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**AN EXPLORATION OF SYNTACTIC DIFFICULTIES IN  
RIGHT BRAIN DAMAGED PATIENTS**

by  
Kumiko G. Murasugi

A Thesis

Submitted to the School of Graduate Studies and Research  
in Partial Fulfillment of the Requirements  
for the Degree of  
Master of Arts

Department of Linguistics  
University of Ottawa  
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This thesis is dedicated to a special friend,  
Päivi Koskinen

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## Abstract

The purpose of this study is to follow up on an earlier investigation by Schneiderman and Saddy (1988) on the role of the right cerebral hemisphere in language processing. Their study revealed that right brain damaged patients (RBDs) exhibit syntactic deficits, suggesting that the right hemisphere has access to the syntactic component of language. The present study undertakes a reanalysis of their stimulus items, and attempts to define more clearly the sentence level difficulties encountered by RBDs:

The study includes 11 RBDs and 6 left brain damaged controls (LBDs). Both brain damaged groups are restricted to cerebrovascular accident (i.e., stroke) patients. Six evaluative measures are used to assess general verbal and nonverbal performance, and to establish a baseline for comparing the general cognitive abilities of the two groups.

The two experimental measures used in this study are the Insertion Test of Schneiderman and Saddy (1988), renamed the S&S Insertion Test, and the Insertion Test II, a modified version of this test. The Insertion Test II examines RBDs' ability to manipulate elements at the lexical, syntactic and semantic levels of language. Based on the literature reporting that RBDs are impaired in their ability to reanalyze and reintegrate linguistic information, the primary hypothesis is that these patients will exhibit impairments with certain categories of stimulus items that require incorporating and changing information. Although the results of this study reveal that such categorial distinctions in item types are not possible, there is evidence of definite linguistic areas which are problematic for RBDs. For example, they exhibit impairments with items involving thematic roles, which require access to different components of language, including syntax. It is proposed that their

syntactic level deficits, as well as their difficulty at other levels such as discourse, reflect a more global deficit in integrating information. We consider where the integrative difficulty may arise in the processing of sentences by relating their deficits to models of language processing.

## 1. INTRODUCTION

### 1.1 Review of the Literature

Research on the differential functioning of the left and right cerebral hemispheres has revealed that they are specialized for different modes of cognitive processing (Witelson, 1983). The left hemisphere, defined as being "sequential" and "analytical," processes information by analyzing stimuli within discrete categories. By contrast, the right hemisphere is "holistic" and "parallel," and can simultaneously integrate given information from different domains into a unified whole. This difference in the primary modes of processing by the two hemispheres is often cited as the basis for the verbal-nonverbal distinction that underlies much of the research linking brain and behaviour. While the right hemisphere is equipped to excel at visuo-spatial tasks such as orientation in space and face recognition, the left hemisphere's mode of cognitive processing is seen as more suitable for the processing of language. This view is strongly supported by clinical and experimental evidence demonstrating language to be left lateralized in 90-99% of right-handed people, and 50-70% of left-handers (Searleman, 1977). In fact, linguistic abilities are generally regarded as the most highly lateralized of cognitive functions.

In the face of overwhelming evidence for language representation (especially for syntax and phonology) in the left hemisphere, the right hemisphere's participation in language processing has tended to be overlooked. It is only in the last ten to fifteen years that researchers have begun to explore the linguistic capabilities of the right hemisphere. Such research has been based on a number of different populations: normals,

young hemispherectomized patients, commissurotomy (or split-brain) patients, and brain damaged populations. These studies have revealed that the right hemisphere contributes in a variety of ways to the processing of language.

Dichotic listening tests on normal populations have shown that the right hemisphere is superior at processing intonation contours (Blumstein and Cooper, 1974) and identifying affective tones of sentences (Ley and Bryden, 1982). These findings are supported by research on brain damaged patients (BDs) which have found that damage to the right hemisphere results in an impairment in judging the intonational meaning of sentences (Tomkins and Mateer, 1985) and in producing normal sentence prosody (Weintraub et al., 1981).

Further evidence of the right hemisphere's linguistic capabilities has emerged from studies focusing on the language processing of adults with right brain (i.e., hemisphere) damage. (See Millar and Whitaker, 1983 and Seidenman, 1977 for reviews.) A number of these studies associate such damage with impairments at the lexical level. Right brain damaged patients (RBDs) have been reported to exhibit word-finding problems, difficulty with abstract concepts, and a tendency to interpret meanings literally (Brownell et al., 1984; Eisenson, 1962; Foldi, 1987; Winner and Gardner, 1977). It is not surprising that right brain damage results in lexical impairment, for the right hemisphere is claimed to possess its own structurally different, but nonetheless rich, lexicon (Zaidel, 1983). Zaidel, in his examination of commissurotomized patients, revealed that the isolated right hemisphere possesses a fairly substantial lexicon and a rich conceptual and semantic system, making it ideal for abstraction and labelling. Similarly, other studies on normal populations have shown a left visual field (i.e., right

hemisphere) advantage for abstract or low imagery level words (Deloche et al., 1987; Young and Ellis, 1985).

A variety of research findings on right brain damage deficits support Zaidel's (1983) claim that the right hemisphere is superior at handling certain pragmatic and extralinguistic aspects of communication. For example, RBDs often fail to notice the subtleties of language, and are impaired in their ability to interpret sarcasm and to appreciate verbal humour (Brownell et al., 1983; Gardner et al., 1975). They have also been reported to experience difficulty in processing complex linguistic material, failing to correctly organize linguistic information at the narrative level. More specifically, RBDs appear unable to fully make use of surrounding context to assess linguistic material and make correct inferences, and to properly integrate world knowledge with linguistic information (Brownell et al., 1986; Ellis et al., 1983; McDonald and Wales, 1986; Wapner et al., 1981). They are often unable to perceive the main point or moral of a story, and their narrative discourse has been shown to contain smaller amounts of information relative to verbal output than that of left brain damaged patients (LBDs) (Joanette et al., 1986; Wapner et al., 1981). Furthermore, RBDs are often insensitive to communicative situations, displaying emotionally inappropriate behaviour in social situations (Cicone et al., 1980).

The findings from these studies suggest that the pragmatic difficulties experienced by RBDs originate from a single, more general deficit involving a "rigidity" in information processing. For example, Brownell et al. (1986) revealed that RBDs could appreciate isolated word meanings and associations and were capable of processing individual sentences. However, they were then fixed on their initial interpretations, unable to revise them

to fit within the larger context of a discourse. One such discourse used in their study contained the following sentences: *Sally brought a pen and paper with her to meet the famous movie star. The article would include comments on nuclear power by well-known people.* Through a set of questions Brownell et al. were able to show that RBDs had not correctly inferred that Sally was a reporter writing a story. Instead, they held to the impression created in the first sentence that she was a fan seeking an autograph. Other studies (McDonald and Wales, 1986; Wapner et al., 1981) have also shown RBDs to be capable of accurately processing linguistic material, both simple and complex. The difficulties arise when new information requires previously encountered information to be revised. Thus, RBDs are impaired in their ability to reanalyze linguistic information once the initial interpretation has been arrived at.

It seems, then, that damage to the right hemisphere results in a rigidity problem that affects inferencing and incorporating information at the discourse level. In the studies discussed above, however, the RBDs' inferencing problems are described as an inability to integrate new and old information without specifying how, or where, in the processing of discourse the deficit occurs. Discourse processing involves integrating the linguistic and extralinguistic components of language. Given the right hemisphere's holistic/parallel mode of processing, it is reasonable to assume that it would be suited to bringing together the more purely grammatical components of language and the extralinguistic, pragmatic components.<sup>1</sup> In order to carry out such a synthesis, however, the right

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<sup>1</sup>Schneiderman (1986), in discussing the role of the right hemisphere in second language acquisition, suggests that its holistic-parallel mode of functioning makes it suited to integrating incoming language stimuli with previously encountered language data and with knowledge from a number of cognitive domains.

hemisphere would require access to those subcomponents of the grammar (phonology, lexicon, syntax and semantics) traditionally associated with the left hemisphere.

We have already discussed findings of impairments at the prosodic, lexical and discourse levels for RBDs. What remains is to look for right hemisphere related deficits at the level of the sentence. The sentence may be considered to be the central component of all language processing, for it relates to both the word and discourse levels.<sup>2</sup> The organization of individual lexical items within the structure of a sentence enables them to convey their meanings. A discourse is composed of a series of related sentences, so that a full understanding of each sentence is required before it can be interpreted within the larger context of the discourse. Thus, if RBDs have difficulty manipulating language at the sentence level, they would likely also experience difficulties at the extrasentential level (Schneiderman and Saddy, 1988).

The few studies on the sentence-level deficits of RBDs have focused on their logical or inferencing impairments. Caramazza et al.'s (1976) study of sentence processing in RBDs is restricted to the use of syllogistic reasoning: *John is taller than Bill. Who is taller? or Who is shorter?* Their interest lies in determining the extent to which the solution of linear syllogisms requires the use of spatial imagery. Grossman and Haberman (1987) investigate the ability of RBDs with different lesion sites to evaluate sentences formed by joining two statements with a logical conjunction such as *because* or *although*. Their stimuli consist of grammatically correct sentences (e.g., *Gloria cleaned the room because the*

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<sup>2</sup> Although prosody clearly plays a role in sentence comprehension, the nature of that role has not been as well specified as that of individual lexical items.

*room was dusty*), and sentences that involve such violations as order (*The room was dusty because Gloria cleaned the room*), cause (*Gloria cleaned the room so the room was dusty*) and negation (*Gloria cleaned the room although the room was dusty*). They found that anterior RBDs had the greatest difficulty with sentences that require rearranging propositions in order to correspond to the real-world order of events. Again, although the RBDs are being assessed at the sentence level, their study is primarily concerned with the mental manipulations and reversals involved in detecting semantic or logical violations of sentences.

Unfortunately, very little research has been carried out on *syntactic* deficits in RBDs, that is, deficits associated with the structure, and not meaning, of sentences. This is primarily due to the traditional association of syntax with left hemisphere functions. As obvious syntactic deficits rarely occur after right hemisphere damage, syntax is generally thought to be inaccessible to the right hemisphere. However, the discovery of deficits in RBDs at the syntactic level of language processing would greatly contribute to our understanding of the extralinguistic deficits associated with right hemisphere damage.

A few studies have reported on the syntactic capacities of the right hemisphere in hemispherectomized (Dennis, 1980; Dennis and Whitaker, 1976) and commissurotomized patients (Gazzaniga and Hillyard, 1971). Hemispherectomized patients who have acquired language after the removal of the left hemisphere have shown impairments in detecting and correcting errors of surface syntactic structure, producing tag questions, and integrating semantic and syntactic information to replace missing pronouns. Gazzaniga and Hillyard's (1971) study of commissurotomized patients revealed that the only syntactic distinction the right hemisphere is capable

of recognizing is affirmative vs. negative. When asked to identify a sentence that described a picture flashed to their left visual field (right hemisphere), commissurotomized patients were unable to correctly choose between future and present, or singular and plural, sentences.

To date, only two studies have focused on the syntactic impairments of RBDs.<sup>3</sup> With their Insertion test, Saddy (1983) and Schneiderman and Saddy (1988) demonstrated that the right hemisphere has some role in the processing of syntax. In the Insertion test, subjects are given a single, well-formed sentence and a separate word or phrase. They must insert the word or phrase into the sentence to produce a modified, but still grammatical, sentence. For example, the correct insertion of the word *wool* into sentence (1a) would produce sentence (1b):

- (1) a. Susan brought the sweater that was mended. (S&S 10)<sup>4</sup>  
 b. Susan brought the wool sweater that was mended. (S&S 10.1)

The Insertion test consists of two types of items which are termed Shift and Non-shift. The Shift items require subjects to reassign the syntactic role of a lexical item in the original sentence before the target item can be inserted. Thus, given sentence (2a), in order to insert *daughter* to arrive at (2b), the lexical role of *her* must be reassigned from *pronoun* to *specifier*. Non-shift items such as (2c) do not require such a reanalysis. All that is required to insert *to him* into the original sentence (2a) is the addition of the PP *to him* to the existing VP node. Sentence (1b) above is also a Non-shift item.

<sup>3</sup> Joannette et al. (1983) examine RBDs on a test battery which includes syntactic tests, but their analysis of these tests is limited to the number of deleted and misused words.

<sup>4</sup> "S&S 10" refers to Item 10 from Schneiderman and Saddy's (1988) Insertion Test. A complete list of their stimulus sentences and Insertions is given in Appendix A.

- (2) a. Cindy saw her take his drink. (S&S 9)  
 b. Cindy saw her daughter take his drink. (S&S 9.1\*)<sup>5</sup>  
 c. Cindy saw her take his drink to him. (S&S 9.3)

Schneiderman and Saddy's results revealed that the RBDs had particular trouble with the Shift items, which apparently required syntactic role reassignment. That is, they were unable to reanalyze the syntactic status of lexical nodes that were already established in a sentence. The significance of these results is that rigidity, which has been shown to be characteristic of right hemisphere damage, extends to the level of left hemisphere-dominated syntax. Thus it appears that the right hemisphere has access to syntactic representation and possibly plays some role in the syntactic processing of language. Assuming, then, that the right hemisphere has access to the grammatical components of language, RBDs' discourse-level deficits can no longer be regarded as being the result of impairments solely at the extrasentential level (Schneiderman and Saddy, 1988).

The present study was undertaken to explore further the notion of syntactic rigidity proposed in Schneiderman and Saddy (1988) (henceforth, S&S). Since the rigidity problem seems to appear in both the linguistic and extralinguistic components of language, it is proposed that it is this rigidity that underlies the language deficits of RBDs.

In processing language, a change or reintegration of information may be required at any one of the various linguistic and extralinguistic levels. Rigidity at one level will necessarily affect interpretation at another, and in the end will affect understanding at the discourse level. The extent of RBDs' difficulty in processing a discourse will vary according to their

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<sup>5</sup> Shift items are marked with an asterisk.

ability to handle required changes at the different levels. The Insertion Test II in this study explores their capacity to manage specific linguistic changes within a sentence. It is possible that RBDs will experience varying degrees of difficulty with different types of changes, depending on the extent to which the right hemisphere contributes to the process involved in the change. For example, because syntax is more strongly associated with left hemisphere processes, syntactic changes may be easier for RBDs than changes in lexical items or thematic roles.

In summary, it appears that the linguistic deficits associated with RBDs involve an impairment in revising previously acquired knowledge when given new information. This rigidity has been shown to exist at the discourse level, when the interpretation of a sentence must be revised on the basis of additional information (Brownell et al., 1986; Wapner et al., 1981). RBDs exhibit this rigidity at the lexical level as well, with their tendency towards literal interpretations of words and metaphors (Brownell et al., 1984; Winner and Gardner, 1977). It has also been found by S&S to exist at the syntactic level, for in their Insertion task RBDs had difficulty manipulating sentences that required a lexical item to change its syntactic role. The following analysis of their stimulus items allows us to further specify the components of syntactic structure which may be accessible to the right hemisphere, and to explore the notion of rigidity in the different subcomponents of sentence-level grammar.

## 1.2 Reanalysis of Schneiderman and Saddy's (1988) Insertion Test

As was noted above, S&S attribute the difficulties experienced by RBDs to an inability to carry out syntactic role reassignment of lexical items in the original stimulus sentence: "... RBD subjects cannot successfully insert an item into a sentence if the insertion requires altering the status of a word already in the sentence. Status here refers to the syntactic relation that the word holds with respect to the other elements of the sentence" (p. 50). Further analysis of their stimuli shows, however, that few of their stimulus items involve an isolated syntactic role change in a simple sentence. Over half of their items involve embedded or complex sentences. In items 9.1 and 11.2 ((3) and (4) below), the original sentences are complex, and in item 7.1 (shown in (5)), the insertion requires embedding in an already complex sentence.

- (3) Cindy saw her daughter take his drink. (S&S 9.1\*)
- (4) Susan heard her husband tell a joke. (S&S 11.2\*)
- (5) The girl that is missing is among the blond. (S&S 7.1\*)

It is possible that the complexity of sentence structure is contributing to the difficulty subjects exhibit with these items.

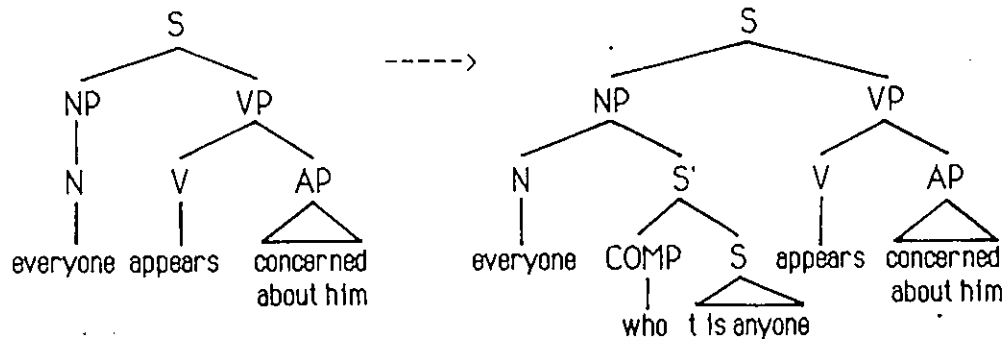
Their item 8.1 (presented below as (6b)) was analyzed as a Shift item because when *playing* is inserted, *be* must be reanalyzed as an auxiliary from a main verb. However, this insertion also involves a change in the lexical meaning of *be*.

- (6) a. He seems to be hard to get. (S&S 8)
- b. He seems to be playing hard to get. (S&S 8.1\*)

Other types of operations found in their Shift items include changing a lexical item and modifying a verb's thematic grid. Thus, although the insertions occur within the sentence, the effect of the insertions extend beyond the syntactic level to the lexical and semantic levels.

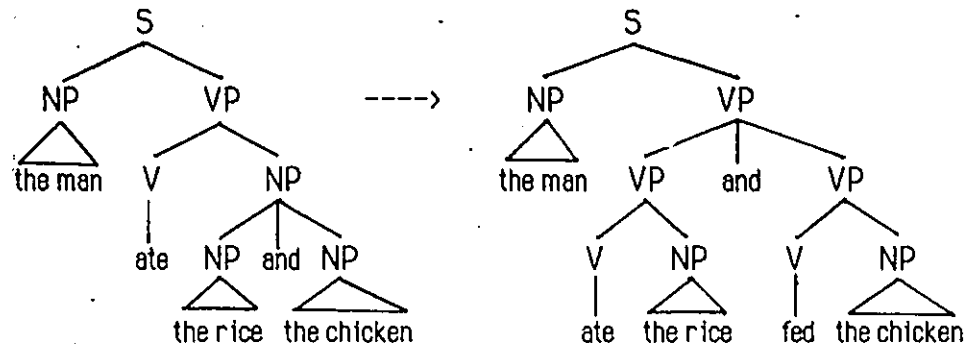
In the initial design of their study, S&S divided their stimulus items into the categories Predicted Problematic and Predicted Non-problematic (E. Schneiderman, personal communication). This was a working categorization, since their stimuli consisted of many groups of items involving different operations. It was only when analyzing their data that they isolated the Shift/Non-shift component in their stimuli as a common denominator underlying errors by RBDs. Thus, not all of the so-called Shift items involve strictly a change in syntactic role. For example, the insertion in item 5.5 ((7) below) requires adding a relative clause:

- (7) Everyone who's anyone appears concerned about him. (S&S 5.5\*)



Item 17.1 ((8) below) involves multiple changes, including adding a verb *feed*, altering the arguments associated with the verb *eat* (*the chicken* changes from being the Theme of *eat* to being the Theme of *feed*), and changing the elements which *and* conjoins (i.e., *and* originally conjoins two NPs, but then conjoins two VPs).

(8) The man ate the rice and fed the chicken. (S&S 17.1\*)



The operations involved in S&S's original Insertion task, including both Shift and Non-shift items, are reanalyzed according to the categories listed in (9). These categories are explained below.

- (9)
1. Add Modifier
  2. Add Complement
  3. Alter Syntactic Role
  4. Alter Lexical item
  5. Alter Lexical Meaning
  6. Add Thematic Role
  7. Alter Thematic Linking Rules

This detailed analysis makes it possible to further categorize the changes required by each insertion, thus isolating the factors involved in the Shift items. Of S&S's total 65 items, 22 (or 33%) do not fit into any of the above categories because they involve a different operation such as negation, or require more complex structural changes.<sup>6</sup> Also, the Government and Binding framework of analysis proposed by Chomsky (1981, 1985) is used here,

<sup>6</sup> The issue of how structural complexity and multiple operations affect RBD performance is beyond the scope of the present study.

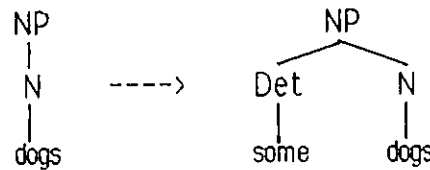
resulting in a somewhat different system of categories and notation than that used by S&S.<sup>7</sup>

### 1.2.1 Add Modifier

The categories considered here to be "modifiers" are Det, Pos, AP and NP. They occur in pre-head position, and are contained within the maximal projection of the modified head. Examples of insertions involving the addition of a modifier are given in (10)-(13):

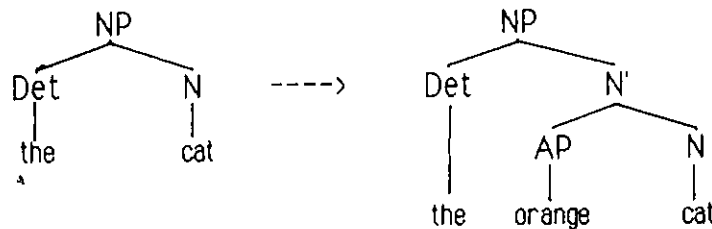
(10) Add Determiner some

Some dogs are friendly animals.



(11) Add AP orange

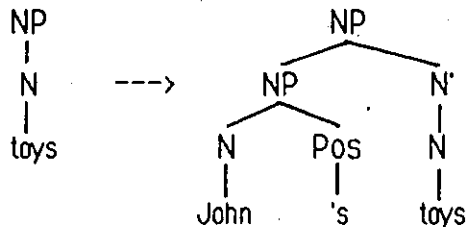
The orange cat that the dog chased scratched him. (S&S 1.1)



<sup>7</sup> Although all of the items so indicated here were employed as stimulus items by S&S, not all of them are discussed in their paper. Note, however, that not all of the examples presented below are from S&S's original set of stimuli.

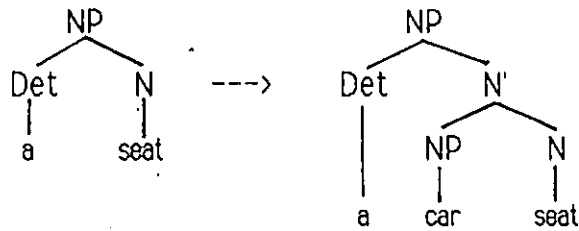
(12) Add Pos and N John

Tracy likes to play with John's toys.



(13) Add NP car

Here is a car seat.

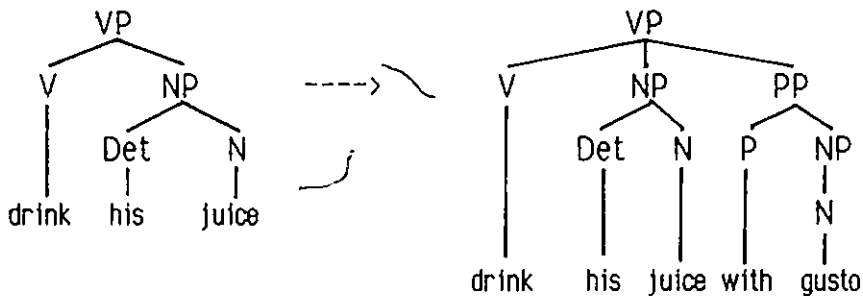


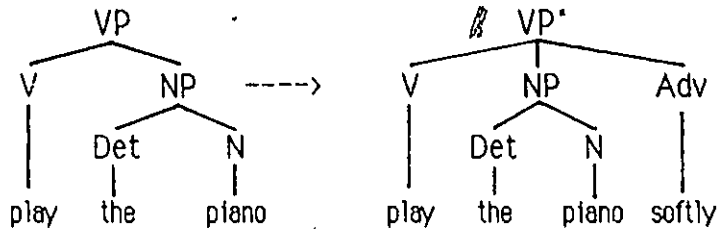
1.2.2 Add Complement

The second type of modification involves the addition of ~~of~~ non-argument complements such as Adverbs and PPs. The complement is added within the maximal projection of the head to which it belongs.

(14) Add PP with gusto

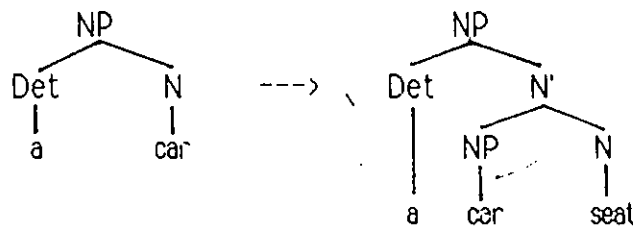
Henry always drinks his juice with gusto.



(15) Add Adverb softlyPlease play the piano softly.

## 1.2.3 Alter Syntactic Role

The changing of syntactic role is the primary concept behind S&S's original Shift Items. Example (16) illustrates a typical Shift, where the insertion of *seat* requires the reinterpretation of *car* from being the head of the NP to being a modifier of *seat*.

(16) Add seatIs a car seat for sale here. (S&S 13.3\*)

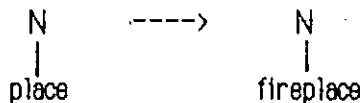
This insertion contrasts with (13), above, where the modifier *car* was added to *a seat* to form the same NP *a car seat*. The syntactic outcomes of the two insertions are the same, but it is predicted below that the two items will differ in difficulty for the RBDs. It is not the actual structure of the newly-formed NP that will be problematic, but the process involved in its construction (i.e., adding a modifier or changing a syntactic role).

### 1.2.4 Alter Lexical Item

This type of modification involves an alteration in the form and meaning of a lexical item without changes in lexical category. In (17) the addition of *fire* to the N *place* results in a new lexical item *fireplace*, but the lexical category N of the newly-formed word does not change.

(17) Add fire

That's Louise's new fireplace.



Similarly, in (18) the insertion of a particle changes the verb from being a one-part to a two-part verb, but the lexical category V remains the same.

(18) Add by

The man that I passed by was drunk. (S&S 15.1\*)



### 1.2.5 Alter Lexical Meaning

This category refers to a change in meaning, but not form, of a lexical item in the original stimulus sentence. The insertion of *wine* into (19a), for example, requires changing the meaning of *glasses* from *spectacles* to *glassware*. In items such as this, it is necessary to determine whether subjects initially interpret *glasses* in the desired way.

- (19) a. John dropped his glasses, smashing them to pieces.  
 b. John dropped his wine glasses, smashing them to pieces.

### 1.2.6 Add Thematic Role

The predicate-argument structure (PAS) of a lexical item is a list of thematic roles that associate a lexical item with its arguments (Williams, 1981)<sup>8</sup>. It is at this level that thematic relations are represented, for the main function of thematic roles is to relate the arguments of a verb to its meaning in semantic interpretation (Carlson and Tanenhaus, 1988). The verb *put* in (20a) has the PAS given in (20b):

- (20) a. Susan put her suitcase in the car.  
 b. PUT: (Agent, Theme, Location)  
 Agent=Susan; Theme=her suitcase; Location=the car

Thematic roles in a verb's PAS are often *implied* in the meaning of a verb, and may be linked to *optional* NP positions in its subcategorization (Carrier-Duncan, 1985). For example, the Theme role is implied in the meaning of the verb *eat*, and may be optionally linked to a syntactically unrealized argument. The Theme role associated with the verb *in* (21b) is said to be *unfilled* or *open*. (Carlson and Tanenhaus, 1988). Williams (1987) refers to such unassigned theta roles as *implicit arguments*.

- (21) a. EAT: (Agent, Theme)  
 b. John likes to eat.  
 c. John likes to eat pizza.

The addition of the NP *pizza* in (21c) results in the *filling* of an open thematic role. Although insertions of this type are categorized as Add

<sup>8</sup> Williams (1981) uses the term "argument structures," which is equivalent to "predicate-argument structures."

Thematic Role, no new thematic roles are actually being added. Rather, the insertion involves the syntactic realization of an existing argument position. Example (22) is another insertion of this type, where the Goal role is optionally open.

- (22) a. Cindy saw her take his drink to him. (S&S 9.3)  
 b. TAKE: (Agent, Theme, Goal)

### 1.2.7 Alter Thematic Linking Rules

*Linking rules* link thematic role labels of arguments with their grammatical realizations. For example, given sentence (23), they would link the Agent role to the subject *Janet*, Theme to the direct object *some books*, and Location to the prepositional object *the library*.

- (23) Janet brought some books back to the library.  
 Agent                      Theme                      Location

Carrier-Duncan (1985) follows Carter (1976) and Ostler (1979) in proposing two hierarchies, one of thematic roles and one of case (for Tagalog) to predict the linking of thematic roles with their grammatical realizations. She proposes a Hierarchical Linking Rule which orders a verb's unlinked thematic roles according to the Thematic Hierarchy shown in (24), and links thematic roles to case-markers in order of precedence on their respective hierarchies.

### (24) Thematic Hierarchy

Agent  
 Theme  
 Goal/Source/Location

Since English does not have case-clitics as in Tagalog, the linking will be expressed in terms of grammatical relations, with the hierarchy based on

the proximity of the argument to the verb. The grammatical relations in this hierarchy are ordered in the following way: subject, direct object, second object, prepositional object.

Insertions of the type in (25) involve a change in the linking rules associated with the original stimulus sentence. In (25a) Agent is linked to the subject NP *Mary*, and Theme to the direct object *the puppy*.

- (25) a. Mary bought the puppy.  
 b. Mary bought the puppy a bone.

With the insertion of *a bone* in (25b), the Theme role is no longer linked to the direct object *the puppy*. Instead it is linked to the second object *a bone*, and the Goal is linked to the direct object *the puppy*.<sup>9</sup> This type of linking violates the Hierarchical Linking Rule, which stipulates that Theme be linked to an argument appearing closer to the verb than the Goal argument: In (25b), Theme is linked to the second object, which is lower on the hierarchy than the direct object that is linked to Goal.

There are three types of items included in the category Alter Thematic Linking Rules:

- (i) Items that involve changing the thematic role of an argument in the original sentence, but no hierarchy violation.

(26) It was Bill's job to load the trucks onto the ship.

In (26), with the insertion of the Location *onto the ship*, *the trucks* must change its thematic role from Location to Theme.

- (ii) Items that involve a change in thematic role as well as a hierarchy violation.

(27) Andrea bought the puppy a bone at the pet shop.

<sup>9</sup> We follow Andrews' (1985) system of relating thematic roles and grammatical relations.

With the insertion of the new Theme *a bone* in (27), the thematic role of *the puppy* must change from Theme to Goal. In addition, there is a violation of the thematic hierarchy since the Goal argument appears before the Theme argument.

(iii) Items that involve only a violation of the thematic hierarchy.

(28) The boy asked his teacher an important question.

Here, the Goal *his teacher* is inserted between the verb and the Theme *an important question*, resulting in a hierarchy violation without altering the thematic role of *his teacher*.

The above categories allow us to make more specific predictions regarding which components of language (i.e., lexicon, syntax and semantics) may be accessible to the right hemisphere. The first three categories (Add Modifier, Add Complement, Alter Syntactic Role) involve the level of syntax; Alter Lexical Item and Alter Lexical Meaning involve the lexicon; and Add Thematic Role and Alter Thematic Linking Rules affect both the syntactic and semantic levels<sup>10</sup>.

The categories just described can be classified into two types, those that Add and those that Alter. It is expected that, due to their general differences in processing language, the LBDs and RBDs will perform differentially on the Add and Alter items. The Alter items require some kind of alteration to the stimulus sentence at either the lexical, syntactic or thematic levels. Changing a lexical item involves *redefining* the lexical item belonging to a lexical node. Changing a syntactic role or thematic linking rules may be considered a *relabelling* of roles at the syntactic or thematic levels. Both redefining and relabelling elements require the

<sup>10</sup> The exact status of thematic roles remains unclear. They are claimed by some (e.g., Jackendoff, 1983) to be semantic/conceptual, while others, including Chomsky (1981), regard them as being syntactic. Thematic linking rules, however, by their very nature, necessarily involve both syntax and semantics.

Interpretation of new information within the context of an old structure; that is, the original structure must be modified to fit the insertion, since no part of it may be deleted. The rigidity problems associated with RBDs suggest that they are impaired in their ability to integrate old and new information. Thus it is reasonable to assume that these patients will have difficulty with the four Alter categories: Alter Syntactic Role, Alter Lexical Item, Alter Lexical Meaning and Alter Thematic Linking Rules.

The Add items require an *elaboration* of elements already contained in the sentence. RBDs are not impaired in their ability to elaborate; in fact, they have been reported to embellish stories with extraneous comments or additions (Wapner et al., 1981). They should therefore not have difficulty with the items in the Add categories: Add Modifier, Add Complement and Add Thematic Role. For these patients, then, it is the Add/Alter distinction that is predicted to determine the degree of difficulty of the items, and not the particular language subcomponent in which the modification occurs.

Due to its anatomical structure and primary mode of operation, the left hemisphere is best suited to processing within single modalities such as language (Goldberg and Costa, 1981). This may partially explain why damage to the left hemisphere results in a number of well-documented aphasic syndromes which can be characterized within the language system (Caplan, 1987). Among these are Broca's aphasia, which involves a disturbance in spontaneous speech and repetition, and Wernicke's aphasia, where auditory comprehension and repetition are disrupted. Despite their impairments at the syntactic level, LBDs do not exhibit discourse-related deficits related to rigidity of information processing. Such deficits are more characteristic of RBDs, since the right hemisphere is better suited to cross-modal types of processing (Goldberg and Costa, 1981). It is therefore

predicted that LBDs will not distinguish between the Add and Alter items. Rather, all items involving the syntactic component should be problematic for them.

As a preliminary investigation of the hypothesized Add/Alter distinction, the reanalyzed stimulus items of S&S's study were grouped according to whether they belonged to an Add or Alter category (Appendix B). After eliminating those items which involved operations in more than one category, there remained 16 items that could be classified into one of the Alter categories. Of these 16 Alter items, 14 were considered Shift items in S&S's original analysis. Similarly, only the Non-shift items that involved simple additions were reclassified as belonging to an Add category.

S&S report that the LBDs in their study performed better than the RBDs on the Shift items, while on the Non-shift items the RBDs did better than the LBDs. On the overall test, both groups had similar scores. When the Shift and Non-shift scores were compared within each BD group, the LBDs showed no significant difference in performance on the two types of items. However, the RBDs did significantly worse on the Shift than on the Non-shift items. Table 1-1 shows the results of a Mann Whitney U test done on the Shift and Non-shift items. This table is a modified version of Table 3 in S&S (p. 43), for it is arranged in terms of number of errors rather than number correct. A Mann-Whitney U test was also carried out on the subset of Alter and Add data. These results are shown in Table 1-2.

The results of the Mann-Whitney U analysis using the Alter/Add distinction (Table 1-2) parallel those of S&S's original Shift/Non-shift analysis (Table 1-1). Moreover, the between-group comparison for the Alter items reveals a greater level of confidence than the between-group comparison for the Shift items (LBD < RBD). The new Add and Alter

categories thus seem to reflect more clearly the differences between the two groups.

**Table 1-1: Mann-Whitney U for Shift and Non-shift Items (No. of Errors)<sup>11</sup>**

<u>All Items</u>	<u>Shift</u>	<u>Non-shift</u>	<u>Shift vs. Non-shift</u>
LBD vs. RBD U=133 N.S.	LBD < RBD U=79.5 p < .025	LBD > RBD U=90 p < .05	LBD Shift vs. LBD Non-shift U=116 N.S.
			RBD Shift > RBD Non-shift U=22 p < .005

**Table 1-2: Mann-Whitney U for Alter and Add Items (No. of Errors)<sup>12</sup>**

<u>All Items</u>	<u>Alter</u>	<u>Add</u>	<u>Alter vs. Add</u>
LBD vs. RBD U=135.5 N.S.	LBD < RBD U=68.5 p < .005	LBD > RBD U=91.5 p < .05	LBD Alter vs. LBD Add U=99 N.S.
			RBD Alter > RBD Add U=57 p < .005

### 1.3 The Present Study

The aim of the present study is to compare the performance of RBDs and LBDs on a revised version of S&S's Insertion test: the Insertion Test II. The stimuli in this experimental task, instead of being divided into Shift and Non-shift items, are classified according to the seven categories described in section 1.2. In addition, we replicate the Insertion Test of S&S.

<sup>11</sup> All probabilities are one-tailed.

<sup>12</sup> All probabilities are one-tailed.

The study also includes evaluative measures of general verbal and nonverbal ability.

Because it is assumed that brain damage will result in some degree of impairment in general cognitive abilities, both LBD and RBD groups are expected to exhibit deficiencies on the evaluative measures. It is also assumed that LBDs will be more impaired in general verbal ability than RBDs, and that the reverse will be true (i.e., RBDs will be more impaired) in visuo-spatial or performance ability. Based on the reanalysis of the results of S&S's Insertion test and on rigidity problems associated with RBDs, it is predicted that the RBDs will be more impaired than the LBDs on insertions that require changing elements already present in the stimulus sentence. These changes may be lexical, syntactic or semantic.

Thus the hypotheses for this study are:

- (29) 1. LBDs will be more impaired than the RBDs on the verbal evaluative measures.
2. RBDs will be more impaired than LBDs on the nonverbal evaluative measures.
3. LBDs will be more impaired than RBDs on the "Add" insertion items of the type Add Modifier, Add Complement and Add Thematic Role.
4. RBDs will be more impaired than LBDs on the "Alter" types of insertion items: Alter Syntactic Role, Alter Lexical Item, Alter Lexical Meaning and Alter Thematic Linking Rules.
5. The results of the S&S Insertion Test will be replicated: LBDs will be more impaired than RBDs on the Non-shift items; RBDs will be more impaired than LBDs on Shift items; and the two groups will perform similarly on the overall test.

## 2. METHODOLOGY

### 2.1 Subjects

There were 11 RBDs and 6 LBDs in the study. Both experimental groups included individuals with damage to the cortical and/or subcortical (basal ganglia and internal capsule) areas. Although one could argue that cortical and subcortical patients should not be grouped together, there is increasing evidence that language functions are not strictly limited to the cortical regions (see, for example, Brunner et al., 1982 and Wallech et al., 1983). Brunner et al. (1982) studied basal ganglia involvement in language, and found that subcortical infarctions involving the basal ganglia led to transient aphasia. Long-lasting abnormalities of language were also detected in these patients. Furthermore, aphasic syndromes resulting from cortical infarctions were more severe when the lesion extended into the basal ganglia. Using an aphasia battery, Wallech et al. (1983) investigated the effects of subcortical lesions (basal ganglia, thalamus and deep white matter) on language functions. Their results revealed that patients with basal ganglia lesions performed worse than both other groups in all parameters of spontaneous speech except fluency and phonemic paraphasias. The deficits, however, were limited to patients with lesions in the left hemisphere. Since left hemisphere basal ganglia patients have been reported to exhibit aphasic symptoms associated with left hemisphere cortical lesions, in the present study we do not distinguish our basal ganglia subjects from our cortical subjects. Caplan (1987) cites a study by Damasio et al. (1982) in which the authors found that there is a powerful

association between aphasia and the internal capsule. We thus include our patient with the lesion in the internal capsule among our LBD subjects.

Both BD groups were restricted to cerebrovascular accident (CVA or stroke) patients with no prior history of neurological disorder. The medical criteria for potential subjects included a history free of epilepsy, multiple sclerosis, Parkinson's disease, traumatic brain injury and brain surgery. The subjects were chosen with the cooperation of the neurological and out-patient services of three hospitals in Ottawa: The Rehabilitation Centre, Saint-Vincent Hospital and the Ottawa Civic Hospital.

All BD subjects had undergone neurological assessment and were chosen on the basis of the comprehensiveness of their neurological and medical history and available results of Computerized Cranial Tomography (CT) scans. Pertinent neurological information included lesion site, lesion type, time elapsed from onset (not less than one month or more than 5 years), and therapeutic treatment (including surgical intervention, medication, etc.). The LBD group was made up of individuals who had been clinically assessed as being mildly to moderately aphasic. A detailed description of the subject sample is given in Table 4-1 of 4.3.

Only right-handed, native speakers of English were chosen as potential subjects. The screening procedure for all subjects included a line crossing test for severe neglect syndrome, as well as simple tests of reading comprehension and visual scanning. Those who were unable to perform these tasks did not undergo further testing.

## 2.2 Screening Measures (see Appendix C)

### 2.2.1 Edinburgh Handedness Inventory

A slightly modified version of the Edinburgh Handedness Inventory (Oldfield, 1971) was used as a measure of assessing handedness. Subjects were asked which hand they used (or had used prior to stroke) for such activities as writing, drawing and throwing. In order to be considered right-handed, individuals had to specify right hand use for at least nine out of the ten activities.

### 2.2.2 Line Crossing

In this test subjects are presented with a sheet of paper containing short, randomly placed lines, and are required to put a stroke through each of the lines. Patients suffering from neglect syndrome will ignore lines on the side of the page contralateral to their injured cerebral hemisphere. Individuals who missed more than one line were excluded from the study.

### 2.2.3 Reading Comprehension

Subjects were given a simple test of reading comprehension to ensure that they had the necessary reading skills to undertake the Insertion Tests. The reading test consisted of several items from the *Mini Inventory of Right Brain Injury (MIRBI)* (Pimental and Kingsbury, 1985) and the *Therapy Guide for the Adult with Language and Speech Disorders, Vol. 2* (Kilpatrick, 1987). Subjects were required to read aloud sentences containing one- and two-step commands, and then follow the commands. They also read aloud a short paragraph and answered questions about its content. Those individuals who

could not read or perform all the commands correctly, or who made errors in answering the paragraph questions, were excluded from the study.

#### 2.2.4 Visual Scanning

This test, a subtest of the MIRBI, was administered to check for any difficulties in visual scanning ability. The test consists of a row of letters closely spaced, and another row of letters spaced further apart. Subjects were asked to circle all the "A"s in both lines. They were allowed to miss one "A" in each line.

### 2.3 Evaluative Measures

In order to establish a baseline for comparing the general cognitive abilities of the two brain damaged groups, six evaluative measures were administered. These tests (described below) cover a range of skills which include semantic knowledge, lexical access, visuo-spatial ability and short-term memory. They are the Similarities, Digit Symbol, Digit Span and Picture Completion subtests of the Wechsler Adult Intelligence Scale-Revised (WAIS-R) (Wechsler, 1981), the FAS Verbal Fluency Test (Benton and Hampshire, 1976), and a Category Naming Test (Grossman, 1978).

#### 2.3.1 Similarities

The Similarities Test is a verbal subtest of the WAIS-R. Subjects are given two stimulus items such as "orange" and "banana," and are required to identify the superordinate category to which the items belong (i.e., "fruit").

### 2.3.2 Digit Span

The Digit Span Test, another verbal subtest of the WAIS-R, is a test of short-term memory in which the subject must recall sequences of numbers, some forwards and some backwards.

### 2.3.3 Digit Symbol

In this performance subtest of the WAIS-R, subjects are presented with symbols that correspond to the digits 1 to 9. They are then given a series of 93 digits, and are required to write the corresponding symbol underneath each digit, working as quickly as possible within the designated time limit of 90 seconds.

### 2.3.4 Picture Completion

Another performance subtest of the WAIS-R, the Picture Completion test requires subjects to identify the missing element from pictures of common items. For example, they are given a picture of eyeglasses that are missing the nosepiece.

### 2.3.5 FAS Verbal Fluency

In this verbal fluency test (Benton and Hampshire, 1976), subjects are given one minute to provide as many words as they can beginning with a designated letter. The test is repeated using the letters F, A and S. Credit is not given for proper names or roots repeated with productive affixes such as 'fruit, fruitful, fruitfulness'. The test score is calculated based on the total number of unique words produced.

### 2.3.6 Category Naming

The Category Naming Test, based on a similar test by Grossman (1978), also tests verbal fluency, but uses semantic criteria instead of letters. Subjects are required to produce the greatest possible number of names of animals and pieces of furniture, each within a one-minute time limit.

## 2.4 Experimental Tasks

### 2.4.1 Insertion Test II

The Insertion Test II is a revised version of the Insertion tests used in Saddy (1983) and Schneiderman and Saddy (1988). However, in this study, the stimuli are classified according to the seven categories described in Section 1.2. The original sentences (without the insertions) vary in length from six to eight words, and the insertions are all between one and three words long. Each category is represented by 12 sentences, for a total of 84 items. Examples of the different types of stimulus sentences, with the insertion component underlined and item number in parentheses, are provided in (1). See Appendix D for a complete list of stimuli.

- (1)
1. Add Modifier  
Mrs. Dixon forgot her red umbrella at home. (Item 8)
  2. Add Complement  
The baby in the stroller smiled happily at everyone.  
(Item 13)
  3. Alter Syntactic Role  
The fire brigade was visible from Ed's window. (Item 26)

4. Alter Lexical Item  
Adam's fireplace certainly needs a good cleaning. (Item 37)
5. Alter Lexical Meaning  
Jack made fun of the sled Susie got for Christmas.  
(Item 55)
6. Add Thematic Role  
John eats his lunch in the company cafeteria every day.  
(Item 61)
7. Alter Thematic Linking Rules  
Andrea bought the little puppy a bone at the pet shop.  
(Item 77)

All of the items were validated by a non brain-damaged population to ensure that errors made by the experimental groups were due to their neurological deficits. A total of 201 English-speaking subjects selected from several classes and cafeterias at the University of Ottawa and Carleton University participated in the validation study. The validation test consisted of the stimulus items presented as a list, with the insertions for each item occurring in parentheses after the item.<sup>1</sup> The subjects were asked to mark with an arrow the place where the insertions belonged. Items that permitted an insertion in more than one place were revised to disallow ambiguity. The only category for which this was not possible was Add Complement, for it is difficult to limit adverbial and prepositional phrases to one place in a sentence. An item that received more than one incorrect response was revised and retested or replaced.

Several of the items belonging to the category Alter Lexical Meaning are ambiguous in meaning, although the sentences were created to bias one

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<sup>1</sup>There were 4 versions of the validation test, each one containing a subset of the total items, because it was felt that there were too many items in the test to present all at once.

meaning over the other. For example, for the item *Ken's a fair man who never lies*, the preferred reading of *fair* is *just* or *impartial*. The insertion of *haired* thus requires the meaning of *fair* to change from *just* to *light* or *blond*. In order to test the preferred reading of the ambiguous words in these items, they were presented to 10 normals who were asked to paraphrase them. The interpretations were virtually unanimous for all the items.

The Insertion Test II is printed on card stock and presented to a subject one item at a time. The experimenter asks the subject to read the sentence aloud. The subject is then given a card bearing a word or phrase, and must show where the word or phrase could be inserted into the sentence by reading aloud the modified sentence. The test consists of a practice trial and 84 items, with one insertion for each item.

#### 2.4.2 S&S Insertion Test

This test is a replica of the Insertion Test used in Schneiderman and Saddy (1988). The procedures for administering this test are the same as those for the Insertion Test II above, except that there are between three and five non-cumulative insertions for each stimulus sentence. An example of an item from this test, with its insertions, is given in (2).

- (2) I opened the book on the table. (S&S 6)
- a. which was
  - b. cloth
  - c. thick
  - d. card

## 2.5 Testing Procedures

Potential subjects were initially selected by examining in-patient charts on the neurological and rehabilitation wards of The Rehabilitation Centre, Saint-Vincent Hospital and the Ottawa Civic Hospital. At The Rehabilitation Centre, out-patient charts were also examined.

Once potential subjects had been identified, permission to test the patient was requested of the attending physician. The patient was then approached, given a brief explanation of the study, and was asked if he/she would be willing to participate in the project. No testing was undertaken without the patient's full cooperation and consent. All in-patient testing was done at the hospital, and the testing of out-patients was conducted at the patients' homes.

The testing of each subject averaged three sessions of approximately one hour each. Some subjects required four sessions, and others finished in two. In one extreme case, six testing sessions were necessary because the patient could not concentrate for more than 20 minutes. The first session involved the signing of the consent form, the recording of pertinent background information otherwise not available, and the administration of the screening tests. In most cases, one block of both Insertion tests and one or two evaluative measures were also administered in the first session. During the second and third sessions the remaining evaluative measures were administered, and both Insertion tests completed.

The order of testing differed for each subject, although in all cases blocks of the two Insertion tests were alternated with the evaluative measures. As in their original study, the items from S&S's Insertion Test were presented in one of two predetermined orders, and the insertions for

each item were presented to the subjects randomly. To ensure against any order effects, the items in the Insertion Test II were randomly ordered uniquely for each subject<sup>2</sup>. An example of a typical testing format is given in (3).

(3) Session 1

Consent Form  
Medical History  
Edinburgh Handedness Inventory  
Line Crossing  
Reading Comprehension  
Visual Scanning  
Insertion II (19 items)  
FAS Verbal Fluency  
S&S Insertion (6 items)

Session 2

Insertion II (18 items)  
Digit Span  
S&S Insertion (6 items)  
Category Naming  
Insertion II (15 items)  
Picture Completion

Session 3

Insertion II (17 items)  
Digit Symbol  
S&S Insertion (6 items)  
Similarities  
Insertion II (15 items)

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<sup>2</sup> We would like to thank Richard Mowrey for writing and running the computer program used to randomly order the items.

### 3. RESULTS

#### 3.1 Evaluative Measures

Table 3-1 provides descriptive statistics for the results of each BD group on the evaluative measures. (See Appendix E for individual subject results.)

**Table 3-1: Descriptive Statistics - Evaluative Measures**

<u>Test</u>	<u>Group</u>	<u>Mean</u>	<u>Std. Dev.</u>	<u>Minim.</u>	<u>Maxim.</u>	<u>Range</u>
FAS	LBD	20.8	15.5	4	46	42
	RBD	28.6	11.7	12	43	31
Category Naming	LBD	16.7	8.3	3	24	21
	RBD	20.8	6.4	10	33	23
Digit Span	LBD	6.3	1.2	5	8	3
	RBD	9.1	2.6	6	13	7
Similarities	LBD	9.7	2.3	7	13	6
	RBD	8.9	3.7	3	14	11
Picture Completion	LBD	6.5	3.1	2	1	8
	RBD	6.2	2.6	3	10	7
Digit Symbol	LBD	3.0	1.3	1	4	3
	RBD	4.6	2.7	2	12	10

Table 3-1 shows that the LBDs were more impaired than the RBDs (in terms of mean scores) on 3 of the 4 verbal measures (FAS, Category Naming and Digit Symbol), and on 1 of the 2 nonverbal measures (Digit Span). The RBDs were more impaired than the LBDs on one verbal measure (Similarities) and one nonverbal measure (Picture Completion). These results are not in complete accordance with Hypotheses 1 and 2, which state that the LBDs will be more impaired than the RBDs on the verbal evaluative measures, and the RBDs will be more impaired than the LBDs on the nonverbal evaluative measures.

### 3.2 Insertion Test II

Possibly due to the small subject sample size, as well as a number of other factors to be discussed in 4.3, no statistically significant results were found for either the Insertion Test II or the S&S Insertion Test. Therefore, a more descriptive method of analysis will be used, with the focus on raw error scores and means.

The error rates for each category of the Insertion Test II, and for the totals of the Add and Alter categories, are given in Table 3-2. (Results for individual subjects are given in Appendix F.) The error rates are the percentages of total possible error by group and category. They were calculated by summing up all the errors made by one group for a given category, dividing that by the total number of possible errors for that category (i.e., number of subjects x number of items), and multiplying by 100.

**Table 3-2: Error Rates for Categories of Insertion Test II (as percentage of total possible error)**

<u>Group</u>	<u>Add Modifier</u>	<u>Add Complement</u>	<u>Add Thematic Role</u>	<u>Total Add</u>	
LBD	2.8	0	0	0.9	
RBD	3.8	2.3	1.5	2.5	
<u>Group</u>	<u>Alter Syntactic Role</u>	<u>Alter Lexical Item</u>	<u>Alter Lexical Meaning</u>	<u>Alter Thematic Linking Rules</u>	<u>Total Alter</u>
LBD	4.2	9.7	2.8	6.9	5.9
RBD	3.0	5.3	7.6	4.5	5.1
<u>Group</u>	<u>Total Errors</u>				
LBD	3.8				
RBD	4.0				

Hypothesis 3, formulated in 1.3, predicts that the LBD error rate would be higher than the RBD error rate for the Add Categories: Add Modifier, Add Complement and Add Thematic Role. However, Table 3-2 shows that the error rates for the LBD group are lower for all of these categories. Hypothesis 4 states that the RBDs should have a higher error rate for the Alter categories: Alter Syntactic Role, Alter Lexical Item, Alter Lexical Meaning, and Alter Thematic Linking Rules. However, their error rate is higher only for the category Alter Lexical Meaning. Thus the results of this last category alone are in accordance with our hypotheses.

The differences in error rates between the two groups vary from 0.8 for Alter Syntactic Role (LBD > RBD) to 4.8 for Alter Lexical Item (LBD > RBD). The RBD error rate for the three Add categories combined exceeds that of the LBDs by 1.6 percentage points. Their error rate for the four combined Alter categories is lower than the LBD error rate by 0.8 percent. Both groups did much worse on the Alter than the Add items, although the difference is more striking for the LBDs (5.9 vs. 0.9) than for the RBDs (5.1 vs. 2.5). The error rates for the two groups on the overall test differ by only 0.8 points (RBD > LBD). These results are contrary to what one might expect given our hypotheses.

### 3.3 S&S Insertion Test

The error rates for the two BD groups on the S&S Insertion Test are given in Table 3-3. (See Appendix G for results by subject.) The error rates were calculated as for the Insertion Test II, by dividing the actual number of errors for each category by the total number of possible errors and multiplying by 100.

**Table 3-3: Error Rates for Categories of S&S Insertion Test (as percentage of total possible error)**

<u>Group</u>	<u>Shift</u>	<u>Non-Shift</u>	<u>Alter</u>	<u>Add</u>	<u>Total</u>
LBD	16.0	7.5	13.5	12.7	11.0
RBD	17.5	4.8	17.6	6.5	9.4

The RBD group made more errors than the LBD group on the Shift items (1.5% difference), and fewer errors than the LBDs on the Non-shift items (by 2.7%). Although the differences between the two groups are small, the results are in the same direction as the results of the S&S study. The within-group results also parallel those of S&S. Both groups made more errors on the Shift items than on the Non-shift items, with the difference being larger for the RBDs (12.7%) than for the LBDs (8.5%). These findings are thus in accordance with Hypothesis 5, which predicted that the results of the S&S Insertion Test would be replicated.

When the Shift and Non-shift items are reclassified as Alter and Add, the results for the two groups become closer to those in the S&S study. Their RBDs did significantly better on the Shift items than on the Non-shift items, while their LBDs showed no significant difference on the two categories. With the reanalysis of items, the 11.1% Alter/Add difference for the RBDs remains close to the 12.7% difference for Shift/Non-shift. For the LBDs, however, the Alter/Add difference drops to 0.8% from 8.5% for Shift/Non-shift, revealing virtually no distinction between the two types of items. The between group differences also change in the direction of the S&S study. They are greater for the Alter category (4.1%) than for the Shifts (1.5%), as well as being greater for the Add category (6.2%) than for the Nonshifts (2.7%).

In summary, the results of this replication parallel those reported by S&S, with the RBDs outperforming the LBDs on the Non-shift and Add Items (lower error rate), the LBDs outperforming the RBDs on the Shift and Alter Items, and the two groups performing similarly on the test as a whole.

## 4. DISCUSSION

### 4.1 Introduction

The purpose of this study was to explore the linguistic capabilities of the right hemisphere by examining the language deficits of RBDs. Evaluative and experimental measures were presented to both LBDs and RBDs in order to test our hypotheses concerning their linguistic abilities. The evaluative measures were included as an assessment of general verbal and nonverbal functioning. The Insertion Test II explored the ability of RBDs to manipulate language at the various levels represented by the categories in the experimental measures, i.e., the lexical, syntactic and thematic levels. It was shown in Chapter 3 that the results of the study are not in complete accordance with our hypotheses. In this chapter we take a closer look at the various tests, and also discuss factors in our subject sample which may have influenced the results.

In examining the errors made by the subjects on the Insertion Test II, we focus on several categories that are problematic. Various analyses at different levels of language are proposed to explain the observed deficits, and these deficits are also discussed within the context of each hemisphere's typical mode of processing. Finally, in the General Discussion we attempt to answer the two key questions of this study: (i) Which components of language are problematic for the two BD groups? and (ii) What do the sentence-level impairments of RBDs reveal about their deficits at the discourse level?

## 4.2 Evaluative Measures

The evaluative measures were included in this study to test general verbal and nonverbal ability. Based on the verbal deficits primarily associated with the left hemisphere and the nonverbal deficits associated with the right, it was hypothesized that the LBDs would be more impaired than the RBDs on the verbal evaluative measures (Hypothesis 1), and that the RBDs would be more impaired than the LBDs on the nonverbal measures (Hypothesis 2). From Table 3-1 we see that two evaluative measures do not conform to our hypotheses: the Similarities and Digit Symbol tests. On the Similarities test, considered a verbal measure, the RBDs were more impaired than the LBDs, and on the non-verbal Digit Symbol test the LBDs were more impaired than the RBDs.

Let us examine more carefully these two subtests of the WAIS-R. Sprandel (1985) describes the Similarities as a test that measures the ability to find relationships not immediately obvious and to formulate generalizations based on these relationships. Identifying the superordinate category to which two words belong requires abstracting common traits or qualities as opposed to defining concrete, specific properties. RBDs are known to have difficulty with abstract concepts (Erownell et al., 1984; Elsenon, 1962). Therefore, although this task is essentially verbal, it requires operations not suited to the damaged right hemisphere. It is not surprising, then, that the RBDs in this study perform poorly on this test.

The Digit Symbol is a performance subtest of the WAIS-R that measures the ability to master a visually-presented task. It is a test that requires, among other skills, visual-motor coordination, manual dexterity and speed (Sprandel, 1985). The poor performance of the LBDs in this study can be

explained by their physical limitations. One debilitating effect of a stroke is the weakening or paralysis of the side of the body contralateral to the lesion site. Patients with damage to the left hemisphere, therefore, exhibit weakness on their right side. Since this study includes only right-handers, as assessed by the Edinburgh Handedness Inventory, our LBDs are essentially right-handers forced to use their left hands. Such a handicap would severely limit their performance on a task such as the Digit Symbol, where manual dexterity and speed are important factors. This test, then, should not be considered a valid evaluative measure for comparing our BD groups.

### 4.3 Subject Sample

Although we hypothesized that there would be differences between the LBD and RBD groups on both the evaluative and experimental measures, our results show that the observed differences are not great enough to be statistically significant. An examination of our subject sample may help us to explain why none of the results of this study are significant.

Table 4-1 gives a breakdown of subjects by sex, age, lesion site, elapsed time in months and years of education. These are factors which may have contributed to our results. In Table 4-1 (and subsequently), the subject numbers of LBDs are preceded by an L, and those of RBDs, by an R.

**Table 4-1: Subject Information**

<u>Subject</u>	<u>Sex</u>	<u>Age</u>	<u>Lesion Site</u>	<u>Elapsed Time</u> (months)	<u>Education</u> (years)
L-01	F	50	Frontal	2.0	14
L-02	M	35	Frontal	30.0	18
L-05	M	69	Frontal	2.5	12
L-06	M	72	Basal Ganglia	42.0	12
L-07	M	59	Basal Ganglia	26.0	14
L-08	M	60	Internal Capsule	1.5	14
LBD Means		57.5		17.3	14.0
LBD S.D.		13.5		17.6	2.2

<u>Subject</u>	<u>Sex</u>	<u>Age</u>	<u>Lesion Site</u>	<u>Elapsed Time</u> (months)	<u>Education</u> (years)
R-01	M	65	Frontoparietal	6.0	18
R-02	M	73	Occipital	3.0	18
R-03	F	77	Basal Ganglia	1.5	4
R-04	M	67	Frontoparietal	3.0	16
R-06	F	55	Frontoparietal	1.0	12
R-07	M	75	Frontal	1.5	16
R-08	M	78	Parietal	14.0	10
R-09	M	45	Frontoparietal	1.0	10
R-10	M	71	Mid. Cerebral Artery	10.0	12
R-11	F	31	Basal Ganglia	1.0	14
R-12	M	42	Frontoparietal	3.0	17
RBD Means		61.7		4.1	13.4
RBD S.D.		16.1		4.3	4.3

The subjects include 6 LBDs and 11 RBDs, for a total of 17 subjects. This is a small sample size and, in addition, one that is not evenly distributed between left and right groups. In fact, there are almost twice as many RBDs as there are LBDs. Although the RBD group may consist of enough subjects for their results to reach statistical significance, the small number of subjects in the LBD group would presumably mitigate against it.

The mean age of the LBD group is slightly lower than that of the RBD group (LBD: 57.5 years, RBD: 61.7). Bayles, Kaszniak and Tomoeda (1987) review studies on the effects of aging on linguistic communication and report that the elderly have been found to be slower in performing sentence comprehension tasks, but that their linguistic knowledge appears to be preserved. Based on the data they review they conclude that certain of the processes important in communication do diminish with age, but that the diminishment is small and more common in the "very old" and the aged sick. The mean ages of the two groups in this study differ only by 4.2 years, but the RBD group includes a greater proportion of subjects in their 70's than the LBD group does. This may have a lowering effect on their performance, although we would not consider 78 (the maximum RBD age) to be "very old."

The LBDs have a mean Elapsed Time (E.T.) more than 4 times greater than that of the RBDs (LBD: 17.3 months, RBD: 4.1 months). In looking at elapsed times after onset of stroke, one must consider the E.T.s in terms of stages. The patient is usually medically unstable in the first few weeks after onset due to tissue swelling resulting in intracranial pressure, compression of brain structures and reduction of cerebral blood flow. Therefore, one month post-onset is considered to be the earliest time that most aphasic patients present a clear pattern of impaired and spared functions (Davis, 1983). One to twelve months post-onset is a time of recovery, with the majority of observable improvements occurring in the first six months. This period of recovery normally ends after about one year, when the patient has reached the maximum level of recovery and is considered to be stable.

None of the LBD or RBD subjects in this study were tested before one month post-onset. However, there is a difference between the two groups in the number of subjects with E.T.s in the recovery (1 to 12 months) and

stable (more than 12 months) periods. Of the 6 LBDs, 3 (or 50%) are in the recovery stage, and an equal number are in the stable stage. In the RBD group, almost all of the subjects (10 out of 11, or 90%) are in the recovery stage, and the one remaining subject, with an E.T. of 14 months, may be considered still to be in that stage. The proportionally large number of LBD subjects with E.T.s greater than one year suggest a more stable group than the RBDs.

The mean level of education for the LBDs is 14.0 years, and for the RBDs, 13.4 years. Joannette et al. (1983) discuss the effects of education on language impairment. In their study they attempt to identify homogenous subgroups of RBD subjects based on the subjects' results on a battery of linguistic tests. One of the social factors which Joannette et al. consider may affect the subjects' performance is level of education. Their conclusion is that dextrals with a lower level of formal education are more likely than those with a higher level to present relatively intense linguistic disturbances. A Pearson's  $r$  on the results of the present study reveals significant negative correlations between education and error rates for the RBD group on both Insertion tests (Tables 4-2 and 4-3). Thus, for this group, a higher educational level corresponds to a lower error rate, supporting Joannette et al.'s findings.

**Table 4-2: Pearson's r - Education with Error Rate on Insertion Test II for RBDs**

	Education
Add Modifier	-.818 <sup>a</sup>
Add Complement	-.795 <sup>a</sup>
Add Thematic Role	-.723 <sup>a</sup>
Alter Lexical Item	-.399 <sup>b</sup>
Alter Lexical Meaning	-.812 <sup>a</sup>
Alter Syntactic Role	-.672 <sup>a</sup>
Alter Thematic	
Linking Rules	-.768 <sup>a</sup>
Total Add	-.868 <sup>a</sup>
Total Alter	-.785 <sup>a</sup>
Total Error	-.846 <sup>a</sup>

<sup>a</sup>p<.005, one-tailed<sup>b</sup>N.S.**Table 4-3: Pearson's r - Education with Error Rate on S&S Insertion Test for RBDs**

	Education	
Shift	-.715	(p<.005)*
Non-Shift	.199	(N.S.)
Alter	-.638	(p<.005)
Add	-.601	(p<.01)
Total Error	-.741	(p<.005)

\*All probabilities are one-tailed.

A similar analysis for the LBD group did not yield significant correlations. It is not clear whether the results of Joannette et al.'s study can be applied to LBDs, since their study involved only RBDs. There are several factors, however, which may explain the lack of significant correlations for the LBDs in the present study. One is the small number of LBD subjects. Six subjects is generally not enough to reveal statistically significant correlations. Secondly, with respect to education, the LBDs

present a more homogeneous group than the RBDs. Thus, there may not be enough variability in educational level among the LBD subjects to yield significant correlations with their test results. Thirdly, it is possible that verbal deficits in LBDs are simply less sensitive to educational level. Perhaps their linguistic deficits are more independent of outside influences compared to the verbal impairments of RBDs. Furthermore, the fact that such a correlation exists only for the RBDs provides further proof of the variability of the subject sample.

The various factors discussed above (low mean age, high E.T., independence of educational level and test performance) suggest that our LBDs are minimally impaired relative to a typical LBD group. The LBDs were included in the study as a control group with which to compare the performance of the RBDs. If these LBD controls are functioning at a high level and do not exhibit the impairments normally associated with LBDs, then they are not a viable group against which to assess the deficits of RBDs. The hypotheses for this study were based on the predicted performances of typical LBD and RBD groups. Because of the atypical nature of this LBD group, we will focus the rest of the discussion more towards an analysis of the deficits exhibited by the RBDs, and less on a comparison of the two groups' performances.

#### 4.4 Experimental Measures

Although the results of the S&S Insertion Test are not statistically significant, possibly due to the various factors discussed above, they do follow the general trend found in the original S&S study. However, the Insertion Test II, which was designed based on the results of the S&S Insertion Test, does not yield results consistent with our hypotheses. Contrary to Hypotheses 3 and 4 (given in 1.3), the RBDs have a higher error rate than the LBDs on all three Add categories, and a lower error rate on three of the four Alter categories. Both LBD and RBD groups had more difficulty with the Alter categories than with the Add categories, except for Add Modifier, which was problematic for the RBDs. (The RBDs' difficulty with this category will be discussed in 4.5.4 below.) It seems, then, that in general the Alter items are more difficult than the Add items. The LBDs' low error rate on the Add categories may be attributed in part to their high level of functioning.

The Alter/Add prediction seems to have been accurate for the S&S Insertion Test, but not for the Insertion Test II. On the other hand, perhaps it is the actual stimulus items, and not the categories, that are affecting the results. The items in this test were created with the aim of further specifying and isolating the changes involved in the S&S items. Thus, they involve only "pure" changes; that is, only one change is involved per item. The structure of the items is also simpler, to avert any difficulties due to complex sentence structure. The few errors made by each subject (see Appendix F) and the low error rates on the items suggest a ceiling effect on the test.

By contrast, on the S&S Insertion Test and on those evaluative measures that were used in both studies, our BD groups had similar error rates and scores to those reported in S&S. Thus, it appears that the items in the Insertion Test II are generally too easy, and that the results of the S&S Insertion Test are dependent on a Shift/Non-Shift distinction compounded by the level of difficulty of the items. In light of these issues, overall trends will not be considered further. Instead, the remainder of our discussion of the Insertion Test II results will focus on specific items that are problematic for RBDs, the categories to which those items belong, and patterns exhibited by the subjects' errors.

#### **4.5 Error Analysis of Insertion Test II**

Table 4-4 lists all the items which were problematic for the RBDs and LBDs. Given in the table are the number and percentage of subjects in each group who made errors on each item. Because there are 11 RBDs and 6 LBDs, we cannot directly compare the number of subjects who made errors on each item; this is why the percentage of RBD and LBD subjects is also given. The 34 items listed in the table account for 40% of all 84 items. In other words, 60% of all the items in the test were correctly answered by all subjects.

**Table 4-4: Problematic Items of Insertion Test II**

<u>Category</u>	<u>Item No.</u>	<u>No. LBD Err.</u>	<u>LBD %</u>	<u>No. RBD Err.</u>	<u>RBD %</u>
Add Modifier	4	1	16.7	2	18.2
	5	0	0	1	9.1
	6	0	0	1	9.1
	7	0	0	1	9.1
	10	1	16.7	0	0
Add Complement	13	0	0	1	9.1
	18	0	0	1	9.1
	22	0	0	1	9.1
Alter Syntactic Role	26	0	0	1	9.1
	30	1	16.7	0	0
	31	0	0	1	9.1
	33	1	16.7	1	9.1
	36	1	16.7	1	9.1
Alter Lexical Item	37	0	0	1	9.1
	38	1	16.7	0	0
	39	1	16.7	1	9.1
	42	1	16.7	0	0
	46	2	33.3	5	45.5
	47	1	16.7	0	0
	48	1	16.7	0	0
Alter Lexical Meaning	49	0	0	1	9.1
	50	0	0	1	9.1
	51	1	16.7	1	9.1
	53	0	0	2	18.2
	54	1	16.7	1	9.1
	58	0	0	2	18.2
	59	0	0	1	9.1
	60	0	0	1	9.1
Add Thematic Role	61	0	0	1	9.1
	63	0	0	1	9.1
Alter Thematic Linking Rules	80	1	16.7	0	0
	82	0	0	3	27.3
	83	1	16.7	0	0
	84	3	50.0	2	18.2

As can be seen in Table 4-4, subject errors are concentrated in five categories of the Insertion Test II: Alter Syntactic Role, Alter Thematic Linking Rules, Alter Lexical Item, Add Modifier and Alter Lexical Meaning. Each category will be examined in turn.

#### 4.5.1 Alter Syntactic Role

The items in this category were created based on the Shift items of the S&S study, which were significantly more problematic for their RBDs than their LBDs. However, as we discussed in 1.2, their Shift items involve many different kinds of operations. The category Alter Syntactic Role of the Insertion Test II is limited to items that require only a change in syntactic role in a simple sentence. The results of the present study reveal that the LBDs made more Alter Syntactic Role errors than the RBDs, and that both groups present low error rates on this category. It appears that the isolated changing of syntactic role is not too problematic for either group and, furthermore, that the RBDs do not present more difficulty than the LBDs. In the general discussion below we consider why RBDs should exhibit any deficits at all with such a syntactic operation.

#### 4.5.2 Alter Thematic Linking Rules

Four of S&S's Shift items were reanalyzed in the present study as involving a shift in the thematic linking rules which link a verb's arguments with their syntactic realizations. (See 1.2.7 above for a discussion of thematic linking rules.) These four items, given below in (1)-(4), were problematic for LBD and RBD subjects in both the S&S and present studies.

- (1) Cindy saw her take Howard his drink. (S&S 9.2\*)
- (2) Susan brought John the sweater that was mended. (S&S 10.2\*)
- (3) Susan heard her tell him a joke. (S&S 11.1\*)
- (4) Susan heard her tell Larry a joke. (S&S 11.3\*)

On these items of the S&S Insertion Test, the RBDs in both studies made more errors than the LBDs. It is of interest to observe here that the most RBD errors occurred on item 9.2 (shown in (1)), which also involves a change in lexical meaning. As noted in S&S, with the insertion of *Howard* the meaning of *take* changes from *steal* to *transport*. The category Alter Lexical Meaning will be discussed in 4.5.5 below. The above items are also all complex sentences, which may be a major factor contributing to their difficulty (see 1.2 above).

In section 1.2.7, three types of thematic linking rule changes were discussed. All of the S&S items reanalyzed as belonging to this category are of the third type (Type 3), where there is a violation of the thematic hierarchy but no change in thematic role of the arguments. These Type 3 items were also the most problematic for the two BD groups in the Insertion Test II (although the error rate was higher for the LBDs than the RBDs, contrary to the results for this type of item in the S&S Insertion Test). Our subjects also made errors on the second type of item (Type 2), where there is both a change in the thematic hierarchy and a change in thematic role. They did not, however, have difficulty with the Type 1 items where the thematic role of an argument undergoes a change without a hierarchy violation.

From these results it would appear that the difficulty with the items in this category is due to the violation of the thematic hierarchy. The Type 1 items which involve no hierarchy violation were not problematic for the

subjects, whereas the Type 2 and 3 Items were. However, it is puzzling that the subjects had more difficulty with the Type 3 Items than the Type 2 Items. For it is counterintuitive that the items which violate the thematic hierarchy *without* any change of thematic role are more difficult than the items which involve a hierarchy violation *with* a change of thematic role. Let us examine more closely the three types of items.

Items 73 and 76 ((5) and (6) below) are Type 1 Items:

- (5) It was Bill's job to load the trucks onto the ship. (Item 73)
- (6) After the dinner we cleared all the tables from the hall. (Item 76)

The insertions require the following change in thematic roles of the verb's arguments:

- (7) Agent Verb Location<sub>i</sub> --> Agent Verb Theme<sub>i</sub> Location

In this notational system, two elements that are coindexed refer to the same NP in the sentence before and after the insertion. Thus, the subscript /<sub>i</sub> signifies that the Location argument changes to the Theme. In Type 1 items, then, the original Location changes to the Theme with the addition of a new Location. This Location is linked to an argument appearing after the Theme, so the thematic hierarchy is not violated.

Items 78 and 80 (shown in (8) and (9)) are Type 2 Items, where there is a change in thematic role as well as a hierarchy violation.

- (8) Sam sent his daughter a package on the train. (Item 78)
- (9) Fred playfully tossed his lazy cat a toy. (Item 80)

Insertions of this type require the thematic roles of the verb's arguments to change in the following manner:

(10) Agent Verb Theme<sub>i</sub> --> Agent Verb Goal<sub>i</sub> Theme

With the insertion of a new Theme, the original Theme role must change to Goal. In addition, there is a thematic hierarchy violation, with Goal appearing before Theme in the sentence. Although these types of items are problematic for subjects, the Type 3 items are more so.

Type 3 items are illustrated in (11) and (12).

(11) My brother made his wife a beautiful jewelery box. (Item 83)

(12) My friend John sold my sister that old bicycle. (Item 84)

The insertion in this type of item requires the following change in the verb's arguments:

(13) Agent Verb Theme<sub>i</sub> --> Agent Verb Goal Theme<sub>i</sub>

In a Type 3 item, a Goal argument is inserted before the Theme, resulting in a hierarchy violation, but in contrast to Type 2 items, there is no change of thematic roles. The final structures of (10) and (13) are the same once the new arguments have been inserted. The difference lies in the processes involved in creating the new structures. Structure (13) involves inserting an argument between the verb and its Theme. Structure (10) involves both adding an extra argument at the end of the VP and reassigning thematic roles.

Carlson and Tanenhaus (1988) discuss the issue of thematic role reassignment in language processing. In particular, they explore the function of thematic roles in recovering from misassignments in ambiguous

sentences. They propose two types of verb ambiguities: "sense" and "thematic." A verb with a sense ambiguity such as *set the clock* may have two "core meanings," i.e., *to place* and *adjust*. Thematic ambiguities involve such verbs as *load*, where *the truck* in *load the truck* may either be Theme or Location. If the reader or hearer initially selects the wrong *sense* of an ambiguous word, then reinterpretation is costly because the other senses would have become inactive, and it is necessary to reopen the lexical entry of the verb.<sup>1</sup> In contrast, in a thematic ambiguity the core meaning remains constant, and what is involved is selecting alternative thematic roles. All unassigned thematic roles in a verb's thematic grid remain active, so that the alternative roles are available to be assigned. Carlson and Tanenhaus claim that thematic role assignment is an indexing and reindexing operation that is performed on-line in sentence processing. Moreover, their experiments reveal that the reassociation of thematic roles with arguments appears to be quite easy and cost-free. This apparent ease of thematic role reindexing may partially explain why Type 2 items, which require changing the thematic role of an argument in addition to violating the thematic hierarchy, are not more problematic than Type 3 items.

What is characteristic of the Type 3 structure is the inserting of a Goal between a verb and its Theme. Such an insertion requires violating the Verb+Theme order. Why should this be so difficult? It cannot simply be because a Goal is inserted before a Theme, thus violating the hierarchy, since the hierarchy is similarly violated in the less problematic Type 2 items. Perhaps the three types of items can be distinguished by an analysis

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<sup>1</sup>In their model of lexical access, all the senses of an ambiguous verb become available in parallel. However, only the one sense of the verb that is contextually most appropriate remains active. See 4.5.5 for further discussion of lexical access models.

that does not involve the thematic hierarchy. The notion of thematic hierarchy is in fact a controversial one. Others have proposed different hierarchies: Agent, Source/Location/Goal, Theme (Jackendoff, 1972) or Agent, Beneficiary, Theme, Location (P. Kiparsky, personal communication). With these alternative hierarchies the three item types exhibit either a different violation or, in the latter case, no violation at all (since what we are considering Goal would be Beneficiary).

Let us consider an alternative analysis of these items based on the processes involved in assigning thematic roles. It is possible to examine the assignment of thematic roles to arguments without referring to a hierarchy of grammatical relations or linking rules.

Carlson and Tanenhaus (1988) propose that arguments are assigned thematic roles immediately, and suggest several factors that influence this provisional thematic role assignment: the meaning of an argument, the core meaning of the verb, and general world knowledge. Thus, for example, *pack the suitcases* prefers *suitcases* as Location, while *pack the clothes* prefers *clothes* as Theme. This is because of the nature of suitcases and clothes, and not because of any grammatical properties of the NPs.

In Type 1 items such as (5) and (6) above, the first NP that is provisionally assigned Location must be reindexed as Theme, which in itself is apparently not difficult. Moreover, what makes this item type even easier is that the insertions are all PPs such as *onto the ship* and *into the car*. The preposition is an obvious clue to which thematic role the NP following it should have, i.e., Location. Thus reanalyzing the sentence simply involves changing the original Location to Theme.

Type 2 items such as (8) and (9) above also involve the reindexing of thematic roles. These items are more difficult than Type 1 items since

there are no prepositions to signal what thematic roles the NPs should have. However, with these items, animacy may be a factor in thematic role assignment, since the first NP is always animate (V. Deprez, personal communication). Thus, when processing the pre-insertion stimulus sentence in (14) below, animacy of *the puppy* may determine that it is first assigned Goal.<sup>2</sup>

(14) Andrea bought the puppy a bone at the pet shop.

When the end of the sentence is reached and there is no argument to be assigned the Theme role, then the first NP must be reassigned from Goal to Theme. The insertion in these items provides the "missing" Theme argument, so that reindexing the original Theme back to Goal is in a sense reverting back to the original analysis. Because all the thematic roles remain active in the grid, reassigning an argument back to a Goal that has been activated once before should not be difficult. The data in Table 4-4 show that there was one LBD and one RBD error for all the items of this type, which is more errors than on the Type 1 items (which had a 0 error rate), and less than on the Type 3 ones.

The Type 3 items were the most problematic for both LBD and RBD groups. In processing sentences of this type (see (11) and (12) above), the NP after the verb is assigned the Theme role, and the Goal role remains open, waiting to be assigned. The NP to be inserted should not be problematic since it is the Goal and it is animate. There is no reassignment of role required, simply assigning an unfilled role to an existing NP. That in itself is not problematic, as the results from the category Add Thematic

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<sup>2</sup> The saliency of animacy is further supported by Stowe (ms.), who discusses the role of animacy in parsing decisions. She explores the effect of thematic information available before and after the point of disambiguation, and concludes that her subjects used animacy information to assign correct structures to ambiguous sentences.

Role show. All factors, then, point to a simple role assignment, but these items are not simple.

It seems that there is something problematic about the Type 3 items which cannot be explained either in terms of thematic role assignment or as a thematic hierarchy violation. Thus the difficulty with Type 3 items remains unresolved. Perhaps we are dealing here with a structural issue that cannot be explained semantically.

The analysis of the Type 3 items presented thus far is based on a semantic concept that depends on a syntactic feature for its interpretation; that is, the notion of thematic roles is semantic, but they pertain to arguments that are syntactically realized. In syntactic terms, a Type 3 insertion involves separating a verb and its direct object. Although inserting a Goal between a verb and its Theme involves no thematic role change, in terms of syntactic structure it involves changing a direct object to a second object. This is the original analysis proposed in S&S for this type of item. In their discussion they report that "although no category change is affected per se, the syntactic role of the NP is altered" (p. 49). The notion of *role* is defined here in terms of grammatical relations, i.e., the role of the NP changes from direct to second object. In the reanalysis of these types of items in the present study, the grammatical relations are viewed at the semantic, and not syntactic, level, for we explore the relations between arguments in thematic terms. It seems, however, that a thematic explanation cannot adequately account for the difference between Type 2 and Type 3 items. Thus, whether our analysis is based on assigning thematic roles or on a thematic hierarchy, it seems that eventually we must resort to a syntactic explanation. It seems reasonable to search for an explanation at the syntactic level, because the difficulty with the Type 3

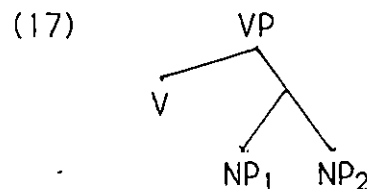
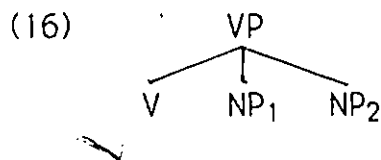
items appears to lie in the structural separation of a verb and its argument. Moreover, the very nature of the Insertion test, that of inserting an item into a sentence, necessitates syntactic involvement.

Let us look at the syntactic representation of the double object construction. Barss and Lasnik (1986) discuss the asymmetrical relation of the two NPs ( $NP_1$  and  $NP_2$ ) in this type of construction. Based on examples from binding, quantificational NP and pronoun relations (among others), they reveal that the second NP is in the domain of the first, but not vice versa. In light of this asymmetry in domains, they consider the possible structures of the double object construction. They first define "domain" as *c-command*, giving the two alternative definitions in (15). With domain equivalent to *c-command*, the issue then is to determine how the first NP asymmetrically *c-commands* the second.

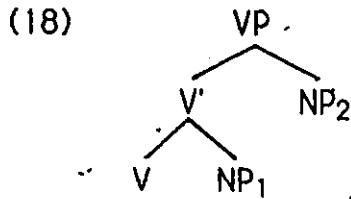
(15) (i) X *c-commands* Y iff every maximal projection that dominates X also dominates Y (Aoun and Sportiche, 1981).

(ii) X *c-commands* Y iff the first branching node dominating X also dominates Y (Reinhart, 1976).

Barss and Lasnik rule out structures (16) and (17) (the latter from Kayne, 1981), where the hierarchical relations between  $NP_1$  and  $NP_2$  are symmetrical.



An alternative structure is (18), from Chomsky and Lasnik (1977):



By the first definition of c-command, in (18) NP<sub>2</sub> c-commands NP<sub>1</sub>, putting NP<sub>1</sub> in the domain of NP<sub>2</sub> which is the reverse of the facts Barss and Lasnik reveal. By the second definition of c-command the NPs in (18) are symmetrical, as in structures (16) and (17), which again is contrary to their findings. Barss and Lasnik therefore suggest a modification of the notion *domain of* that incorporates the second c-command definition with linear precedence: Y is in the domain of X iff X c-commands Y and X precedes Y. With this new definition of *domain of*, the structure (18) properly accounts for the asymmetries between the two NPs.

The notions of domain and c-command may be used to explain the syntactic "closeness" of a verb and its direct object, and the syntactic change involved in Type 3 items. For our purposes we will consider (18) to be the structure of the double object construction. We can see from this tree that the verb and the first NP are at the same level in the tree. They share a certain structural proximity that excludes the second NP. We can explain this proximity with Definition (ii) of c-command. Although Barss and Lasnik use Definition (i) to account for the asymmetries between the two NPs, we are considering the relationship of the verb with its NPs, and not that of the two NPs. Therefore, we will use Definition (ii). By this second definition the verb c-commands NP<sub>1</sub> (the direct object), but not NP<sub>2</sub> (the second object). In other words, NP<sub>1</sub>, but not NP<sub>2</sub>, is in the c-command domain of the verb. This fact nicely distinguishes between the Type 2 and Type 3 items. In the Type 2 items such as *Andrea bought the puppy a bone*,

the insertion of *a bone* involves adding an NP that is not in the c-command domain of the verb. Such an insertion does not affect the verb and the NP it c-commands. Type 3 items, on the other hand, require moving an NP out of the verb's c-command domain, and inserting a new NP in its place.<sup>3</sup>

The consequences of such a syntactic change can also be seen at the semantic level (i.e., with changes in thematic roles and linking rules), which is the level at which we first attempted to explain the Type 3 items. One issue that must be resolved is that of how the two levels relate. The key may lie in the notion c-command. C-command is central to the notion of government, which plays an important role in the modules of Chomsky's (1981) Theory of Government and Binding. One such module is Theta Theory, which concerns the argument structure of verbs. This may be the link between the structural property of the Type 3 items and their consequences at the semantic level, for theta-marking is carried out under government.<sup>4</sup>

The question which remains to be answered is why the RBDs have more difficulty than the LBDs with Type 3 items. If the core of the problem is syntactic, then the LBDs should exhibit more deficits, since the left hemisphere is presumed to be more involved than the right in syntactic processing. A possible explanation is that the right hemisphere's role in language processing requires access to syntactic information that is normally available to it, but which cannot be accessed due to stroke-related

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<sup>3</sup> This parallels the change involved in items of the category Change Syntactic Role, where a lexical item is moved into another syntactic role, and a new item is inserted in its place. This issue will be discussed further in the General Discussion (section 4.6).

<sup>4</sup> Although the definition of government usually considers Definition (1) of c-command above, Chomsky (1986) states that direct theta-marking involves a condition of "sisterhood" that is independent of government. In structure (18) above, the verb would directly theta-mark only the NP that is its complement in terms of X-bar theory, i.e., its sister NP<sub>1</sub>, but not NP<sub>2</sub>. This same outcome can be achieved using the second definition of c-command.

damage. Let us look at some models of language comprehension which may help us to see where this inaccessibility might occur.

Psycholinguistic models of language comprehension generally consist of two components: a syntactic component and a more general component that incorporates the output of the syntactic analyzer with outside information. Rayner et al. (1983) propose a model which consists of distinct syntactic and semantic processors, each autonomous within its domain. The syntactic component is uninfluenced by factors such as real-world knowledge and discourse information. It is the thematic processor which incorporates these nonsyntactic factors with the output of the syntactic processor to select the correct interpretation of a sentence. In the interactive model of Crain and Steedman (1985), there is an almost word-by-word interaction between the syntactic and semantic processors. Sentences are processed using contextual cues that are based on specific knowledge about the discourse and general knowledge about the world. We suggested in Chapter 1 that the right hemisphere, because of its holistic/parallel mode of processing, is suited to bringing together the grammatical and pragmatic components of language. In very general terms, it may be that the analytic left hemisphere is responsible for building syntactic structure, and the holistic right hemisphere incorporates nonlinguistic information with the output of the left hemisphere "processor." Perhaps right brain damage hampers the ability to incorporate syntactic and nonsyntactic information. In 4.6 we will develop further the relation between the deficits observed in RBDs and the processing models discussed here.

(Although many two-part models of sentence processing have been proposed so far, it is only very recently that research has been carried out on the precise association between the syntactic processor and non-

linguistic information. Carlson and Tanenhaus (1988) suggest thematic roles as a mechanism for interaction among the syntactic processor, the discourse model and real-world knowledge, and for creating coherence in local discourse structure: It seems reasonable to assume, then, that the right hemisphere plays a central role in assigning thematic roles by integrating linguistic and nonlinguistic information. This would explain why RBDs have more difficulty than LBDs with items involving thematic roles and why it is difficult to characterize this deficit as purely syntactic or semantic.

#### 4.5.3 Alter Lexical Item

Although the category Alter Lexical Item is problematic for both BD groups in this study, each group tends to have difficulty with different items. One common problem for both groups is items that form a compound within the lexical node, such as item 39 ((19) below):

(19) Captain Jim lives in an old lighthouse. (Item 39)

Such insertions involve replacing one lexical item with another. Because the lexicon is presumed to be available to both hemispheres (Zaidel, 1983; Chiarello, 1985), it is not surprising that both BD groups have difficulty with these items.

LBDs had greater difficulty than RBDs on Alter Lexical Item sentences which require substituting PRO (as in (20a)) with a lexical item (20(b)). In fact, the LBDs made errors on all the items that involved PRO.

- (20) a. I expect PRO to be home soon. (Item 47)  
 b. I expect my parents to be home soon.

Caplan and Hildebrandt (1987) reveal that their LBD aphasic patients also exhibited difficulty with empty categories, including PRO. Since the empty NP "PRO" is a syntactic phenomenon (Chomsky, 1981; Caplan and Hildebrandt, 1987), it is not surprising that LBDs have difficulty with these items.

The RBDs, on the other hand, only had difficulty with one of the PRO items, Item 46 ((24) below). This item appears to be problematic for the RBDs for another reason: it involves a possessive. The RBDs in this study (but not the LBDs) have particular difficulty with possessives, which we will discuss in the next section.

#### 4.5.4 Possessives (Add Modifier)

Items 4, 5 and 6 of the category Add Modifier (and Item 46) involve adding a possessive.

- (21) Nancy's children love to play in these puddles. (Item 4)
- (22) On cold days his father's car won't start. (Item 5)
- (23) I'm glad that your cousins are now my friends. (Item 6)
- (24) Nancy's playing the guitar badly annoys my brother. (Item 46)

Semantically, adding a possessive changes the extension of an NP. The extension of an NP is defined as the group of objects to which an NP refers (Cooper, 1973). In Item 4, the NP *children* refers to all children in general. With the insertion of *Nancy's*, *children* is limited to the subset of children belonging to Nancy. The same change occurs with Item 46, where *anybody's* playing the guitar<sup>5</sup> becomes limited to *Nancy's* playing. In Item 5 the change in extension does not involve a subset relationship. Rather, there is a change in the actual NP *car* that is being referred to; that is, instead of referring to *his car*, the reference is now to *his father's car*. The same is

<sup>5</sup> Another interpretation is of *his brother's* playing the guitar.

true of item 6, where in the original sentence the cousins are *each other's* friends, but then become *my* friends with the insertion.

It appears that RBDs have difficulty changing the extension of an NP, i.e., the object in the real (and perhaps imaginary) world to which the NP refers. However, adding a possessive is not the only way to modify an NP's extension. Adding a determiner or noun modifier also changes the group of objects being referred to. Consider items 1 and 11 ((25) and (26) below):

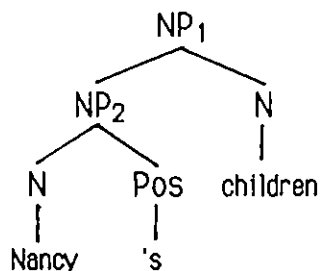
(25) These flowers are beautiful when in full bloom. (Item 1)

(26) John bought his wife a diamond necklace. (Item 11)

Item 1 involves the insertion of a determiner, and in item 11, a noun modifier is added. These and other items from the category Add Modifier were hardly problematic for both BD subject groups.

It seems that in addition to changing the reference of an NP, there is something more that is problematic about the possessive. Perhaps examining the syntactic structure of this construction will provide some clue to its difficulty. Syntactically, a possessive NP such as NP<sub>2</sub> in (27) is considered to be the subject of the overall NP<sub>1</sub> (Chomsky, 1981).

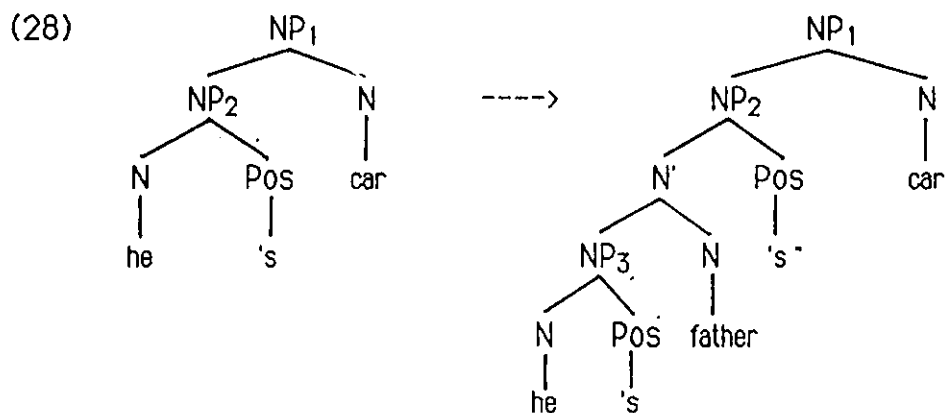
(27)



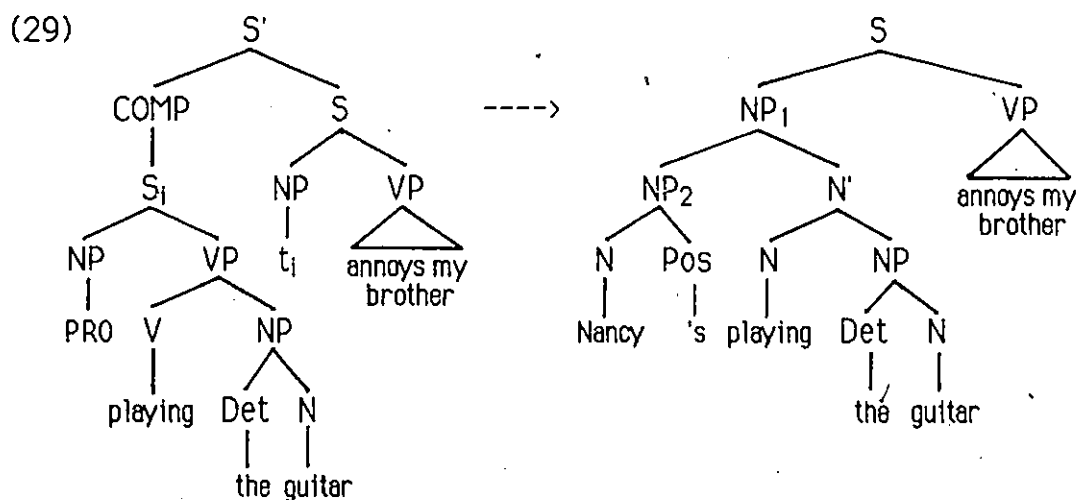
Adding a possessive such as *Nancy's* in item 4 to the simple NP *children* requires modifying the argument structure of the NP to accommodate the addition of a subject. The same process is involved with item 6, when the

*J*

subject *my* is added to the NP *friends*.<sup>6</sup> In Item 5 (see (22) and structure (28)), the argument structure of NP<sub>1</sub> does not change, since it already contains a subject, *his*. However, inserting *father's* involves embedding the subject into a new subject NP *his father's*, thus changing the relation of *his* and *car*.



In item 46, with the insertion of *Nancy's*, the VP *playing the guitar* of the original sentence changes to an NP, of which *Nancy's* becomes the subject. There are several big shifts involved here, making this a difficult item.



<sup>6</sup> One may argue in this case that there is some kind of understood subject present in the original NP *friends* understood as *each other's*, with *your cousins* as its antecedent.

Syntactically, then, what is involved with the possessives is a modification of the argument structure of an NP. It seems that once again a purely semantic approach (in this case, reference) is not adequate for explaining the RBDs' difficulty with these items. In our discussion of the category Alter Thematic Linking Rules in 4.5.2 above, we proposed that RBDs were impaired in accessing syntactic information. A similar deficit is observed here with the possessive.

We have argued that reference itself does not adequately account for the RBDs' problems with the possessive. However, reference is an area that deserves further study, for it is involved in several levels of language. At the syntactic level are referential dependencies between noun phrases and their antecedents which are defined strictly in terms of syntactic constructions (Reinhart, 1976). The results from the S&S Insertion Test reveal that items such as *Everyone appears unconcerned about himself* (S&S 5.2), which involve changing the reference of a pronoun, are problematic for RBDs. The semantic (or philosophical) level involves the reference or extension of NPs as discussed above with respect to the possessive. At the discourse level are the more abstract and mental long-distance dependencies controlled by nonsyntactic factors such as pragmatics (Hankamer and Sag, 1976).

It may be worth exploring difficulties RBDs encounter in following changes of reference in a discourse. Carlson and Tanenhaus (1988) suggest that recovery from misconstruing the reference of a series of phrases is not unduly taxing. For example, in a conversation, if the listener believes the speaker is talking about one person, but learns that someone else is being referred to, then the listener can easily transform all the information about the mistaken person onto the intended individual. Would RBDs find this as

easy? Only further research will provide answers to this and other questions relating to reference.

#### 4.5.5 Alter Lexical Meaning

The category Alter Lexical Meaning was problematic for the RBDs in this study, but hardly so for the LBDs. For the RBDs, 8 of the 12 items in this category were problematic. Examples of these can be seen in (30)-(33), where the insertion requires changing the lexical meaning of a word in the original sentence.

- (30) Carla was upset when Tony broke her wine glasses. (Item 50)
- (31) Ken's a fair haired man who never lies. (Item 51)
- (32) Ted runs by his father's store every afternoon. (Item 58)
- (33) Bob caught sight of a large salmon swimming upstream. (Item 60)

The RBDs' difficulty with changing the meaning of a lexical item may be explained in light of the right hemisphere's role in lexical access. Burgess and Simpson (1988a) explore hemispheric asymmetries in the retrieval of ambiguous word meanings. The aim of their study was to investigate the availability of dominant and subordinate meanings of ambiguous words to the left and right hemispheres, and the speed with which they are retrieved. Subjects were presented with ambiguous primes, and made lexical (word/nonword) decisions to targets presented in the left or right visual fields. Burgess and Simpson explain their findings in terms of a multiple access model, where all the meanings of an ambiguous word are activated when the word is encountered (see Simpson, 1984 for a review of different lexical ambiguity models). Based on experiments in an earlier study (Simpson and Burgess, 1985), their model predicts that all meanings are activated automatically, in a frequency-coded order; that is, all meanings

will be eventually activated, but the most frequent one will be activated first. Attention is then focused on the most dominant meaning, resulting in the inhibition of the subordinate meanings. In the case of ambiguous words appearing in sentences, one of the meanings would be selected based on context, with the unselected meanings becoming suppressed. Context is used only after the meanings have been activated, and has no role in the actual accessing process (Onifer and Swinney, 1981; Seidenberg et al., 1982).

Burgess and Simpson's (1988a) results for the left hemisphere (right visual field) reveal that both the dominant and subordinate meanings are activated, but the subordinate meaning then becomes inhibited and declines in activation. The results for the right hemisphere, however, are completely different. The dominant meaning shows priming effects at an early onset of the target, but then activation declines. The subordinate meaning, on the other, shows little facilitation at the early onset time, but then builds in activation, revealing an absence of inhibition. In the right hemisphere, then, facilitation declines for the dominant meaning while the subordinate meaning shows an increase in activation.

Burgess and Simpson (1988b) propose a model of lexical ambiguity resolution that integrates the different lexical access patterns of the two hemispheres. They suggest a mechanism in which the left hemisphere calls upon the right hemisphere when it requires access to memory information. In processing a sentence containing an ambiguous word, the dominant meaning will presumably remain activated in the left hemisphere until the sentence is disambiguated by context. Subordinate meanings, however, lose activation after about 300 msec. (Simpson and Burgess, 1985). Thus, if a sentence involves a less frequent meaning with disambiguating information

appearing after this time, it would require costly reactivation since the subordinate meaning is now less available in the left hemisphere. Burgess and Simpson propose that the appropriate meaning is still activated and available in the right hemisphere after it has declined in the left hemisphere. They also discuss the role of the right hemisphere in recovering from garden path sentences, where the wrong sense of an ambiguous verb is initially selected. Instead of reactivating the alternative sense that has been inhibited in the left hemisphere, it would be less costly in terms of time and processing mechanisms to access it from the right hemisphere. It may be interesting to explore this issue further by examining the ability of RBDs to recover from garden paths.

With respect to brain damaged patients, Burgess and Simpson (1988b) predict that both LBD and RBD groups would have access to the dominant meaning. LBDs, moreover, should also have the subordinate meaning available, since it remains activated in the right hemisphere. The subordinate meaning may not be available to the RBDs, however, except for the short time it is in the left hemisphere before becoming inhibited. The results of the present study support their speculations. The RBDs had difficulty with the items in the category Alter Lexical Item, which require accessing alternative meanings of words.

#### **4.6 General Discussion**

It has been shown in this study that RBDs exhibit deficits with specific groups of stimulus items; that is, they have difficulty with items which involve (i) thematic roles, (ii) possessives, (iii) changing a lexical item, and (iv) changing lexical meaning. Their impairments seem to be localized to

these particular types of items. The LBDs also show deficits with items involving thematic roles and, in addition, appear to have difficulty with PRO. However, in general, the LBDs' errors seem to follow less of a distinct pattern and are more evenly distributed among the various categories. The small number of subjects and errors may account for these observations, and it is understood that any conclusions deriving from this study must be confirmed with additional data.

There are two questions which we set out to answer with this study. The first relates to the components or levels of language which are problematic for the BD groups. It was speculated that the LBDs would have difficulty with items that involved specific syntactic changes or additions because of the lateralization of language to the left hemisphere. This hypothesis seems to be supported by the difficulty they had with syntactic items. The category Alter Syntactic Role involves a change at the syntactic level, and the LBDs show a higher error rate than the RBDs on this category. This was not, however, the most problematic category for the LBDs, for they made the most errors in the category Alter Lexical Item. From Table 4-4 in 4.5 we can see that over half the errors in this category were made on items 46-48, which involve PRO, a syntactic phenomenon. Since thematic linking rules involve both the syntactic and semantic levels of language, items in the category Alter Thematic Linking Rules were difficult for LBDs. In other syntactic categories such as Add Modifier and Add Complement, the LBDs did not make many errors (in fact, they made no errors in Add Complement). This may be due to the relative simplicity of the Add categories.

For the RBDs, it was hypothesized that because of their rigidity deficit they would not exhibit impairments at a specific level, but rather, on items that require some kind of change. Although the Alter items were more

problematic for these subjects than the Add items, their error rate on the Alter items was not higher than that of the LBDs. Moreover, their difficulty with the Alter items may be due to the fact that these items are in general harder than the Add items, and not because they involve a change *per se*. From their performance on the various syntactic categories, unlike the LBDs, they cannot be characterized as having a general syntactic level deficit. This does not mean, though, that they have no syntactic impairments. The nature of the Insertion test (i.e., inserting words into sentences) necessarily involves syntax, so that any impairments shown in this test reveal some kind of syntactic deficit. In addition, the RBDs' difficulty with some of the items, such as the possessive and double object construction, could only be adequately explained in syntactic terms.

The question to be considered now is: At what level do the RBDs' deficits occur? Their deficits are revealed at the syntactic level, but is this just a reflection of an impairment at some other level? We propose that since the right hemisphere is not responsible for syntactic processing, the deficits occur at some other level and are simply manifested at the syntactic level of the Insertion tests. We further propose that the RBDs' impairments result from the right hemisphere's role as an interactive mechanism for the various components of language.

Let us assume that language processing involves the interaction of various linguistic and extralinguistic components: the lexicon, syntax, semantics and general world knowledge. The lexicon is presumably available to both hemispheres, although its organization and content differs in each hemisphere (Zaidel, 1983; Chiarello, 1985). Syntax is generally considered to be in the domain of the left hemisphere. Semantics involves many different elements, but in general terms is the interpretation of the

meaning of sentences. It is at this level that the right hemisphere plays an important role, since semantics involves both syntactic form and nonsyntactic information such as word associations and reference.

It was revealed in the present study that RBDs find the double object construction and possessives particularly problematic. Their difficulty with these kinds of items was discussed above as resulting from an impairment in accessing syntactic information. They are not, however, restricted from accessing all syntactic information, since they do not exhibit deficits in all the syntactic categories. For example, they performed well on items of the category Alter Syntactic Role. We mentioned in 4.4.2 above that the change required in Alter Syntactic Role is similar to that involved in moving the direct object NP in the double object construction to the second object position. Yet there is a difference in the degree of difficulty of these changes for the RBDs, with the former being easier.

Let us consider what is involved in these two types of changes. Alter Syntactic Role requires a change in the syntactic role of a lexical item, such as changing the role of *town* in *The town hall is deserted on cold winter days* (Item 25) from head of the NP *the town* to the modifier of the new head *hall*. This kind of syntactic change can presumably be handled by the left hemisphere, with no right hemisphere involvement, since it is limited to lexical items and syntactic structure. On the other hand, changing an NP from direct to second object position involves modifying c-command relations, which are syntactic, but it also involves thematic relations between a verb and its arguments. We have suggested that the right hemisphere plays a central role in incorporating linguistic and nonlinguistic information via thematic roles. It follows, then, that this type of change

would be problematic for RBDs because of the thematic component involved. The changing of syntactic role, on the other hand, requires less input from the right hemisphere, and is presumably more restricted to left hemisphere functions.

The possessive items also involve a modification which extends beyond the syntactic level, as adding a possessive changes the argument structure of the original NP. An argument structure, whether of a verb or an NP, involves relations between elements which may be considered thematic or semantic. The exact nature of argument relations is not entirely clear, but there is no doubt that they involve more than lexical items and syntactic structure. Thus, again it is not surprising that RBDs find possessives difficult, for they involve a nonsyntactic component which relies on right hemisphere functions.

We have shown that the possessive and the items in the category Alter Thematic Linking Rules both involve argument structure, which is where the syntactic and semantic levels may be seen to interact. The argument structure of an NP such as *children* incorporates the reference of the NP with its syntactic structure. The argument structure of a verb relates thematic roles to their realization in syntax. Argument structure, then, is a linguistic element that relates two components of language. The RBDs' difficulty with items involving this structure seems to support our predictions about their integrative problems. We propose that the RBDs' linguistic deficits are caused by their inability to integrate the nonsyntactic and syntactic information necessary to interpret a syntactic structure. This would mean, then, that their syntactic level deficits reflect a more global deficit in integrating information.

Let us consider now where the integrative difficulty may arise in the processing of sentences. In 4.5.2 we discussed two types of processing models, those of Rayner et al. (1983) and Crain and Steedman (1985). These two models differ in the way the syntactic and semantic components relate. In Rayner et al.'s model the two components are autonomous; syntactic structure is therefore computed independently of semantic factors. Crain and Steedman propose an interactive model, where the syntactic and semantic processors work closely together. From the results of our study it appears that the interactive model is the more plausible one, for RBDs have difficulty specifically with items that require semantic interpretation as well as access to the syntactic component. If syntax is computed independently of semantics, then right hemisphere damage should not affect the processing of the left hemisphere "processor." What we see instead is a deficit in RBDs at the syntactic level when semantics is involved, which seems to suggest that the right hemisphere plays a role in computing syntactic structures. It does not have an active role in syntactic processing, but its interactive, holistic nature affects the syntactic outcome.

The second question we wished to answer was what the sentence-level deficits of RBDs can tell us about the discourse-level impairments associated with right brain damage. We have argued that sentence level deficits can be subsumed under a general integration deficit that is reflected at the level of syntax, and that its source is the inability to integrate syntax with the other components of language (semantics, pragmatics and discourse representations). Argument structures and thematic roles are examples of "intersection points" between syntax and semantics. From this perspective, the discourse level may be considered as

another component in which the integration deficit is manifested. An inability to integrate discourse information with sentence structure, for example, would result in an impairment in following discourse. Since a discourse is composed of a series of related sentences, without understanding each sentence a full understanding of a discourse will not be possible. Thus, the RBDs' impairment in integrating information affects understanding at all levels of language.

This study began with an examination of the S&S Insertion Test, and the deficits in RBDs revealed by the test. With the Insertion Test II we attempted to define the impairments more clearly, and although the results did not support our original hypotheses, we found various linguistic deficits associated with right brain damage. Lexical deficits of RBDs reveal that the right hemisphere has access to its own lexicon, which is the basic component of language. RBDs have also been shown to have deficits at the syntactic, semantic and discourse levels of language. We suggest that what underlies these deficits is an impairment in integrating the different components necessary for language processing. The linguistic deficits observed in RBDs can thus be explained in terms of the right hemisphere's interactive mode of processing.

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## Appendix A

## Stimulus Items of S&amp;S Insertion Test

\*classified as Shift Items

1. THE CAT THAT THE DOG CHASED SCRATCHED HIM
  1. ORANGE
  - \*2. AFTER
  3. SEVERELY
  4. SELF
  
2. PLAYING THE GUITAR ANNOYS MY BROTHER
  - \*1. HIS
  2. ALWAYS
  3. AND BILL TOO
  - \*4. NANCY'S
  
3. THE STORE IS OPEN FOR BUSINESS
  1. HARDWARE
  - \*2. HOURS ONLY
  3. NOT
  
4. YOU SEEM EASY TO PLEASE
  1. FAIRLY
  2. TO BE
  - \*3. ENOUGH
  4. DON'T
  
5. EVERYONE APPEARS CONCERNED ABOUT HIM
  1. UN
  2. SELF
  3. NOT
  4. TO BE
  - \*5. WHO'S ANYONE
  
6. I OPENED THE BOOK ON THE TABLE
  - \*1. WHICH WAS
  - \*2. CLOTH
  3. THICK
  4. CARD

7. THE GIRL THAT IS MISSING IS BLOND
  - \*1. AMONG THE
  2. OLDER
  3. FROM THE CAMP
  4. HAIRED
  - \*5. A
8. HE SEEMS TO BE HARD TO GET
  - \*1. PLAYING
  2. FREQUENTLY
  3. AND DOUG DOES TOO
  - \*4. HOLD OF
9. CINDY SAW HER TAKE HIS DRINK
  - \*1. DAUGHTER.
  - \*2. HOWARD
  3. TO HIM
10. SUSAN BROUGHT THE SWEATER THAT WAS MENDED
  1. WOOL
  - \*2. JOHN
  3. FOR HIM
  4. BY SALLY
11. SUSAN HEARD HER TELL A JOKE
  - \*1. HIM
  - \*2. HUSBAND
  - \*3. LARRY
12. IT IS STRANGE THAT CHRISTINE LEFT
  1. IN HIS CAR
  2. ALONE
  3. MORE THAN
13. IS A CAR FOR SALE HERE
  1. SPORTS
  - \*2. THERE
  - \*3. SEAT
14. JOHN ATE THE CARROTS THAT HE COOKED
  1. WITHOUT PEELING
  2. HIMSELF
  3. FOR SUSAN

15. THE MAN THAT I PASSED WAS DRUNK

- \*1. BY
- 2. WITHOUT GREETING
- \*3. PUNCH

16. THEY HAVE CUT GLASS

- \*1. TO
- 2. THE
- 3. SOME
- 4. FOR SALE

17. THE MAN ATE THE RICE AND THE CHICKEN

- \*1. FED
- \*2. DID TOO
- \*3. ATE THE CORN

18. I WALKED TO THE STORE

- 1. MARY AND
- 2. HAVE
- \*3. HER

Sample Item

I CAN SEE THE SNOW  
WHITE  
ON THE TREES  
FALLING

## Appendix B

## Reclassification of S&amp;S Stimulus Items

\*classified as Shift in S&S

ALTER ITEMS

- \*1.2 THE CAT THAT THE DOG CHASED AFTER SCRATCHED HIM
- 1.4 THE CAT THAT THE DOG CHASED SCRATCHED HIMSELF
- \*2.1 HIS PLAYING THE GUITAR ANNOYS MY BROTHER
- \*2.4 NANCY'S PLAYING THE GUITAR ANNOYS MY BROTHER
- \*3.2 THE STORE IS OPEN FOR BUSINESS HOURS ONLY
- 5.2 EVERYONE APPEARS CONCERNED ABOUT HIMSELF
- \*6.2 I OPENED THE BOOK ON THE TABLECLOTH
- \*8.4 HE SEEMS TO BE HARD TO GET HOLD OF
- \*9.1 CINDY SAW HER DAUGHTER TAKE HIS DRINK
- \*9.2 CINDY SAW HER TAKE HOWARD HIS DRINK
- \*10.2 SUSAN BROUGHT JOHN THE SWEATER THAT WAS MENDED
- \*11.1 SUSAN HEARD HER TELL HIM A JOKE
- \*11.2 SUSAN HEARD HER HUSBAND TELL A JOKE
- \*11.3 SUSAN HEARD HER TELL LARRY A JOKE
- \*13.3 IS A CAR SEAT FOR SALE HERE
- \*15.1 THE MAN THAT I PASSED BY WAS DRUNK

ADD ITEMS

- 1.1 THE ORANGE CAT THAT THE DOG CHASED SCRATCHED HIM
- 1.3 THE CAT THAT THE DOG CHASED SCRATCHED HIM SEVERELY
- 2.2 PLAYING THE GUITAR ALWAYS ANNOYS MY BROTHER
- 3.1 THE HARDWARE STORE IS OPEN FOR BUSINESS
- 4.1 YOU SEEM FAIRLY EASY TO PLEASE
- \*4.3 YOU SEEM EASY ENOUGH TO PLEASE

- \*5.5 EVERYONE WHO'S ANYONE APPEARS CONCERNED ABOUT HIM
- 6.3 I OPENED THE THICK BOOK ON THE TABLE
- 6.4 I OPENED THE BOOK ON THE CARD TABLE
- 7.2 THE OLDER GIRL THAT IS MISSING IS BLOND
- 7.3 THE GIRL THAT IS MISSING FROM THE CAMP IS BLOND
- 8.2 HE FREQUENTLY SEEMS TO BE HARD TO GET
- 9.3 CINDY SAW HER TAKE HIS DRINK TO HIM
- 10.1 SUSAN BROUGHT THE WOOL SWEATER THAT WAS MENDED
- 10.3 SUSAN BROUGHT THE SWEATER THAT WAS MENDED FOR HIM
- 10.4 SUSAN BROUGHT THE SWEATER THAT WAS MENDED BY SALLY
- 12.1 IT IS STRANGE THAT CHRISTINE LEFT IN HIS CAR
- 12.2 IT IS STRANGE THAT CHRISTINE LEFT ALONE
- 13.1 IS A SPORTS CAR FOR SALE HERE
- 14.1 JOHN ATE THE CARROTS THAT HE COOKED WITHOUT PEELING
- 14.2 JOHN ATE THE CARROTS THAT HE COOKED HIMSELF
- 14.3 JOHN ATE THE CARROTS THAT HE COOKED FOR SUSAN
- 15.2 THE MAN THAT I PASSED WITHOUT GREETING WAS DRUNK
- \*15.3 THE MAN THAT I PASSED WAS PUNCH DRUNK
- 16.4 THEY HAVE CUT GLASS FOR SALE

## Appendix C

## Screening Measures

## Edinburgh Handedness Inventory (Revised)

Indicate which hand you prefer for each of the following activities and objects by placing a checkmark / / in the appropriate column. Where your preference for one hand is so strong that you would never try to use the other hand unless absolutely forced to, put two checkmarks / / in the appropriate column.

	Left	Right
1. Writing		
2. Drawing		
3. Throwing		
4. Scissors		
5. Toothbrush		
6. Knife (for slicing bread)		
7. Spoon		
8. Broom (upper hand)		
9. Striking a match (match)		
10. Unscrewing a jar (lid)		
11. Which foot do you prefer to kick with?		
12. Which eye do you use when using only one?		

A. Are any of your (biological) relatives listed below left-handed?

	yes	no
mother		
father		
brother		
sister		

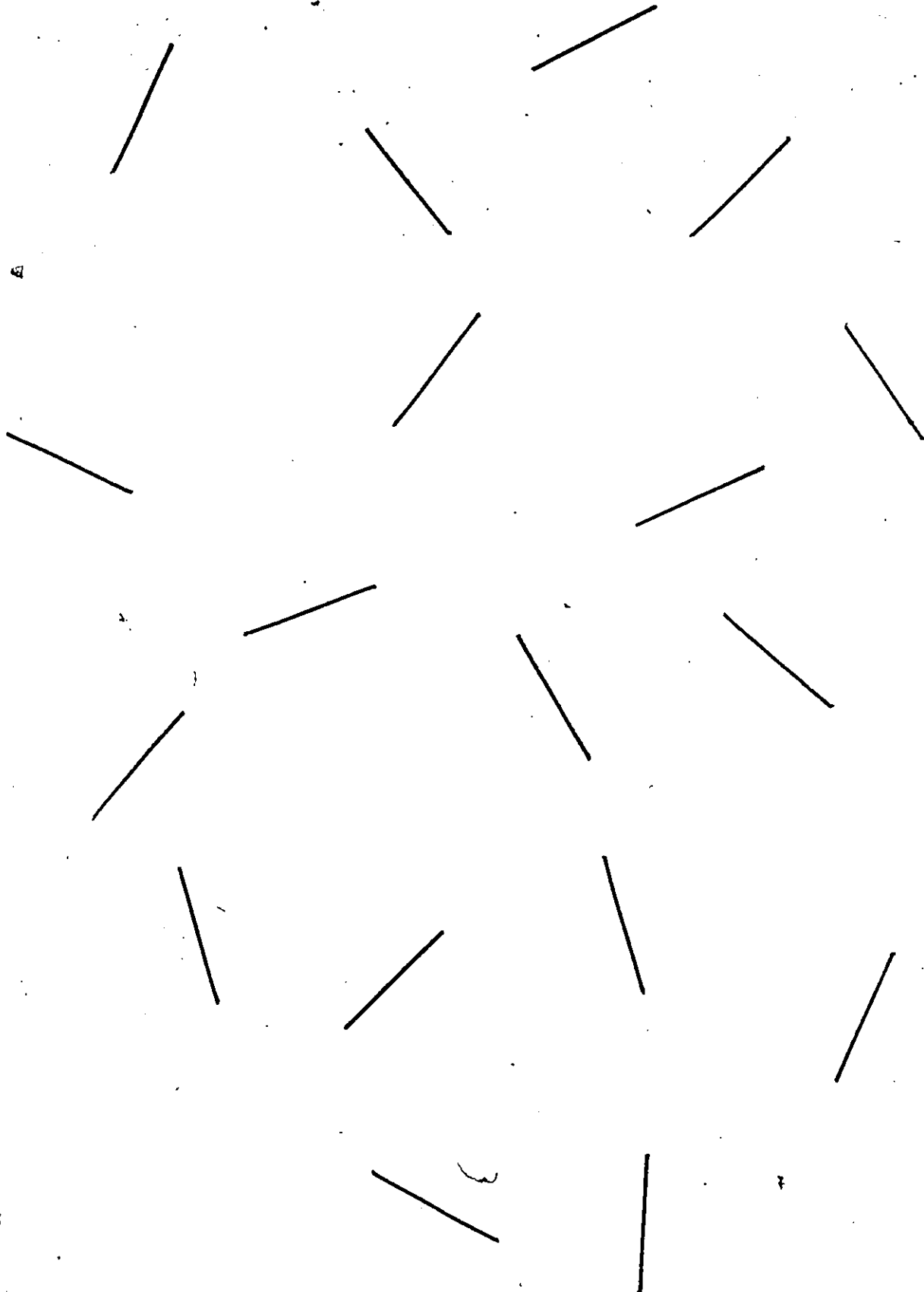
B. Do you know of any other members of your (biological) family (eg. grandparent, uncle, aunt, cousin, etc.) who are left-handed? Please specify.

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Line Crossing Test (reduced in size)



## Reading Comprehension

## Following Directions

1. PUT THE PENNY ON TOP OF THE BOOK. \_\_\_\_\_
2. OPEN THE BOOK AND THEN GIVE ME THE KEY. \_\_\_\_\_
3. TOUCH YOUR NOSE AND THEN POINT TO THE DOOR. \_\_\_\_\_
4. HOLD UP YOUR HAND AND THEN POINT TO YOUR CHIN. \_\_\_\_\_

## MIRBI

1. General Reading Ability \_\_\_\_\_ (0-3)

NANCY IS GOING ON VACATION. SHE IS GOING TO VISIT HER FRIEND PAT IN CHICAGO. SHE IS GOING TO TRAVEL ON A PLANE. SHE WILL BE OUT OF TOWN FOR A MONTH.

2. Reading Comprehension
  - a. Who is planning a vacation? \_\_\_\_\_ (0-1)
  - b. Where is she going? \_\_\_\_\_ (0-1)
  - c. Who will she visit? \_\_\_\_\_ (0-1)
  - d. How long will she be gone? \_\_\_\_\_ (0-1)

Visual Scanning

A ARYIAYIAKAARKOEYARMAWAVWAKNRAYEJEMA

A AIYEAMEHJAIYMATRJAMAE B

## Appendix D

### Stimulus Items of Insertion Test II

#### I. ADD MODIFIER

##### DET:

1. THOSE FLOWERS ARE BEAUTIFUL WHEN IN FULL BLOOM
2. HE WENT TO THIS SCHOOL UNTIL HE WAS 14
3. IT'S VERY COLD BUT SUSAN WON'T WEAR ANY GLOVES

##### POSS:

4. NANCY'S CHILDREN LOVE TO PLAY IN THESE PUDDLES
5. ON COLD DAYS HIS FATHER'S CAR WON'T START
6. I'M GLAD THAT YOUR COUSINS ARE NOW MY FRIENDS

##### AP:

7. FUNNY STORIES LIKE THESE MAKE ME LAUGH SO HARD
8. MRS. DIXON FORGOT HER RED UMBRELLA AT HOME
9. IT'S HARD TO SEE OUT OF THESE DIRTY WINDOWS

##### NP:

10. THE HARDWARE STORE IS NOW OPEN FOR BUSINESS
11. JOHN BOUGHT HIS WIFE A DIAMOND NECKLACE
12. APPLE PIE TASTES BETTER WITH ICE CREAM

#### II. ADD COMPLEMENT

##### PP:

13. THE BABY IN THE STROLLER SMILED HAPPILY AT EVERYONE
14. THE NEIGHBOURHOOD CHILDREN PLAYED ON THE SWINGS UNTIL SUNDOWN
15. MY FRIEND FROM SPAIN FINDS THE WINTERS HERE LONG
16. I SHOULD READ ALL THOSE BOOKS ON MY DESK

**ADVERB:**

17. SAM OFTEN WALKS TO WORK INSTEAD OF DRIVING
18. JOANNE LEFT THE PARTY EARLY BECAUSE SHE WAS ILL
19. IT IS SUPPOSED TO GET COLDER SOMETIME TOMORROW AFTERNOON
20. EVERYONE ADMIRES DIANA BECAUSE SHE PLAYS THE PIANO SKILLFULLY

**RELATIVE CLAUSE**

21. THE YOUNG MAN WHO FELL DOWN HURT HIS LEG
22. THE WOMAN THAT SUSAN MET GREETED HER WITH A HUG
23. DON'T OPEN THOSE PRESENTS THAT GRANDMA SENT UNTIL TOMORROW
24. HEATHER HAS A FEAR OF BIG DOGS THAT GROWL

**III. ALTER SYNTACTIC ROLE**

25. THE TOWN HALL IS DESERTED ON COLD WINTER DAYS
26. THE FIRE BRIGADE WAS VISIBLE FROM ED'S WINDOW
27. THE TELEPHONE BOOK IS IN THE HALLWAY
28. BEN'S CAR RADIO WAS STOLEN LAST WEEK
29. THIS TRAIN STATION IS REALLY EMPTY TONIGHT
30. CINDY TOOK HER PARENTS TO THE AIRPORT
31. STEVE IS VERY EXCITED ABOUT HIS NEW RECORD PLAYER
32. TINA ASKED PAUL TO PASS HER THE BUTTER KNIFE
33. WE ALWAYS BUY FRESH FRUIT PIES AT THE MARKET
34. ANY KIND OF RUNNING SHOE HURTS HIS FEET
35. THE SKATING RINK BEHIND THE OLD BARN IS GREAT
36. WAS THE DANCING MUSIC GOOD AT HER BIRTHDAY PARTY

**IV. ALTER LEXICAL ITEM**

37. ADAM'S FIREPLACE CERTAINLY NEEDS A GOOD CLEANING
38. THAT SNOWMAN OVER THERE LOOKS RATHER UNSTEADY
39. CAPTAIN JIM LIVES IN AN OLD LIGHTHOUSE
40. THE MAILMAN ALWAYS COMES AT THE SAME TIME
41. GEORGE NEEDS A NEW SUITCASE FOR HIS TRIP

42. SALLY LOVES THE DOLLHOUSE THAT UNCLE BERNIE BROUGHT  
 43. THAT DOG LIKES TO CHASE AFTER OUR CAT  
 44. THE CHILD LOOKED UP AT HIS FATHER AND SMILED  
 45. WHEN THE JUDGE ARRIVES WE MUST STAND UP  
 46. NANCY'S PLAYING THE GUITAR BADLY ANNOYS MY BROTHER  
 47. I EXPECT MY PARENTS TO BE HOME SOON  
 48. THE WOMAN WANTED HER BROTHER TO WIN THE GAME

#### V. ALTER LEXICAL MEANING

49. THOSE SHEETS OF PAPER ARE TOO WRINKLED TO USE  
 50. CARLA WAS UPSET WHEN TONY BROKE HER WINE GLASSES  
 51. KEN'S A FAIR HAired MAN WHO NEVER LIES  
 52. JANE SAYS THAT THIS SOFA IS TOO HARD TO KEEP CLEAN  
 53. BARBARA TOOK SOME APPLES THAT WERE FREE OF CHEMICALS  
 54. DAVE CALLS ON HIS MOTHER EVERY WEEK  
 55. JACK MADE FUN OF THE SLED SUSIE GOT FOR CHRISTMAS  
 56. JENNY WILL PICK UP THE FLOWERS FOR THE WEDDING  
 57. THE NOISY CLOCK IS THE ONE SIMON TOOK APART  
 58. TED RUNS BY HIS FATHER'S STORE EVERY AFTERNOON  
 59. SCOTT GOT ON A BICYCLE THAT WAS TOO BIG  
 60. BOB CAUGHT SIGHT OF A LARGE SALMON SWIMMING UPSTREAM

#### VI. ADD THEMATIC ROLE

61. JOHN EATS HIS LUNCH IN THE COMPANY CAFETERIA EVERY DAY  
 62. MR. ALLEN TAUGHT ENGLISH TO IMMIGRANTS FOR OVER TWENTY YEARS  
 63. JEFF INTRODUCED HIS NEW WIFE TO HIS FRIENDS AT THE PARTY  
 64. WE CANNOT ANSWER YOUR LETTER UNTIL TOMORROW AFTERNOON  
 65. HIS EVERY MOVE WAS WATCHED CAREFULLY BY THE POLICE  
 66. THE CHILDREN WEREN'T PUT TO BED BY THEIR BABYSITTER UNTIL MIDNIGHT  
 67. GREG WILL LOAD THE FURNITURE ONTO THE TRUCK THIS EVENING  
 68. LISA WASN'T READY WHEN THE GUESTS ARRIVED AT THE PARTY

- 69. BRAD USED EXPRESS MAIL TO SEND A PACKAGE TO HIS NEPHEW
- 70. ON THANKSGIVING GAIL SERVED TURKEY AND CASSEROLE TO HER FAMILY
- 71. WE FINALLY GOT OUR CAR FIXED BY MARK
- 72. ALL THOSE MAGAZINES ON GARDENING HAVE BEEN READ BY TOM

## VII. ALTER THEMATIC LINKING RULES

### CHANGE, NO HIERARCHY VIOLATION

- 73. IT WAS BILL'S JOB TO LOAD THE TRUCKS ONTO THE SHIP
- 74. JOHN CRAMMED HIS SUITCASES INTO THE CAR IN A HURRY
- 75. KATE HAD TROUBLE STUFFING A TURKEY THAT SIZE INTO THE FREEZER
- 76. AFTER THE DINNER WE CLEARED ALL THE TABLES FROM THE HALL

### CHANGE, HIERARCHY VIOLATION

- 77. ANDREA BOUGHT THE PUPPY A BONE AT THE PET SHOP
- 78. SAM SENT HIS DAUGHTER A PACKAGE ON THE TRAIN
- 79. CARL PRESENTED THE FAMOUS SINGER WITH AN AWARD AT THE BANQUET
- 80. FRED PLAYFULLY TOSSED HIS LAZY CAT A TOY

### NO CHANGE, HIERARCHY VIOLATION

- 81. THE BOY ASKED HIS TEACHER AN IMPORTANT QUESTION
- 82. SUSAN BROUGHT HER BROTHER THE SWEATER SHE HAD MENDED
- 83. MY BROTHER MADE HIS WIFE A BEAUTIFUL JEWELRY BOX
- 84. MY FRIEND JOHN SOLD MY SISTER THAT OLD BICYCLE

## Appendix E

## Results of Evaluative Measures

	Subject	Hemi	FAS	Categ	Dig Span	Similar	Pict Compl	Dig Symb
1	L-01	Left	15	24	7	9	6	4
2	L-02	Left	31	14	5	12	9	4
3	L-05	Left	4	3	5	9	2	1
4	L-06	Left	9	13	7	7	8	2
5	L-07	Left	20	23	8	8	4	3
6	L-08	Left	46	23	6	13	10	4
7	R-01	Right	37	23	10	14	3	3
8	R-02	Right	43	21	7	14	6	4
9	R-03	Right	12	14	6	5	4	3
10	R-04	Right	42	33	11	11	9	5
11	R-06	Right	41	28	12	11	5	12
12	R-07	Right	36	19	6	7	5	4
13	R-08	Right	19	19	7	6	6	2
14	R-09	Right	14	10	7	3	3	3
15	R-10	Right	25	17	9	6	10	4
16	R-11	Right	28	25	12	11	10	6
17	R-12	Right	18	20	13	10	7	5

FAS: FAS Verbal Fluency  
 Categ: Category Naming  
 Dig Span: Digit Span  
 Similar: Similarities  
 Pict Compl: Picture Completion  
 Dig Symb: Digit Symbol

## Appendix F

## Results of Insertion Test II by Category (Number of Errors)

Table F-1: Add Items

	Subject	Hemi	Add Mod	Add Compl	Add Them Role	Total Add
1	L-01	Left	0	0	0	0
2	L-02	Left	0	0	0	0
3	L-05	Left	2	0	0	2
4	L-06	Left	0	0	0	0
5	L-07	Left	0	0	0	0
6	L-08	Left	0	0	0	0
7	R-01	Right	0	0	0	0
8	R-02	Right	0	0	0	0
9	R-03	Right	2	2	2	6
10	R-04	Right	0	0	0	0
11	R-06	Right	0	0	0	0
12	R-07	Right	0	0	0	0
13	R-08	Right	2	0	0	2
14	R-09	Right	1	1	0	2
15	R-10	Right	0	0	0	0
16	R-11	Right	0	0	0	0
17	R-12	Right	0	0	0	0

Mod: Modifier  
Compl: Complement

Them Role: Thematic Role

Table F-2: Alter Items and Total Number of Errors

	Subject	Heml	Alter Lex Item	Alter Lex Mean	Alter Synt Role	Alter Them Link Rules	Total Alter	Total Errors
1	L-01	Left	0	0	1	0	1	1
2	L-02	Left	0	0	0	0	0	0
3	L-05	Left	4	1	2	2	9	11
4	L-06	Left	2	1	0	2	5	5
5	L-07	Left	0	0	0	1	1	1
6	L-08	Left	1	0	0	0	1	1
7	R-01	Right	1	0	0	0	1	1
8	R-02	Right	1	0	0	0	1	1
9	R-03	Right	2	3	1	3	9	15
10	R-04	Right	0	0	0	0	0	0
11	R-06	Right	0	0	0	0	0	0
12	R-07	Right	1	1	0	0	2	2
13	R-08	Right	0	1	1	0	2	4
14	R-09	Right	1	3	2	2	8	10
15	R-10	Right	1	1	0	0	2	2
16	R-11	Right	0	1	0	1	2	2
17	R-12	Right	0	0	0	0	0	0

Lex Item: Lexical Item  
 Lex Mean: Lexical Meaning

Synt Role: Syntactic Role  
 Them Link Rules: Thematic Linking Rules

## Appendix G

## Results of S&amp;S Insertion Test by Category (Number of Errors)

	Subject	Heml	Shift (27)	Non-Shift (38)	Alter (16)	Add (25)	Total (65)
1	L-01	Left	4	4	2	6	8
2	L-02	Left	0	1	0	1	1
3	L-05	Left	9	2	6	2	11
4	L-06	Left	8	7	5	5	15
5	L-07	Left	4	3	0	5	7
6	L-08	Left	1	0	0	0	1
7	R-01	Right	1	0	1	0	1
8	R-02	Right	5	0	3	0	5
9	R-03	Right	13	4	6	4	17
10	R-04	Right	1	0	1	0	1
11	R-06	Right	0	0	0	0	0
12	R-07	Right	5	2	4	1	7
13	R-08	Right	10	7	6	6	17
14	R-09	Right	12	6	7	5	18
15	R-10	Right	5	1	3	2	6
16	R-11	Right	0	0	0	0	0
17	R-12	Right	0	0	0	0	0