phonological structure. Rules of word formation apply in the lexicon and may change the specifications of a lexical item.

Within the government and binding theory, the lexicon is a major and powerful component of the grammar. It is the lexicon, along with the categorial component of the syntax, that constitutes the base. Deep structures are generated from the application of base rules to the categorial component and the lexicon. Thus, an impairment of the lexical component would severely compromise the grammar as a whole. As was noted in the introduction, these right hemisphere damaged subjects have no severe productive impairment that would correspond to an internal disturbance of the lexicon. The task the right hemisphere damaged subjects found difficult within the insertion test was responding to the categorial and morphological specifications demanded of a lexical item by the syntactic component during an insertion. In other words, the path from the lexical component to the other components of their grammar is intact, but they appear to have difficulty going from the other components back into the lexicon.

5.1.2 SENTENCE ANAGRAM

The right hemisphere damaged subjects were impaired on the sentence anagram test with respect to both the non-brain damaged group ($p < .005$) and the left hemisphere damaged group ($p < .01$). As in the insertion test, the right brain damaged group had trouble with a common restricted set of sentences within the test. The sentences that the right brain damaged subjects could not construct from their individual words were:

<u>Sentence</u>	<u># incorrect</u>
6. There came onto the scene a tall man	3
8. John considers himself intelligent and Doug does too	5
9. His playing the violin irritates Mary	3
14. It is good that Harold went skiing	4

Although all of these problem sentences can be interpreted in terms of the lexical re-analysis deficit posited to explain the right hemisphere damaged subjects' performance on the insertion test, it will be seen below that there is, in fact, a more general way of characterizing this deficit. We will start by looking at the sentence anagram errors in terms of simple lexical re-analysis.

Some of the constructions produced for sentence 9 'His playing the violin irritates Mary' were as follows:

playing the violin irritates his Mary
the playing his violin irritates Mary
his violin playing irritates the Mary

It was apparent during testing and from the above constructions

(f) [[his][[_ playing][the violin]]]
 NP NP N N NP

As can be seen from the sentences produced by the right hemisphere damaged subjects, they had no trouble producing the VP 'playing the violin' and using it correctly. If we assume, contrary to Chomsky, that 'his' can only exist in a structure like (d), then the addition of 'his' to 'playing the violin' would force re-analysis of the VP to an N, thereby forcing the re-analysis of 'playing' from a V to an N. As we have already seen, this is the type of task the right hemisphere damaged subjects have difficulty with.

Denis Bouchard (1983) argues for just such an analysis of structures like 'his playing the violin'. Following from principles presented in his thesis (Bouchard 1982) he argues that a strong theory of grammar will minimize the distinction between empty categories and lexical NPs. According to Bouchard, PRO is either an anaphor governed by its antecedent or a pronoun freely indexed. This is contrary to Chomsky (1981) where Pro is both pronominal and anaphoric. Bouchard proposes an 'Elsewhere Principle' - don't put a pronoun in a position where an anaphor is possible - as a more principled alternative to Chomsky's 'Avoid Pronoun Principle' - avoid lexical pronoun when possible. The Avoid Pronoun Principle was proposed by Chomsky to account for the highly preferred reading of 'his' as being non-coreferential with 'John' in gerunds like (g) and (h) below.

(g) John prefers [PRO going to the movies]
 X

(h) John prefers [his going to the movies]
 X

Bouchard argues that, in (g) the head of the gerund '-ing' is verbal, no case is assigned, and X is an S (a verbal gerund being an S not an \bar{S}). Therefore, PRO is governed across the S by its antecedent 'John' and is an anaphor. In (h) on the other hand, the gerund is nominal and 'his' gets case. X is an NP and government of 'his' is blocked by the NP boundary. Therefore, 'his' is a pronoun and receives its index at S-structure freely.

Thus, the positions occupied by PRO and 'his' can be seen as distinct and the nature of the structural difference between 'playing the violin' and 'his playing the violin' suggests the need for lexical re-analysis to perform the anagram task in sentence 9.

Sentence 6 can be treated in a similar manner. The sentences the right hemisphere damaged subjects produced for 'There came onto the scene a tall man' were:

There a tall man came onto the scene

The tall man came there onto a scene

A tall man came there onto the scene

Here it is apparent that the subjects took 'there' to be an adverb of location. To treat it as the existential 'there' required by 'there' insertion to mark the empty subject position in the extraposed structure

[[e][came onto the scene][a tall man]]
 S NP VP NP

would require the re-analysis of the lexical specifications of 'there' from a locative to a pleonastic element.

Sentence 14 'It is good that Harold went skiing' engendered the following responses from the right hemisphere damaged

subjects:

Harold went skiing is that good (note absence of 'it')

Harold went skiing that it is good

Harold went skiing is it that good

Is it that good Harold went skiing

As in sentence 6, the 'it' required for the grammatical solution of the sentence is of an existential nature and is determined by a rule of 'it' insertion. This is the same rule that inserted 'there' in sentence 6 (see Chomsky 1981:87). In this case, 'it' marks the empty subject position in the extraposed structure:

[[e] [is good] [[that] [Harold] [went skiing]]]
S NP VP S Comp NP VP

The right hemisphere damaged subjects, treating 'it' as a full NP, are unable to re-analyse it as an 'it/there' insertion marker.

The difficulty the right hemisphere damaged subjects had with sentence 8 can also be explained, at least in part, in terms of a lexical re-analysis deficit. The sentences they produced for sentence 8 'John considers himself intelligent and Doug does too' were as follows:

John considers himself too intelligent and Doug does

John considers himself too intelligent and does Doug

Doug does and John considers himself too intelligent

John does considers himself intelligent and Doug too

Considers himself intelligent John does and Doug too

It is apparent that the subjects were determined to keep 'does' and 'too' separated. It seems that they wanted to treat 'do' as a full verb as in 'John does the dishes'. Taking 'does' to be a full verb, the right brain damaged subjects had to use 'too' as a modifier of some other element in the sentence. Associating 'too' with 'does' would force the re-analysis of 'does' from a full verb to a do-support auxiliary.

From the above discussion it can be seen that the right hemisphere damaged subjects' impaired ability to perform lexical re-analysis contributed to their difficulty with sentences 6, 8, 9 and 14. However, it is not enough to say that the problem the right hemisphere damaged subjects had in composing sentences 6, 8, 9 and 14 is due entirely to their impairment in re-analysing lexical nodes. In composing sentences from the words provided, the right brain damaged subjects followed a common strategy. If possible, they would initially make simple subject-verb-object sentences, and then attempt to fit in any remaining words. The lexical re-analysis deficit, as described above, should have frequently interfered with this process. Yet, in all but the above sentences, this strategy was successful.

A possible reason for the right hemisphere damaged subjects' ability to perform the anagram task for a majority of the sentences lies in the nature of the task itself. The sentence anagram task allowed the subjects far more flexibility in their approach to determining lexical category membership than the insertion task did. No fixed syntactic structure was imposed and the subject was free to change syntactic constructions at will. This freedom to change grammatical relations allowed the right

hemisphere damaged subjects to overcome situations where lexical node re-analysis was required. Thus, an impaired ability to re-analyse lexical nodes, as proposed in the analysis of the results of the insertion test, does not adequately account for the difficulty these subjects had with sentences 6, 8, 9 and 14. With this in mind, we will reconsider the nature of the problems the right hemisphere damaged subjects had in the sentence anagram test.

Sentence 9 seems to be a fairly straight forward example of the lexical re-analysis deficit. As in the case of the insertion test, the status of the element that had to be re-analysed in sentence 9, 'playing', was determined structurally by the subject. It was not the lexical analysis of the item 'his' that caused the trouble but, rather, the re-analysis of 'playing'. In the other three sentences, however, the subjects had determined some kind of sentential structure and then appeared to have trouble determining the lexical status of the item they were trying to include in that structure. As is evident from the fact that these subjects successfully generated the other sentences in the sentence anagram test, manipulation of structure was not a problem for them. Also, as demonstrated by their performance on many of the insertions in the insertion test, the determination of the lexical status of a single lexical item to be inserted into a structure was not a problem. Thus, the problem the right hemisphere damaged subjects had with 'does' and 'too', 'there' and 'it' in sentences 8, 6 and 14, respectively, seems unusual. Furthermore, it is not clear that the re-analysis of 'playing' in

sentence 9 was the only problem, as at least one of the incorrect sentences produced, 'His violin playing irritates the Mary' incorporated the [NP N] construction.

One important characteristic that these sentences have in common is that they all involve the generation and interpretation of empty categories. In sentence 9, the solution of the anagram turned on the distinction between 'his' and 'PRO'. In sentences 6 and 14, 'it' and 'there' mark empty subject positions and sentence 8 is an example of VP anaphora.

It is not the case, however, that the presence of an empty category in the target sentence was enough to cause the right hemisphere damaged subjects trouble. Many of the sentences they had no trouble with required the generation of empty categories. Sentence 3 is an example:

John robbed the bank then baked sugar cookies

[[John] [robbed the bank] [[then] [e] [baked sugar cookies]]]
 S NP VP S Comp NP VP

Here the subject NP in the lower S is empty and is coindexed with 'John', the subject NP of the matrix S.

Note also sentence 7, where there is a raising structure with a trace left in the subject position of the lower S:

Everyone seems to be here

[[everyone] [seems] [[e] [to be here]]]
 S NP VP S NP VP

Sentence 10 contains a passive structure with a trace in object position:

Every Italian is loved by his mother

[[Every Italian] [is loved] [e] [by his mother]]
 S NP VP NP PP

And there is sentence 16, in which the subject position in the relative clause is empty and co-indexed with the subject of the matrix S:

The boy that is missing is sick

[[the boy] [[that] [e] [is missing]] [is sick]]
 S NP S S Comp NP VP VP

Sentences 6, 8, 9 and 14 are not problematic, then, simply because of the presence of empty categories in the target sentences. One aspect of 6 and 14 that appears problematic is their indexing. In 6, 'there' is understood as co-indexed to, or referring to the post-verbal NP 'a tall man'. Similarly in 14, 'it' is understood to be co-indexed with the extraposed clause 'that Harold went skiing'. As is discussed in Chomsky (1981:218), these cases represent violations of principle C of the binding theory which states that an R-expression is free (Chomsky 1981:188). Thus, the determination of the reference of 'it' and 'there' fall outside of the strictures of the binding theory. To account for the perceived co-indexing, Chomsky proposes the device of co-superscripting, an indexing device important to the interpretation of empty categories in LF (the level of logical form). Sentence anagrams 6 and 14, then, can be seen to require the application of the interpretive device of co-superscripting in their solution. In sentence 9, however, co-superscripting is not involved. Either 'PRO' or 'his' would have to be co-superscripted with AGR. This would be ruled out as an occurrence of an 'i within i' relation, as the whole of the subject position of the sentence would also be co-superscripted with AGR. Co-superscripting is not the device to be employed in determining

the referent of the empty VP in sentence 8, although some form of indexing would be necessary to relate the two VPs at LF. Furthermore, the structures the right hemisphere damaged subjects produced for sentence 8 indicate that they may have been respecting VP anaphora. Thus, while indexing may be related to the underlying deficit, it cannot be the source of the problem the right hemisphere damaged subjects are having with the sentence anagram tasks.

If we consider, however, those sentences which involved empty categories but that did not cause the right hemisphere damaged subjects difficulty and compare them with the four sentences that did cause the right hemisphere damaged subjects difficulty, we can posit the following generalization. The right hemisphere damaged subjects appear unable to lexically insert into an empty category position at S-structure.

Assuming the projection principle to be valid, we expect that the D-structure representation of any sentence will contain all of the categories - empty, null and lexically filled - relevant to the sentence being generated. For example the D-structure for sentence 7 can be represented as follows:

[[] [seems] [[] [[everyone] [to be here]]]]
 S NP VP S Comp S NP VP

The rule 'move a' may apply to the D-structure representation to move a category and 'fill' an empty or null category position. Thus in 7, S deletion occurs followed by 'move a' to produce:

[[everyone] [seems] [[e] [to be here]]]
 S NP VP S NP VP

The result of application of the rule 'move a' is S-structure.

At S-structure the nature of the categories of the S are fully specified categorially and in terms of indexing and Case.

As is evidenced by the right hemisphere damaged subjects ability to perform sentences 3, 7, 10 and 16, the generation of well formed S-structures was not a problem for them. It was therefore possible for the right hemisphere damaged subjects to generate S-structures appropriate for the solution of sentences 6, 8, 9 and 14:

6) [[e][came][a tall man][onto the scene]]
 S NP VP NP PP

8) [[[J][considers himself intelligent] and [[D][e]]]
 S S NP VP S NP VP

9) [[[PRO][playing the violin]]] irritates][Mary]
 S NP NP VP VP NP

14) [[e][is good][[that][[Harold][went skiing]]]
 S NP VP S Comp S NP VP

It is at roughly this point in the solution of sentence anagrams 14 and 6 that the subject must determine what to do with either 'it' or 'there'. Similarly, in sentences 8 and 9 the subjects will have generated some S-structure before attempting to determine what to do with 'too' and 'does' and 'his'. Thus, the presence of empty categories in sentences 6, 8, 9 and 14 results in the subjects facing a task very much like the insertion test. They have succeeded in producing the 'base' sentence, a fully specified S-structure, and must insert lexical items into the positions of the fully specified empty categories they have generated. Sentences 3, 7, 10 and 16, although they contained empty categories, did not require insertion of lexical material into those positions after an S-structure had been

generated and therefore caused the right hemisphere damaged subjects no trouble.

Given the above discussion, an interesting possibility presents itself. Perhaps the right hemisphere damaged subjects can be considered to be treating empty categories as indistinguishable from fully lexically specified categories at S-Structure during the solution of the sentence anagram tasks.

Distinguishing between the lexical and non-lexical nature of a category seems to be unnecessary until the level of S-structure, as the projection principle guarantees that all lexical and categorial material relevant to the generation of S-structure is available at D-structure. Under this analysis, the problem that faced the right hemisphere damaged subjects in solving the sentence anagrams was the re-analysis of the specifications of the empty categories.

Consider sentences 3 and 8. In both sentences we have a conjoined structure with an empty category in the second S understood to represent material identical to the same category occupying the same position in the first S:

3) John robbed the bank (and) then [] baked sugar cookies.

4) John considers himself intelligent and Doug [] too.

The empty position in 3 is understood as 'John'. The empty position in 8 is understood as 'considers himself intelligent'. In structures like 3 no filler is required to mark the empty NP position. In 8, a lexical rule of 'do support' is required to mark the empty VP position. However, if the VP position in 8 is lexically specified '... and Doug considers himself intelligent too', do support is not required. Given that the right hemisphere

damaged subjects produced structures like

John does considers himself intelligent and Doug too
and

Considers himself intelligent John does and Doug too
for sentence 8, it is not unreasonable to claim that they could interpret the empty VP. If, having generated an interpretable S-Structure for sentence 8, the right hemisphere damaged subjects could not discern that the second conjoined VP was not lexically represented in that S-structure, do support would not be seen as applicable. Under these circumstances, we would not expect the right hemisphere damaged subjects to be able to properly accommodate the do support 'does' in sentence 8, even though they could produce a suitable S-structure. Similarly, the insertion of 'it' and 'there' would be interfered with if the subjects interpreted the subject positions of the extraposed structures as fully specified.

The nature of the errors that the right hemisphere damaged subjects made on the insertion test indicated that they were impaired in re-analysing the specifications of a lexical node fixed in a sentence structure. We concluded the analysis by suggesting that their impairment may block re-entry into the lexical component of the grammar, thereby interfering with the word formation rules required by the insertions. However, we have seen that this explanation is inadequate to account for the right hemisphere damaged subjects' performance on the sentence anagram test. We are now suggesting that the problem the right hemisphere damaged subjects are having with the sentence anagram test is recognizing that an empty category is empty at S-structure. In

other words, they are impaired in re-analysing the specifications of a lexical category at S-structure. If we take the base sentences provided in the insertion test as a close approximation of S-structures, we can see that the description of the right hemisphere damaged subjects' impairment on the insertion test is subsumed under this description of their impairment on the sentence anagram test. Once the specifications of a lexical category have been established at S-structure the right hemisphere damaged subjects cannot re-analyse or re-assess those specifications. Thus, in the insertion test, the category identity of a particular lexical item specified at S-structure could not be re-analysed in order to accommodate a lexical insertion. Similarly, in the sentence anagram test, the lexical status of a category specified at S-structure could not be re-analysed in order to accommodate lexical markers. In fact, the earlier conclusion that the operation of word formation rules was somehow blocked was correct. However, they are not blocked because of restricted access to the lexicon, but because this deficit in re-analysis at S-structure prevents the recognition of the need for the application of word formation rules.

5.1.3 Where in the grammar

In analysing the right hemisphere damaged subjects' performance on the insertion test it was possible to show that their impairment lay outside the lexicon, as an impairment within the lexicon would result in considerable disruption of the grammar. It is now possible to further specify where in the subjects' grammar a disturbance is taking place.

It is the case that the rule of 'it/there' insertion must apply after S-structure has been generated in the grammar. In raising structures like sentence 7, 'Everyone seems to be here', 'move a' applies to the D-structure:

[[] [seems] [[] [[everyone] [to be here]]]]
 S NP VP S Comp S NP VP

to produce an S-structure:

[[everyone] [seems] [[e] [to be here]]]
 S NP VP S NP VP

If 'it' insertion applied to D-structure, the grammar would generate 'it seems' in all cases and raising would be blocked. Similarly, if 'there' insertion were free to apply at D-structure, 'move a' could not apply to D-structures like

[[e] [came] [a tall man] [onto the scene]]
 S NP VP NP PP

to produce structures such as

[[a tall man] [came] [onto the scene]]
 S NP VP PP

Thus, 'it/there' insertion must be ordered after the transformational component and, given the organization of the grammar, must apply at S-structure.

As was argued earlier, the right hemisphere damaged subjects appeared capable of generating S-structure. The above argument indicates that, at least in the cases of 'it/there' insertion, the re-analysis of lexical categories was not required until after S-structure was generated.

The claim that the right hemisphere damaged subjects' grammar is intact, at least as far as the level of S-structure, is in accord with the published claims that right hemisphere

damaged individuals exhibit no aphasic disturbances. The kind of impairment described here would not be expected to affect expressive ability, making grammaticality judgments, repetition, naming or performance on any of the standard aphasia tests. Furthermore, the fact that right hemisphere damaged individuals do not manifest any phonological disturbances indicates that the level of PF (phonetic form) in their grammar is undisturbed. Thus, given the framework of the theory of grammar adopted here, we can delimit the domain of the grammar in which the impairment occurs. The right hemisphere damaged subjects described here have a disturbance that neither affects the operation of their grammar below the level of S-structure, nor directly disturbs PF. Therefore, the disturbance must lie in the component of the grammar that acts upon S-structure to generate logical form (LF).

5.1.4 Manifestation of the deficit

Clearly, these individuals have not suffered wholesale destruction of their ability to generate LF. They are capable of carrying on normal conversations and of understanding written text, etc. Their impairment affects their ability to reassess the lexical specifications of categories represented at S-structure. In many instances of normal language use, this is not required and mapping to LF should be undisturbed. However, in those instances where such reassessment is required, the subjects would be expected to be impaired.

Consider what the speech and conversation of an individual suffering from such an impairment would be like. We would expect individual utterances to be unimpaired. Similarly, we would

expect brief text and monologue production to be unimpaired. In prolonged monologues, however, we can expect some hesitation, as there may arise occasions when it is necessary for the speaker to re-analyse his own production. Finally, in discourse we would expect the individual to follow and participate in conversation quite well. The exceptions would be those occasions in which re-analysis is required in order to follow the trend of the conversation. This is, in fact, exactly what therapists involved in working with right hemisphere damaged individuals have reported about their speech patterns. It is often reported that right hemisphere damaged individuals have no apparent speech problems, but that they may lose the thread of a conversation. Such anecdotal reports are common, although the problem is traditionally dismissed as the result of a general cognitive deficit. The linguistic analysis of the deficit demonstrated in this study provides a potential explanation for this communication problem.

Recent reports in the literature attribute certain communicative problems to right hemisphere damage. For example, right hemisphere damaged subjects have been reported to be impaired in their ability to interpret jokes, sarcasm, indirect speech acts and in their recognition of ambiguity and certain types of anomaly (see Wapner et al. 1981, Delis et al. in press, Gardner 1975). These discourse impairments seem closely related to the right hemisphere damaged subjects' impairment on the story arrangement test as reported in Wapner et al. (1981) and Delis et al. (in press). As is discussed below, it may be possible to

attribute these various communicative impairments to a single re-analysis deficit. The results of the current study point to a deficit affecting operations that apply to the level of S-structure. The nature of the relationship between the impairments reported by Wapner et al. (1981), Delis et al. (in press) and Gardner (1975) and the re-analysis deficit described here, however, is a topic for further research.

5.1.5 The story arrangement test revisited

It may now be possible to interpret the story arrangement results in terms of this same deficit. Recall that the right hemisphere damaged subjects had no particular problem performing the story arrangement test presented in the present study. This contradicted results reported in Wapner et al. (1981) and Delis et al. (in press). As was noted earlier, there was a basic difference in the presentation of the story arrangement task between the present and earlier studies. In the current study, the subjects were presented with randomly ordered sentences and asked to produce a coherent paragraph. In the previous studies, the subjects were first given a theme sentence that outlined the sequence of events to be portrayed in the paragraph. They were then given randomly ordered sentences and asked to produce a paragraph that conformed to the theme sentence. One would presume that the theme sentence would be an aid in forming a coherent paragraph. According to Delis et al. (in press) and Wapner et al. (1981), this was not the case.

There is some similarity between the task presented by Delis et al. and Wapner et al. and the insertion type tasks of the

present study. If we take S-structure to represent the framework of the sentence and the thematic sentence to represent the framework of the paragraph, we can see that in both cases the subject is asked to, in some way, determine the relationship between an element given in the task (either a word or a sentence) and incorporate it into a predetermined structure (S-structure or the thematic framework). In the story arrangement task presented in the present study, the subjects could rely on pronoun-antecedent and other pragmatic strategies to build their paragraphs. The introduction of a theme sentence compels the subjects to not only use pragmatic strategies, but also to check on whether the paragraph they are constructing conforms to the framework established by the theme sentence. Thus, in solving the story arrangement task as presented by Delis et al. and Wapner et al., the subject has to assess the propositions expressed by each sentence he is assembling into a paragraph with respect to the segment of the paragraph he has already assembled and also with respect to the theme sentence. The re-analysis of the propositions becomes an important aspect of the story arrangement task when it is so presented. Much more work would have to be done, however, to be able to demonstrate that impaired performance on the story arrangement test and on the insertion and sentence anagram tests stem from the same deficit.

5.1.6 The performance of the left hemisphere damaged group

It should be noted that the left hemisphere damaged group made few errors in common with the right hemisphere damaged group. In fact, there was only one insertion that more than one left hemisphere damaged subject had trouble with. This was 7.2:

She saw her take his drink

Howard

The other insertions that were problematic for the right hemisphere damaged group proved to be no problem for the left hemisphere group.

The left hemisphere damaged subjects used in this study were chosen to be as free from aphasic deficits as possible. However, any insult to the left hemisphere of the brain may result in some compromise of language functioning. Given that the left hemisphere damaged subjects are minimally impaired, it would be expected that their impairment would show up only on those tasks that make the greatest demand on their grammar. Successful insertion of 'Howard' in 7.2 affects Case relations, theta role assignment and argument structure within the base sentence. Given the demands that such analysis makes at all levels of the grammar, it is not surprising that this was the one insertion that the left hemisphere damaged subjects had trouble with.

The left hemisphere damaged subjects had no particular problem with the sentence anagram test and made no errors in common with the right hemisphere damaged subjects.

6.0 Summary

The results of this study have shown that damage to the right hemisphere of the brain can result in an impairment of the core language system. The fact that the left hemisphere damaged subjects did not make errors similar to those made by the right hemisphere damaged subjects indicates that this impairment is not due to the non-specific effects of brain damage. It has been argued that this impairment is highly restricted in nature; it interferes with the re-analysis of the specifications of lexical categories within linguistic structures. Furthermore, this impairment has effects only at a certain level of the grammar; it disturbs rules acting on S-structure. Nothing in the literature refers to such a clearly circumscribed linguistic deficit resulting from right hemisphere damage. The nature of this deficit reflects a previously unsuspected linguistic role played by the right hemisphere of the brain.

The right hemisphere damaged subjects' difficulty with lexical identity and the involvement of their deficit at a late stage of the grammar allowed properties of the core grammar to be considered. The existence of a complex verb word formation rule as proposed in Stowell (1981) was supported in the analysis of errors made on the insertion test by the right hemisphere damaged subjects. In addition, the highly specific difficulty that the right hemisphere damaged subjects had with empty categories provides external support for the existence of empty categories and the central role they play in an individual's grammar.

6.1 Future Research

This study raises many topics for further research. Replication is, of course, a first requisite. In particular, it will be necessary to investigate the failure of the present study to replicate the story arrangement results reported in Delis et al. (in press) and Wapner et al. (1981). To determine if it is the presence of the theme sentence that causes the difficulty for right hemisphere damaged subjects, it will be necessary to present them with identical story arrangement tasks with and without a theme sentence. The present study suggests that right hemisphere damaged subjects should be able to perform the story arrangement task without a theme sentence, but should be impaired on the task when a theme sentence is presented.

The analysis presented here claims that right hemisphere damage results in a particular difficulty with empty categories. A number of relevant constructions were not represented in the present study and should be investigated. Gapping constructions, wh-movement and parasitic gaps, in particular, warrant further study.

Also, the analysis presented here locates the region of the grammar that is affected by the right hemisphere damaged subjects' impairment. If the mapping of S-structure onto LF is in some way disturbed, we could expect some change in the subjects' interpretive abilities. In particular, we would want to examine their interpretation of ambiguous structures like sentence 8 of the sentence anagram test:

John considers himself intelligent and Doug does too.
Is it John or Doug who Doug considers intelligent? In general,

their ability to handle scope of quantification should be investigated. There is some slight evidence in the sentence anagram test that the right hemisphere damaged subjects handled scope differently than the other subjects. Sentence 10:

Every Italian is loved by his mother
was constructed by all right hemisphere damaged subjects as:

His mother is loved by every Italian.

When queried about this construction the subjects responded with something like 'You know, his mother is Sophia Loren'. It is possible that the reading in which every Italian is loved by his own, respective mother is not available to these subjects. This is just speculation, however, and further investigation is needed on these matters.

Another area of potential investigation is the production of 'it/there' constructions in the spontaneous speech of right hemisphere damaged individuals. It would be expected, given the analysis presented here, that these constructions would be difficult for them to use and should be absent from their speech. As these are rare constructions in English, some test would have to be devised that could reliably prompt the generation of these constructions.

The kind of linguistic performance impaired by right hemisphere damage may reflect the nature of the grammar acting at S-structure. While the re-analysis of categories has effects at LF, the insertion of 'it/there' is relevant also to PF (the level of phonetic form). It is of interest to recall the performance of the right hemisphere damaged subjects on insertion 1.4. In this

insertion the base sentence was 'the cat the dog chased scratched him' and the insertion was 'that'. The error made by right hemisphere damaged subjects was to insert 'that' in the Comp position of the second S. However, in reading the base sentence aloud one subject read 'the cat that the dog chased...'. Thus, this error in insertion was attributed to the fact that the right hemisphere damaged subjects may have interpreted the first Comp position as filled. The only Comp position they recognised as available was in the second S. It may be that, in the case of center embedded structures like 1.4, a filled Comp position is obligatory until the level of S-structure. At S-structure a rule similar to 'it/there' insertion may apply that deletes the phonetic specifications of 'that' in such constructions. Again, this is a kind of category reanalysis which is relevant to PF. The suggestion here is that the routes to PF and LF are not distinct. There may be a component of 'interpretive' rules whose application to S-structure is 'visible' in different ways to LF and PF.

The analysis of a linguistic deficit resulting from right hemisphere damage presented here offers wide possibilities for further investigation. The deficit described here applies very late in the grammar, in contrast to aphasic deficits. The right hemisphere deficit does not fundamentally alter the functioning of processes within the components of the grammar, but can interfere with the interaction of the components. It may, therefore, be possible that this linguistic deficit can be developed as a tool to investigate specific aspects of linguistic functioning.

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APPENDIX I

EXPERIMENTAL MEASURES

INSERTION TEST

ORD. TIME

1. THE CAT THE DOG CHASED SCRATCHED HIM

1. TABBY
2. AFTER
3. SEVERLY
4. THAT

2. HIS PLAYING ANNOYS HIM

1. GUITAR
2. CONSTANT
3. FREQUENTLY

3. A PRONOUN MAY NOT COMMAND ITS CATEGORY

1. RELATIVE
2. STRICTLY
3. OWN

4. IF SALLY COMES SHE WILL BRING SALAD

1. EARLY
2. THEN
3. SURELY
4. ON THE TRAIN

ORD. TIME

5. THE BOY THAT IS MISSING IS SICK

1. AMONG THE
2. OLDER
3. FROM THE CAMP
4. TERRIBLY

6. HE STRIKES ME AS PROUD

1. OF HIMSELF
2. BEING
3. FREQUENTLY

7. CINDY SAW HER TAKE HIS DRINK

1. DAUGHTER
2. HOWARD
3. FROM HIM

8. IT IS STRANGE THAT CHRISTINE LEFT

1. IN HIS CAR
2. ALONE
3. MORE THAN

9. THE STORE IS OPEN FOR BUSINESS

1. HARDWARE
2. HOURS ONLY
3. NOT

10. EVERYBODY APPEARS CONCERNED ABOUT HIM

1. IN THIS ROOM
2. OVERLY
3. TO BE
4. NOT

11. I OPENED THE BOOK ON THE TABLE

1. WHICH WAS
2. CASUALLY
3. THICK

12. I WILL TAKE YOU FOR A DRIVE

1. IN MY NEW CAR
2. I PROMISE
3. SCENIC

EXAMPLE

I CAN SEE THE SNOW

1. WHITE

2. FALLING

3. ON THE TREES

6. THERE CAME ONTO THE SCENE A TALL MAN

7. EVERYONE SEEMS TO BE HERE

8. JOHN CONSIDERS HIMSELF INTELLIGENT AND DOUG DOES TOO

9. HIS PLAYING THE VIOLIN IRRITATES MARY

10. EVERY ITALIAN IS LOVED BY HIS MOTHER

ORD. TIME

11. IF I HAD SEEN THE THIEF I WOULD HAVE CALLED THE POLICE

12. IF IT RAINS I WILL TAKE THE CAR

13. ALTHOUGH HE SAW THE CAR COMING THE BOY STEPPED IN FRONT OF IT

14. IT IS GOOD THAT HAROLD WENT SKIING

15. IN THE BOX ON THE TABLE IS A DOLLAR BILL

16. THE BOY THAT IS MISSING IS SICK

EXAMPLES

EX.1 STILL WATERS RUN DEEP

EX.2 THE DOG BIT THE BOY

EX.3 THE DOG THE BOY KICKED BIT HIM

STORY ARRANGEMENT TEST

ORD. TIME

1.

1. JOHN AND JILL ARRIVED EARLY AT THE AIRPORT
2. THEY CHECKED THEIR BAGGAGE AND WENT TO HAVE A COFFEE
3. THE SERVICE WAS VERY SLOW
4. WHEN THE COFFEE ARRIVED IT WAS TIME TO BOARD THE PLANE
5. THEY WERE ANNOYED AND REFUSED TO PAY

2.

1. THE BOX GERRY NEEDED WAS ON THE TOP SHELF OF THE CLOSET
2. SHE COULDN'T REACH IT
3. AFTER THINKING A MINUTE SHE WENT TO THE LIVING ROOM
4. SHE BROUGHT BACK THE COFFEE TABLE AND A SMALL CHAIR
5. SETTING THE CHAIR ON TOP OF THE TABLE SHE CLIMBED UP AND REACHED

BOX

3.

1. THE GAME WAS GOING VERY WELL
2. UNFORTUNATELY A THUNDERSTORM BOKE OUT SHORTLY BEFORE IT WAS OVER
3. THE STORM CAUSED A BLACKOUT
4. THE ROOM WAS IN DARKNESS SO THE GAME COULDN'T BE FINISHED

4.

1. IN THE FADING LIGHT YOU COULD SEE THE RIPPLES ON THE LAKE'S SURFA
2. THE REFLECTIONS OF THE TREES TURNED FROM GREEN TO GRAY
3. SOUNDS DOMINATED AS THE DARKNESS DEEPENED
5. SOON THERE WAS ONLY THE SLAPPING OF THE WAVES AND THE RUSTLING OF THE BRANCHES

5.

1. THE LIGHT WAS RED
2. THE CHILDREN WAITED AT THE CURB IMPATIENTLY
3. THEY COULD SEE THE PLAYGROUND JUST ACROSS THE STREET
4. AT LAST THE LIGHT TURNED GREEN
5. THEY WERE ACROSS THE STREET AND ON THE SWINGS IN SECONDS

6.

1. MICHAEL PLACED THE RECORD ON THE TURNTABLE
2. THE SOUND OF ISAAC STERN'S VIOLIN BLASTED FROM THE SPEAKERS
3. HE WAS PLAYING BRAHM'S SONATA NO.3 IN D MINOR
4. MIKE CHECKED TO SEE THAT NOONE WAS WATCHING
5. HE PICKED UP A RULER AND ENTHUSIASTICALLY BEGAN TO CONDUCT

7.

1. TYPING IS NOT ONE OF MY STRONG POINTS
2. I USUALLY START WITH THE BEST OF INTENTIONS
3. I WILL RETYPE A FIRST PAGE UNTIL IT IS ERROR FREE
4. AS I PROGRESS I BECOME LESS AMBITIOUS AND WILL USE CORRECTING PAPER
5. BY THE END ANY ERRORS I MAKE WILL BE LEFT TO BE CORRECTED BY HAND

8.

1. ROWING CAN BE A VERY PEACEFUL PASS-TIME
2. THE AIR ON THE WATER IS COOL
3. OFTEN THERE IS A BREEZE
4. THERE IS JUST THE RESTFUL SOUND OF YOUR OARS IN THE WATER
5. THEN ALONG COMES A WATER SKIER AND NEARLY SWAMPS YOU

9.

1. IN THE EAST THE AUTUMN IS MARKED BY A CHANGE OF COLOURS
2. OFTEN BEFORE THE WEATHER IS COOL THE FIRST LEAVES BEGIN TO CHANGE
3. BY THE END OF SEPTEMBER THE TREES ARE BRIGHT YELLOWS AND REDS
4. BY NOVEMBER THE SHOW IS OVER AND THE TREES ARE BARE

10.

1. JOHN ALWAYS CARRIED AN UMBRELLA
2. HE CLAIMED THAT IF HE WAS WITHOUT ONE IT WOULD SURELY RAIN
3. ONE DAY HE LOCKED HIMSELF OUT OF HIS HOUSE WITHOUT HIS UMBRELLA
4. IT WAS A BEAUTIFUL DAY WITH NOT A DROP OF RAIN
5. INSTEAD IT SNOWED

EXAMPLES

1. BILL WAS THIRSTY
2. HE TOOK A GLASS FROM THE CUPBOARD
3. HE Poured HIMSELF A GLASS OF WATER AND DRANK IT

1. JOHN'S PIPE WAS EMPTY
2. HE FILLED THE BOWL WITH FRESH TOBACCO
3. THEN HE LIT IT UP

1. SHELLY LOVES HER PLANTS
2. SHE CHECKS THEM EVERY DAY
3. WHEN THEY ARE DRY SHE GIVES THEM WATER

APPENDIX II

RAW SCORES ON EXPERIMENTAL MEASURES
S=score, T=response latency in seconds

RIGHT HEMISPHERE DAMAGED SUBJECTS:

STORY ARRANGEMENT

maximum score per item = 3
maximum score for test = 30

NAME ITEM	LD		IB		GP		YB		JS	
	S	T	S	T	S	T	S	T	S	T
1.	3	40	3	16	3	45	1	45	1	45
2.	3	57	3	38	3	45	0	113	0	32
3.	3	75	3	19	3	23	3	25	0	25
4.	0	45	3	28	3	60	0	80	2	46
5.	2	40	1	30	3	28	3	34	0	38
6.	0	410	3	28	2	50	2	47	1	50
7.	3	240	3	30	3	60	0	113	1	43
8.	3	65	2	34	2	47	2	117	0	48
9.	3	30	3	31	3	22	2	77	1	35
10.	3	60	3	19	1	60	1	117	1	43
Totals	23	1062	27	273	26	380	14	768	6	405

mean score = 19.20

standard deviation = 8.98

mean latency = 577.60

standard deviation = 328.83

RIGHT HEMISPHERE DAMAGED SUBJECTS

SENTENCE ANAGRAM

maximum score per item = 1
maximum score for test = 16

ITEM	NAME	LD		IB		GP		YB		JS	
		S	T	S	T	S	T	S	T	S	T
1.		1	58	1	25	1	200	1	90	1	68
2.		0	191	1	174	1	45	1	80	1	51
3.		1	112	1	10	1	62	1	183	1	26
4.		1	0	1	0	1	16	1	40	1	5
5.		1	0	1	0	1	3	1	0	1	8
6.		1	28	0	39	1	17	0	70	0	51
7.		1	5	1	10	1	3	1	14	0	55
8.		0	406	0	162	0	91	0	84	0	55
9.		0	135	1	7	1	3	0	220	0	90
10.		1	10	1	180	0	45	1	78	1	222
11.		1	110	1	15	1	34	1	90	1	307
12.		1	4	1	15	1	0	1	28	0	230
13.		1	42	1	70	1	40	1	292	0	420
14.		0	149	1	80	0	42	0	136	0	79
15.		1	60	1	15	1	15	0	49	1	333
16.		1	10	1	42	0	56	1	63	1	12
Totals		12	1326	14	808	12	754	11	1517	9	2012

mean score = 11.60

standard deviation = 1.82

mean latency = 1283.40

standard deviation = 522.86

RIGHT HEMISPHERE DAMAGED SUBJECTS

INSERTION

maximum score per item = 1
 maximum score for test = 40

NAME	LD		IB		GP		YB		JS	
	S	T	S	T	S	T	S	T	S	T
1.1	1		1		1		1		1	
1.2	0		0		1		1		1	
1.3	1		1		1		1		1	
1.4	1		1		1		0		0	
		44		53		310		44		76
2.1	1		1		1		1		1	
2.2	1		1		1		1		1	
2.3	1		1		1		1		1	
		25		27		39		21		19
3.1	1		1		1		1		1	
3.2	1		1		1		1		1	
3.3	1		1		1		1		1	
		44		22		48		21		38
4.1	1		1		1		1		1	
4.2	1		1		0		1		0	
4.3	1		1		1		1		1	
4.4	1		1		1		1		1	
		41		35		34		30		37
5.1	0		1		1		1		0	
5.2	1		1		1		1		1	
5.3	1		1		0		1		1	
5.4	1		1		1		1		1	
		137		30		70		40		45
6.1	1		1		1		1		1	
6.2	1		1		1		1		1	
6.3	1		1		1		1		1	
		22		23		29		24		38
7.1	1		1		0		1		0	
7.2	0		0		0		0		1	
7.3	1		1		1		1		1	
		55		60		64		100		45
8.1	1		1		1		1		1	
8.2	1		1		1		0		1	
8.3	1		1		1		1		1	
		34		25		52		60		31
9.1	1		1		1		1		1	
9.2	0		0		0		1		0	
9.3	1		1		1		1		1	
		60		53		35		40		43

con't.

INSERTION con't. (RIGHT HEMISPHERE SUBJECTS)

NAME	LD		IB		GP		YB		JS	
	S	T	S	T	S	T	S	T	S	T
ITEM										
10.1	1		0		1		1		1	
10.2	1		1		1		1		1	
10.3	1		1		1		0		1	
10.4	0		1		1		1		0	
		39		40		34		40		31
11.1	1		1		1		1		1	
11.2	1		1		1		1		1	
11.3	1		1		1		1		1	
		31		25		30		22		21
12.1	1		1		1		1		1	
12.2	0		1		1		1		1	
12.3	1		1		1		1		1	
		34		30		18		19		28
Totals										
	34	536	36	413	35	763	36	461	34	452

mean score = 35.00

standard deviation = 1.00

mean latency = 525.00

standard deviation = 140.30

LEFT HEMISPHERE DAMAGED SUBJECTS:

STORY ARRANGEMENT

maximum score per item = 3
 maximum score for test = 30

NAME	AD		LF		EH		SL	
	S	T	S	T	S	T	S	T
ITEM								
1.	3	22	2	34	0		3	12
2.	3	15	0	50	3		3	11
3.	3	24	3	46	3		3	12
4.	3	60	1	80	3		3	10
5.	2	63	3	172	2		3	16
6.	3	52	0	98	3		3	15
7.	3	40	3	119	3		3	28
8.	3	25	2	39	3		2	17
9.	3	18	3	55	3		1	13
10.	3	30	1	26	2		2	18
Totals	29	349	18	719	25		26	152

mean score = 24.50

standard deviation = 4.65

mean latency = 406.67

standard deviation = 287.87

LEFT HEMISPHERE DAMAGED SUBJECTS

SENTENCE ANAGRAM

maximum score per item = 1
maximum score for test = 16

NAME	AD		LF		EH		SL	
	S	T	S	T	S	T	S	T
ITEM								
1.	1	64	1	110	1	133	1	67
2.	1	60	1	323	0	124	0	63
3.	1	30	1	250	1	93	1	35
4.	1	0	1	0	1	0	1	7
5.	1	0	1	0	1	0	1	0
6.	1	44	1	240	1	30	1	38
7.	1	9	1	8	1	6	1	5
8.	1	58	1	240	1	12	1	65
9.	1	32	1	67	1	15	1	6
10.	1	15	1	26	1	10	1	6
11.	1	27	1	124	1	27	1	35
12.	1	30	1	28	1	10	1	6
13.	1	20	1	30	1	61	1	35
14.	1	18	1	64	1	40	1	50
15.	1	14	1	74	1	45	1	95
16.	1	50	0	32	1	30	1	13
Totals	16	471	15	1016	15	636	15	562

mean score = 15.25 standard deviation = 0.50

mean latency = 671.25 standard deviation = 239.53

LEFT HEMISPHERE DAMAGED SUBJECTS

INSERTION

maximum score per item = 1
maximum score for test = 40

NAME	AD		LF		EH		SL	
	S	T	S	T	S	T	S	T
1.1	1		1		1		1	
1.2	1		1		0		1	
1.3	1		1		1		1	
1.4	1		1		1		1	
		45		110				60
2.1	1		1		1		1	
2.2	1		1		1		1	
2.3	1		1		1		1	
		20		20				18
3.1	1		1		1		1	
3.2	1		1		1		1	
3.3	1		1		1		1	
		27		21				28
4.1	1		1		1		1	
4.2	0		0		1		1	
4.3	1		1		1		1	
4.4	1		1		1		1	
		42		25				35
5.1	1		1		1		1	
5.2	1		1		1		1	
5.3	1		1		1		1	
5.4	1		1		1		1	
		30		75				30
6.1	1		1		1		1	
6.2	1		1		1		1	
6.3	1		1		1		1	
		15		14				17
7.1	1		0		1		1	
7.2	0		1		0		0	
7.3	1		1		1		1	
		68		30				41
8.1	1		1		1		1	
8.2	1		1		1		1	
8.3	1		1		1		1	
		29		16				22
9.1	1		1		1		1	
9.2	1		0		1		1	
9.3	1		1		1		1	
		17		170				18

con't.

INSERTION con't. (LEFT HEMISPHERE SUBJECTS)

NAME	AD		LF		EH		SL	
	S	T	S	T	S	T	S	T
ITEM								
10.1	1		1		1		1	
10.2	1		1		1		1	
10.3	1		1		1		1	
10.4	1		1		1		1	
		26		23				29
11.1	1		1		1		1	
11.2	1		1		1		1	
11.3	1		1		1		1	
		19		13				20
12.1	1		1		1		1	
12.2	1		1		1		1	
12.3	1		1		1		1	
		18		13				11
Totals	38	356	37	530	38		39	329

mean score = 38.00 standard deviation = 0.82

mean latency = 405.00 standard deviation = 109.09

NON-BRAIN DAMAGED SUBJECTS:

STORY ARRANGEMENT

maximum score per item = 3
 maximum score for test = 30

NAME	SR		MN		BD		RC		RG		SS	
	S	T	S	T	S	T	S	T	S	T	S	T
1.	3	14	3	22	3	25	3	19	3	15	3	17
2.	3	24	3	22	3	85	3	32	3	12	3	21
3.	3	13	3	18	3	60	2	28	2	10	3	16
4.	2	34	3	32	2	70	1	53	3	11	2	24
5.	2	11	3	19	2	27	3	40	1	35	2	20
6.	3	15	2	43	3	90	3	40	1	18	3	33
7.	2	31	3	26	1	85	1	40	1	25	2	31
8.	2	56	2	31	2	134	2	46	3	17	3	20
9.	3	16	3	20	2	55	3	40	3	15	2	29
10.	3	14	3	21	1	62	2	21	2	25	2	17
Totals	22	228	27	254	20	693	19	359	20	183	25	211

mean score = 22.17 standard deviation = 3.19

mean latency = 321.33 standard deviation = 191.89.

NON-BRAIN DAMAGED SUBJECTS

SENTENCE ANAGRAM

maximum score per item = 1
 maximum score for test = 16

NAME	SR		MN		BD		RC		RG		SS	
	S	T	S	T	S	T	S	T	S	T	S	T
ITEM												
1.	1	20	1	34	1	142	1	80	1	137	1	23
2.	1	30	1	194	1	155	1	75	1	193	1	28
3.	1	26	1	26	1	75	1	41	1	53	1	31
4.	1	27	1	0	1	0	1	30	1	6	1	0
5.	1	0	1	0	1	0	1	0	1	0	1	0
6.	1	19	1	37	1	71	0	108	1	31	1	34
7.	1	3	1	7	1	7	1	25	1	0	1	0
8.	1	113	1	16	1	101	1	265	1	198	1	42
9.	1	70	1	21	1	19	1	90	1	101	1	23
10.	1	5	1	42	1	35	1	27	1	42	1	19
11.	1	23	1	24	1	49	1	107	1	34	1	20
12.	1	5	1	5	1	13	1	16	1	20	1	6
13.	1	48	1	28	1	105	1	69	1	33	1	51
14.	1	115	1	66	1	18	0	240	1	15	1	33
15.	1	26	1	40	1	60	1	5	1	10	1	30
16.	1	24	1	159	1	32	1	10	1	302	1	47
Totals	16	554	16	699	16	882	14	1188	16	1175	16	310

mean score = 15.67

standard deviation = 0.82

mean latency = 801.33

standard deviation = 348.91

NON-BRAIN DAMAGED SUBJECTS

INSERTION

maximum score per item = 1
 maximum score for test = 40

NAME ITEM	SR		MN		BD		RC		RG		SS	
	S	T	S	T	S	T	S	T	S	T	S	T
1.1	1		1		1		1		1		1	
1.2	1		1		1		1		1		1	
1.3	1		1		1		1		1		1	
1.4	1		1		1		1		1		1	
		24		32		44		66		57		25
2.1	1		1		1		1		1		1	
2.2	1		1		1		1		1		1	
2.3	1		1		1		1		1		1	
		13		20		17		20		25		18
3.1	1		1		1		1		1		1	
3.2	1		1		1		1		1		1	
3.3	1		1		1		1		1		1	
		26		20		20		40		26		24
4.1	1		1		1		1		1		1	
4.2	1		0		1		1		0		1	
4.3	1		1		1		1		1		1	
4.4	1		1		1		1		1		1	
		20		24		23		28		41		26
5.1	1		1		1		1		1		1	
5.2	1		1		1		1		1		1	
5.3	1		1		1		1		1		1	
5.4	1		1		1		1		1		1	
		35		42		43		49		37		44
6.1	1		1		1		1		1		1	
6.2	1		1		1		1		1		1	
6.3	1		1		1		1		1		1	
		15		15		14		22		17		16
7.1	1		1		0		1		1		1	
7.2	1		1		1		1		1		1	
7.3	1		1		1		1		1		1	
		57		80		109		50		44		53
8.1	1		1		1		1		1		1	
8.2	1		1		1		1		1		1	
8.3	1		1		1		1		1		1	
		29		19		17		19		19		27
9.1	1		1		1		1		1		1	
9.2	1		1		1		1		1		1	
9.3	1		1		1		1		1		1	
		38		20		44		16		21		26

con't.

INSERTION con't (NON-BRAIN DAMAGED SUBJECTS)

NAME ITEM	SR		MN		BD		RC		RG		SS	
	S	T	S	T	S	T	S	T	S	T	S	T
10.1	1		1		1		1		1		1	
10.2	1		1		1		1		1		1	
10.3	1		1		1		1		1		1	
10.4	1		0		0		0		1		1	
		20		32		28		22		20		22
11.1	1		1		1		1		1		1	
11.2	1		1		1		1		1		1	
11.3	1		1		1		1		1		1	
		17		16		17		16		15		15
12.1	1		1		1		1		1		1	
12.2	1		1		1		1		1		1	
12.3	1		1		1		1		1		1	
		13		20		14		12		20		15
Totals												
	40	307	38	340	38	390	39	360	39	342	40	341

mean score = 39.00 standard deviation = 0.89

mean latency = 341.67 standard deviation = 31.04