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The relationship of semantic and syntactic aspects of verb representation

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Rice University, 1992
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THE RELATIONSHIP OF
SEMANTIC AND SYNTACTIC ASPECTS OF VERB REPRESENTATION

by

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November, 1991
ABSTRACT

THE RELATIONSHIP OF
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by

SARAH DUBOIS BREEDIN

Most theories of language recognize the importance and complexity of verbs. Verbs convey both semantic and syntactic information, and therefore, the study of verb representation and processing can provide important insights into the nature and relationship of semantic and syntactic representation within the language processing system. Two models of verb representation were examined: 1) Semantic Complexity (Johnson-Laird, 1983); and 2) Conceptual Constituents (Pinker, 1989). The validity of these models was investigated by examining patterns of verb disruption in seven language impaired individuals. Investigation of patients' verb processing did not provide evidence for a model of verb representation based on semantic complexity, however, it did provide support for semantic representation of thematic roles within the lexicon separate from syntactic representation as posited by the conceptual constituent model. These findings were followed by an experiment investigating whether the language processing system has a bias for particular thematic roles in specific syntactic positions. The results indicated no bias for the syntactic position of specific thematic roles.
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The Relationship of Semantic and Syntactic Aspects of Verb Representation

Most theories of language recognize the importance and complexity of verbs. Verbs are laden with both semantic and syntactic information, and therefore, the study of verb representation and processing can provide important insights into the nature and relationship of semantic and syntactic representation within the language processing system. Some theorists view semantics and syntax as separate and distinct from one another, while other theorists hypothesize substantial interactions between semantics and syntax.

The first part of this paper focuses on the verb as a unit within the lexicon and the kind of information that needs to be specified about verbs within the lexicon. Two models of how verbs might be represented within the lexicon will be reviewed. The validity of these models was investigated by examining patterns of verb disruption in seven language impaired individuals.

The second part of this paper will review research on the effect of semantic and syntactic aspects of verb representation on sentence processing. An experiment investigating the effect of thematic roles on sentence processing will be presented.

Lexical Representations of Verbs

Fillmore (1968b) considered what information needs to be available from the lexicon in order for the average speaker of a language to comprehend an utterance. Presumably, this same information would be needed to correctly produce an utterance. He chose to look at predicate terms, specifically verbs. He writes:

I should like now, however, to itemize a few of the various facts about verbs that a complete theory of lexical information will have to account for. I conceive of the lexicon as a list of minimally redundant descriptions of the syntactic, semantic and phonological properties of lexical items, accompanied by a system of redundancy rules, the latter conceivable as a set of instructions on how to interpret the lexical entries (Fillmore, 1968b, p. 389).

What follows is a list of ten facts about verbs that a model of verb representation needs to explain. At times, it is difficult to distinguish which facts are syntactic and which are
semantic. First, there is the central meaning of the verb. For example, the verbs "hit" and "touch" both involve surface contact, however, they differ in the intensity of impact. Second, the number and types of roles required by the basic meaning of the verb must be specified. For example, the verb "break" requires that an object be broken. The verb "hit" requires that there be an object which is hit and an agent who does the hitting. Third, some verbs impose additional meaning onto one of their arguments. The verb "bend" requires that the object which is bent offer some resistance. Fourth, some verbs indicate the nature of one of the arguments so clearly that it does not need to be specified. The verbs "slap," "kick," and "kiss" contain the information that the body parts being used to perform the action are the "hand," "foot," and "lips" and therefore, the body part does not need to be stipulated. Fifth, the non-inherent cases which are compatible with the verb need to be defined. The notion of case involves the thematic roles that one assigns to the noun phrases within a sentence. The verb "hit" does not have an intrinsic notion of agent (the instigator of the action), but agent may be specified. For example, both the sentence "John hit the window with a rock" (where "John" is the specified agent) and "The window was hit by a rock" (the agent is not specified) are acceptable. In contrast, the verb "sleep" requires that the agent be specified as in "I slept" or "They made me sleep." Sixth, the lexicon should indicate which cases must be expressed and which can be suppressed. Seventh, it is necessary to know which cases can appear in which positions within a sentence. For example, the verb "rent" allows either the agentive case to appear as the subject of the sentence (e.g., "Mary rented the house to John") or the dative case to appear as the subject of the sentence (e.g., "John rented the house from Mary"). Eighth, for elements of a sentence which are neither the subject nor the direct object, the appropriate prepositions for the noun phrases need to be indicated. Ninth, some verbs contain semantic information which determines the choice of the subject or object of the sentence. For example, look at the following two sentences: 1) "Bees swarm in the garden"; and 2)
"The garden swarms with bees." The two sentences convey slightly different meanings. Both sentences indicate that there are bees in the garden but the second sentence contains the additional information that the entire garden is full of bees. Tenth, modifications to the verb are necessary for certain subject choices. The verb "rent" can have either the tenant or landlord as the subject; however, if the rented property is to be the subject, the verb "rent" must appear in the passive form as in "The house was rented by Mary."

Fillmore (1968b) outlined the type of information needed in the lexicon to correctly use verbs. Some of this information is clearly semantic in nature, some of it clearly syntactic, and some of it seems to have both semantic and syntactic components. This early guideline of what is needed by the lexicon has since been expanded by many researchers and theorists. Researchers in several disciplines have proposed models for verb representation: linguists like Fillmore (1968b, 1971), Jackendoff (1983, 1990), and Talmy (1975, 1988); individuals working in the area of artificial intelligence (Schank & Abelson, 1977; Schank, 1980); and psychologists studying language processes (Miller & Johnson-Laird, 1976; Gentner, 1975; Pinker, 1989). Tests of these models have been limited and in general the development of models has been based on theorists' intuitions about verb representation rather than an empirical investigation of people's use of verbs.

In general, the type of lexical information proposed for verb representation has been divided into two areas of study with fairly little overlap: 1) semantics; and 2) syntax. Fillmore (1968a) noted that the syntactic properties of verbs can be categorized in two ways: 1) by their subcategorization properties; and 2) by the specifications of the argument structures into which they can be inserted. At this point, the type of information assigned to these three categories will be discussed.

Semantics

When people study the semantic representation of verbs, they are generally interested in the action and thematic roles specified by verbs. The first five aspects of verb
representation discussed by Fillmore (1968b) are typically the subject of study for those interested in verb semantics.

**Action**

The action is used to refer to the central meaning of a verb. For example, the verb "smell" in some cases indicates the use of the nose to perceive odors. The verb "taste" indicates the use of the tongue to perceive flavors. The two verbs are similar in that they both involve perception and require an animate entity to do the perceiving. The two verbs differ in the mechanisms used for perception (e.g., nose for "smell" and tongue for "taste") and in the things which are perceived (e.g., odors for "smell" and flavors for "taste").

**Thematic Roles**

Thematic roles refer to the roles played by a given verb's arguments. Thematic roles indicate "who did what to whom" for a given sentence. Radford (1988) notes that linguists differ in the thematic roles that they deem as necessary to a language. Radford provides a list and definitions of some of the more commonly agreed upon thematic roles:

(a) **Theme** - Entity undergoing the effect of some action  
(Mary fell over)
(b) **Agent** - Instigator of some action  
(John killed Harry)
(c) **Experiencer** - Entity experiencing some psychological state  
(John was happy)
(d) **Benefactive** - Entity benefitting from some action  
(John bought some flowers for Mary)
(e) **Instrument** - Means by which something comes about  
(John wounded Harry with a knife)  
(Radford, 1988, p. 373).

Verbs differ in the types and number of roles they can assign to their noun phrases. As Fillmore (1968b) pointed out, some verbs require that certain roles be specified while others do not. In addition, Pinker (1989) notes that noun phrases often play more than one thematic role (e.g., the ball in "I batted the ball into center field" is the goal of the motion of bat but the theme of the motion that ends in center field). Although a distinction between action and thematic roles is being made, the two are very strongly linked.
Syntax

Subcategorization

Subcategorization restrictions refer to the types of sentence frames into which various verbs can fit. Verbs differ in the types of sentence frames and the number of different sentence frames in which they can appear. Simple transitive verbs like "fix" appear in a verb (V) noun phrase (NP) sentence frame (e.g., John fixed the car NP). Nonalternating datives can occur in both V_NP frames and V_NP prepositional phrases (PP) frames (e.g., Anne returned the book NP or Anne returned the book NP to the library PP).

Alternating datives are acceptable in the two frames that nonalternating datives appear in and can also appear in a V_NP NP frame (e.g., Valerie bought the sweater NP for her sister PP or Valerie bought her sister NP the sweater NP). Finally, some verbs can be followed by a _NP or a sentence complement (S') (e.g., Bob accepted the job NP or Bob accepted that he lost the job S').

Argument Structure

A second way in which verbs differ syntactically is in their argument structure. Argument structure refers to how thematic roles are assigned to the noun phrases within a sentence. For example, the verbs "mail," "receive," and "like" are all transitive and fit into a _NP sentence frame, but the thematic roles assigned to the noun phrases differ for the three verbs. The verb "mail" fits into a sentence where the subject of the sentence assumes the role of agent as in "The girl mailed the book." In contrast, the initial noun phrase for the verb "receive" plays the benefactive role as in "The girl received the book." And finally the verb "like" assigns the role of experiencer to the initial noun phrase as in "The girl liked the book."

Verbs differ in the number of argument structures into which they fit as well as the types of thematic roles assigned to given arguments. Simple transitive verbs, which have a V_NP syntactic structure) require two arguments which are typically the agent and the
theme as in "John fixed the car." Nonalternating (V_NP; V_NP PP) and alternating datives
(V_NP; V_NP PP; V_NP NP) have two possible argument structures which are either
agent and theme or agent, theme, and goal. This last example demonstrates that verbs can
differ in subcategorization complexity yet not in argument structure complexity. The
opposite pattern is also possible where verbs do not differ in subcategorization complexity
but do differ in argument structure complexity.

One of the problems with discussing argument structures is that it is not clear whether it
is a syntactic or semantic distinction. To return to an earlier example, the meaning of the
verb "break" requires that an object be broken. The verb "hit" defines a situation in which
an object is hit by an agent or instrument. Therefore, the verb "break" requires that only
one thematic role be specified, whereas, the verb "hit" stipulates that at least two thematic
roles be provided. The specification of the number and types of thematic roles appears to
be an inseparable part of the verb's meaning. Wilkins (1988) points out that investigators
of thematic roles accept that any discussion of the mechanisms used for the syntactic
positioning of thematic roles must be based on the number of semantic roles specified by
the verb's meaning. But analyses of thematic roles have typically taken two routes: 1) a
semantic approach in which the thematic roles are listed for verbs without considering the
rules for assigning roles to syntactic positions; and 2) a more syntactic approach which
looks at the interaction of thematic relations and syntactic positions irrespective of specific
semantic roles.

Models of the Semantic Representation of Verbs

The experiments investigating the nature of verb representation presented in this paper
will primarily be concerned with the semantic representations of verbs within the lexicon.
Occasionally issues related to subcategorization frames and argument structure will be
discussed but only as they relate to the representation of verb semantics. Two models of
verb meaning representation will be examined: 1) the Semantic Complexity Model; and 2) the Conceptual Constituent Model.

**Semantic Complexity Model**

Johnson-Laird (1983) proposed a model for verb semantics based on the idea of semantic complexity. One measure of semantic complexity is the number of components necessary to define a given verb. For example, the verbs "have" and "keep" both involve the concept of possession; however, "have" can be defined as "being in the possession of," whereas the verb "keep" can be defined as "maintaining possession of." According to Johnson-Laird (1983), "keep" would be considered more complex than "have," because to understand "keep" one must know the meaning of "have." Thus, Johnson-Laird (1983) hypothesizes that verbs are represented in terms of a conceptual hierarchy where some verbs are more primitive in meaning and others are more complex.

Johnson-Laird and Quinn (1976) tested the semantic complexity model for verbs. They hypothesized that it should be easier to define semantically complex verbs than semantically simple or primitive verbs because there are more components available for definition (i.e., one can use primitive verbs as part of the definition). They gave subjects groups of eight verbs thought to differ in complexity from four categories. The categories were motion, possession, visual perception, and communication. Subjects were asked to define the verbs and rate the difficulty of defining the verbs. As predicted, subjects gave poorer definitions for the primitive verbs and rated primitive verbs as more difficult to define.

There is also some evidence from the study of aphasic patients' language production to suggest that a distinction between semantically simple and complex items within the lexicon may be valid. Researchers have observed that aphasic patients tend to use simple verbs in their sentence production. These simple verbs are often called empty verbs because they contribute little semantic information to the sentence. Examples of empty verbs are: to be, make, give, take, do, have, get, etc. Kohn, Lorch, and Pearson (1989) looked at verb
production in a group of nine aphasic patients. They tested patients on two tasks: one was synonym generation; and the other was sentence generation. For the sentence generation task, patients heard either a noun or a verb and were asked to produce a sentence containing the given word.

On the synonym generation task, four of the patients showed greater difficulty producing verbs than nouns. On the sentence generation task, four of the patients tended to produce more empty verbs than empty nouns. However, performance on the synonym generation task did not predict performance on the sentence generation task and vice versa. Kohn et al. (1989) made a distinction between verb-finding difficulty that reflects a general lexical disturbance and verb-finding difficulty that is specific to the sentence planning process. This point relates back to the distinctions Fillmore (1968b) proposed as necessary for the lexical representation of the verb. Presumably a person only needs the central meaning of the verb for the synonym generation task; however, for the sentence generation task a person needs to know the roles specified by the verb, whether or not the verb imposes meaning onto its objects and in what position in the sentence certain thematic roles can appear. Clearly, the sentence generation task involves more than just the definition of the verb. At the same time, it is conceivable that a subject could perform the sentence generation task without being entirely clear on the meaning of the verb if the other types of lexical information outlined by Fillmore (1968b) were intact (e.g., the acceptable subcategorization frames or argument structures for a given verb).

From the perspective of semantic complexity, finding that patients produce empty verbs can be interpreted as demonstrating that patients retain sets of primitive concepts for verbs but lose the higher-level components that define complex verbs. Alternatively, it may be that because complex verbs are less frequent than simple verbs, patients have difficulty activating the phonological representation for complex verbs and produce the simple verbs instead. That is, the patients may not have a semantic disruption for verbs but rather a
disruption of phonological representations. If the latter is the case, patients should be able
to comprehend the complex verbs even though they are unable to produce them. In order
to establish that patients have a disruption of semantic knowledge, one needs to
demonstrate that patients do not understand the semantic distinction between the simple and
complex verbs by testing verb comprehension.

**The Conceptual Constituent Model**

Pinker (1989) developed a theory for the semantic representation of verbs based on the
earlier work of Jackendoff (1983) and Talm (1975, 1988). According to this model, the
semantic information for verbs is based on a limited set of conceptual categories or features
and sets of functions that combine or increase the specificity of the features into complex
representations for verbs. Examples of conceptual categories are: THING, EVENT,
ACTION, PATH, PLACE. Various functions serve to expand these conceptual
constituents. For example, the constituent PATH has "path-functions" such as: to, into,
toward. Similarly, the constituent PLACE has "place-functions" such as: at, on, in.
Pinker also proposes four basic predicate terms (GO, HAVE, BE, ACT) which are defined
by two features: 1) dynamics; and 2) control. The predicate GO is dynamic but does not
involve control while the predicate ACT is dynamic and involves direct control. Verbs vary
in the number of predicate terms used for definition and for some verbs the same predicate
term is used several times.

According to Pinker (1989) all verbs can be represented using some subset of
conceptual constituents and the appropriate functions. Thus, the verb "to enter" is an
EVENT involving some THING GOing "along" some PATH ending "in" some PLACE.

Pinker specifically addresses the issue of how thematic roles are represented and how
thematic roles get mapped onto appropriate argument structures and subcategorization
frames. In Pinker's model, each verb has a thematic core as part of its semantic
representation. A verb's thematic core is specified by the relationship of arguments to
predicate terms. Thus, the first argument of ACT is the "agent," while the second argument of ACT is the "patient." The first argument of GO or BE plays the role of "theme." The second argument of GO is the "path" and the second argument of BE is the "location" and the second argument of "to" plays the role of "goal."

Examination of Pinker's tree-structure for the verb "to sell" (see Figure 1) should help clarify Pinker's model of verb representation. The verb "to sell" involves three thematic roles: 1) agent; 2) theme; 3) goal. According to Figure 1, the verb "to sell" is an EVENT in which an ACT occurs where the first argument (agent-Elizabeth) causes something to happen to the second argument (patient-crayons). This initial EVENT has an effect that leads to a second EVENT and results in an obligation EVENT. The effect of ACT is a second EVENT involving the predicate GO where the first argument (theme-crayons) moves along a PATH "to" a second argument (goal-boy). The obligation EVENT indicates that the boy is obligated to give Elizabeth money.

Pinker claims that the thematic core is then mapped onto argument structures by linking rules. He is quite clear, however, that thematic roles are semantic entities and that argument structure "is a strictly syntactic entity, namely the information that specifies how a verb's arguments are encoded in syntax" (Pinker, 1989; p. 71). Pinker hypothesizes that thematic roles are mapped onto appropriate argument structures via the interaction of lexical rules and linking rules where lexical rules serve to change the semantic structure of a verb's lexical entry. Argument structures are seen as predictable from the verb's semantic structure and the application of linking rules.
Figure 1. Schematic representation of the verb "to sell".
Examples of possible linking rules suggested by Pinker are:

1) Link the first argument of ACT (the agent) to the syntactic position of subject.
2) Link the second argument of ACT (the patient) to the syntactic position of object.
3) Link the first argument of GO (the theme) to the syntactic position of subject if it is not already linked otherwise link it to the syntactic position of object.
4) Link the argument of "to" (the goal) to the syntactic position of indirect object.

Applying these rules to the semantic structure for the verb "to sell" presented in Figure 1, the agent (Elizabeth) would be the subject, the patient and theme (crayons) would be the object, and the goal (boy) would be the indirect object. This argument structure would eventually lead to a sentence like "Elizabeth sold the crayons to the boy."

Investigation of aphasic patients' verb and sentence processing provides some evidence for the existence of lexical and linking rules. Schwartz, Linebarger, and Saffran (1985) introduced what they call the "mapping hypothesis" to explain some types of sentence production deficits found in agrammatic patients. These patients often make thematic role reversals in picture description tasks. Thus, when shown a picture of a girl running toward a man they describe the picture as "The man is running the girl." Because these same patients showed preserved knowledge of syntax in grammaticality judgment tasks, Schwartz et al. concluded that the patients' production performance could not be attributed to impaired syntax. Instead, they hypothesized that "agrammatic aphasics are deficient in the translation between descriptions of sentence form and descriptions of sentence meaning ... [and] appear to be unable to make use of available syntactic devices (e.g., NP order around the verb) to communicate thematic roles" (Schwartz et al., 1985, pp. 121-122).

The majority of research examining patients with a possible thematic mapping impairment tested patients' sentence production and comprehension. It is difficult to distinguish between a thematic mapping deficit and a syntactic parsing deficit when patients are dealing with sentences. Byng (1986, 1988) continued to explore the nature of a
thematic mapping deficit by testing patient's comprehension of thematic roles outside of an entire sentence. Aphasic patients were tested to see if they comprehended the difference between verbs that involve a similar action but differ in the assignment of thematic roles. For example, the verbs "buy" and "sell" both involve the exchange of money in the process of obtaining some object. In the case of "buy" the agent obtains the object and in the case of "sell" the agent gives up the object. In order to test patients' comprehension of the distinction between reverse-role verbs, patients were shown a split-screen video, on one side of the screen someone was shown selling, on the other side of the screen someone was shown buying. The patient was given a target verb either "buy" or "sell" and had to point to the half of the screen which depicted the appropriate action. Byng noted that patients could do poorly on the verb comprehension task as a result of semantic similarity rather than as a result of damage to thematic role assignment mechanisms. To control for this possibility, patients were also tested on their comprehension of reverse-direction (e.g., lift-drop) and reverse-action verbs (e.g., start-stop) because these verbs are semantically similar in meaning but do not differ in the way thematic roles are assigned. Byng found that four out of the six patients she tested were significantly worse at distinguishing between the reverse-role verbs than the reverse-direction or reverse-action verbs. She did not find the opposite pattern, someone who was good at the reverse-role verbs but impaired at the reverse-direction or reverse-action verbs. Note, however, that subjects may have performed poorly on the reverse-role verbs because they are semantically more complex than the reverse-direction and reverse-action verbs. If subjects had been tested on finer details of verb meaning (e.g., buy vs. steal) they may have shown a general semantic impairment rather than a thematic role impairment.

Although, Schwartz et al.'s (1985) and Byng's (1986, 1988) research provides support for Pinker's theory of argument structure representation, it is not clear what component of the model is causing impaired performance. According to Pinker's model
there could be at least three possible causes for impaired performance on thematically reversible verbs. Comparison of the tree-structures for the thematically reversible verbs "sell" and "buy" (see Figure 2 for tree-structure of "buy") helps to demonstrate the different possible causes of impaired performance on thematically reversible verbs. Notice that for the verb "to sell", the goal of the motion of the crayons is to the boy; for the verb "to buy", the goal of the motion of the crayons is to Elizabeth. In addition, the verb "to sell" specifies that the goal (the boy) be in possession of money which he moves to the agent (Elizabeth), while the verb "to buy" indicates that the agent (Elizabeth) has the money and moves it to the source (the boy).

Given these representations of the verbs "to sell" and "to buy" a patient could have one of several problems which would result in difficulty distinguishing between these two verbs. First, the patient could have damage to the aspects of the semantic representation which specify thematic roles. Second, the patient could have difficulty mapping the arguments into the appropriate slots within the semantic representation (e.g., the patient could place Elizabeth into a slot where the boy belongs thereby creating a representation for the reverse-role verb). Third, a patient could have problems involving linking rules and thus be unable to map verb semantics onto the appropriate argument structures (e.g., the patient might link the agent to the object position rather than the subject position).
Figure 2. Schematic representation of the verb "to buy".
An Experimental Investigation of Verb Representation

Two models of verb representation have been presented: 1) complexity (Johnson-Laird, 1983), and 2) conceptual constituents (Pinker, 1989). Although evidence has been presented demonstrating that subjects are sensitive to these two distinctions for verbs, there is no conclusive evidence that verbs within the lexicon are actually organized according to these distinctions. For example, Johnson-Laird and Quinn (1976) showed that subjects have more difficulty defining semantically primitive verbs (e.g., have, perceive, move). This provides at best minimal support for the hypothesis that the lexicon is organized with the primitive verbs at the center and more complex verbs connected to the primitive. Note, however, that these two models of verb representation need not be mutually exclusive. For example, Pinker (1989) could be correct about how verb meaning is represented, whereas Johnson-Laird (1983) could be correct about how verb representations are organized within the lexicon with primitive verbs at the center and complex verbs radiating outward from the semantic primitive.

An alternative method for investigating the nature of verbs' semantic representations is to examine patterns of verb disruption in language impaired populations. There have been a number of studies within the literature on aphasic patients indicating that aphasic patients have impaired verb representation. Most of this research has focused on how nouns and verbs are represented differently within the lexicon and has involved verb production rather than verb comprehension (Zingeser & Berndt, 1988, 1990; Kohn et al., 1989; Mitchum & Berndt, 1989). In one study that examined both production and comprehension, McCarthy and Warrington (1985) presented evidence that patient ROX's semantic representation of verbs was impaired while his semantic representation for nouns was intact. McCarthy and Warrington, however, did not discuss what the specific nature of ROX's semantic impairment might be. Kohn et al. provided evidence that verbs might be represented within the lexicon according to semantic complexity when they reported that some aphasic patients
tend to produce empty or primitive verbs in sentence generation tasks. For example, a patient might say "do" when "repair" is the more appropriate verb. As was noted earlier, however, this finding may be the result of word frequency rather than semantic representation. Thus, patients may have well established phonological representations for the "empty" verbs which are also the most frequent in the language. Kohn et al. did not examine patients' comprehension of the verbs which they could not produce.

Several experiments will be presented which investigated the nature of verb representation within the lexicon by examining patterns of disruption in verb production and comprehension in aphasic patients. Before discussing the actual experiments, a simple model of word comprehension and production will be reviewed, and the implications of various patterns of language impaired performance for verb representation will be discussed.

Single Word Comprehension and Production

Research has been done examining the representational structure of the lexicon using both comprehension and production procedures. A simple model of auditory single word comprehension and production similar to that of Ellis and Young (1988) is shown in Figure 3. Presumably, similar processes are involved for visual word comprehension and written word production. According to this model, words are comprehended in a three stage process. Initially, the word is analyzed acoustically then the results of the auditory analysis are mapped onto a corresponding item stored in the auditory input lexicon. The item in the auditory input lexicon activates representations of: 1) the word's meaning in the semantic system; and 2) its grammatical class within the syntactic system. In order to produce a word, one must first have some concept that one wants to express. The meaning in the semantic system then activates an appropriate item in the speech output lexicon which then activates the necessary phonemic units and one produces the word.
Comprehension and production processes are seen as sharing one semantic/syntactic system but having different lexicons. Although Figure 3 portrays the semantic and syntactic system as a single unit, they may be distinct from one another. Separate input and output lexicons have been proposed as a result of dissociations between word comprehension and production found in aphasic patients (see Ellis & Young, 1988 for review).

Due to discrepancies in the use of the term "lexicon" by linguists and neuropsychologists, clarification of the term is needed. Up to this point, the word "lexicon" has been used to refer to all the information within the auditory input lexicon, semantic/syntactic system, and speech output lexicon. Typically within the psycholinguistic literature, the lexicon is viewed as containing phonological, morphological, semantic, and syntactic information about each lexical item. Levelt (1989) has noted that some theorists make a distinction between lexical form information (phonology and morphology) and what some call the "lemma" (semantics and syntax). As noted earlier, research with aphasic patients has revealed a dissociation between input form information and output form information. Consequently, from this point on the term "lexicon" will be used to refer to form information on either the input or output side of language processing. The term "central semantic/syntactic system" will be used to refer to semantic and syntactic information and the functions and rules involved in specifying verbs.
The central semantic/syntactic system is the area of interest for the present research. Patients with verb representation deficits within the central semantic/syntactic system can provide information about the nature of verb representation. Because the central semantic/syntactic system is the area of interest, one needs to be sure that patients do not have deficits in the processing structures feeding into and out of the central semantic/syntactic system. For example, if a patient's auditory analysis system is dysfunctional and he or she does poorly on verb comprehension tasks with auditory presentation, clearly nothing can be inferred about the representation of verbs within the central semantic/syntactic system because presumably the stimuli never progress beyond the auditory analysis system.

In the present paper, patients were tested on several different tasks to insure that language processing impairments could be attributed to the correct location in the language processing system. There were six tasks: 1) verb repetition; 2) verb reading; 3) single verb production; 4) verb comprehension; 5) sentence production; and 6) grammaticality judgments. Several possible patterns of performance can emerge from these six tasks.
Different patterns of performance help pinpoint areas of deficiency within the language processing system.

There are two possible explanations for impaired performance on the verb repetition task. First, the patient may not have heard the verbs correctly due to problems in the auditory analysis system. Second, the patient may have heard the verbs correctly but have been unable to repeat them because of impairments in articulation at the phoneme level in speech production.

The verb reading task helps to distinguish between impairments in the auditory analysis system and the phoneme level of speech production. If the patient is able to read verbs out loud that he or she could not repeat, then one can rule out impairments at the phoneme level of speech production and thus attribute impaired performance to the auditory analysis system.

The verb production and comprehension tasks differentiate between lexical impairments and central semantic system deficits. If a patient is unable to produce verbs that he or she can comprehend then there must be a deficit on the output side of language processing. If in addition, the patient's verb repetition is good, one can rule out peripheral deficits in phoneme mapping and articulation. Thus, one would attribute the impaired performance to the speech output lexicon. If the patient had difficulty with both verb comprehension and production but showed no evidence of peripheral processing deficits (i.e., was able to repeat and read verbs), then one would attribute the impaired performance to the central semantic system.

The sentence production and grammaticality judgment tasks were included to investigate the relationship between semantic and syntactic aspects of verb representation. If a patient has impaired performance on verb comprehension and production but shows preserved knowledge of verb syntax, then one can argue for a separation in the representation of syntactic and semantic information.
Three Types of Information Necessary for Verb Comprehension and Production

We have briefly examined the cognitive processes involved in single word comprehension and production. Various hypotheses about the nature of verb representations have been reviewed. Three aspects of verb representation seem to be of particular importance for the successful comprehension and production of verbs: 1) the action conveyed by the verb; 2) the thematic roles required by the verb; and 3) the subcategorization frames onto which thematic roles are mapped. At an intuitive level, there is little question that these three facets of verb representation are important for the correct usage and comprehension of verbs. However, as was noted in the review section of this paper, the data from the normal population has yet to provide conclusive evidence about how important these three verb distinctions are and how they relate to one another in language processing.

Research from the area of cognitive neuropsychology has been fruitful in developing models of conceptual organization within the semantic, syntactic, and lexical systems of the brain. For example, brain damaged patients have been reported who show deficits for specific semantic categories such as: 1) abstract and concrete words (Warrington, 1975); 2) fruits and vegetables (Hart, Berndt, & Caramazza, 1985); 3) living things and inanimate objects (Warrington & McCarthy, 1987); and 4) vehicle (Jonsdottir, 1990). As was noted earlier, there have been several studies with aphasic patients showing a dissociation between verb and noun production (Miceli, Silveri, Villa, & Caramazza, 1984; Zingeser & Berndt, 1988, 1990; and Mitchum & Berndt, 1989) and verb and noun comprehension (McCarthy & Warrington, 1985). There have also been many studies indicating that patients have difficulty assigning thematic roles to the correct syntactic frame (Schwartz et al., 1985).

However, there has been relatively little research investigating the relationship between different facets of verb representation. It may be the case that verb production and
comprehension deficits can be divided into different categories such as impaired representation of: 1) the action; 2) the verb's thematic roles; and 3) the verb's subcategorization frames. On the other hand, it may be that these three verb distinctions are so inter-related that if one has a deficit in the representation of verbs all three aspects would be impaired.

Possible Results and Implications

There are numerous patterns of performance that may result from testing language impaired patients' comprehension and production of verbs.\(^1\) In this section some of the possible outcomes and the implications of those outcomes will be discussed. Table 1 summarizes some of the possible results and the type of deficit that would be indicated.

In the hypothesized situation presented in Table 1, patient I performed well on all of the tests and therefore no deficit in verb representation is indicated. Patient II performed poorly on all of the tests, consequently, we can say little about the nature of the verb deficit other than that the patient has an overall deficit in verb representation. Patients III-V show selective impairments of the three verb distinctions: 1) meaning; 2) thematic roles; and 3) subcategorization frames. Any one of these patterns of deficits provides evidence for the hypothesis that verb representation is organized along the lines of meaning (patient III), thematic roles (patient IV), or subcategorization frames (patient V). The pattern of results exhibited by patients VI and VII indicate a deficit at a level other than the central semantic/syntactic system. Performance like patient VI would indicate a deficit on the output side of the word production system either at the level of the speech output lexicon or at the phonemic level. A pattern of performance like patient VII would indicate a deficit on the input side, perhaps at the level of lexical activation.

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\(^1\) In this discussion, it is assumed that patients do not have peripheral processing deficits (i.e., impaired auditory analysis system or articulation deficits).
Table 1

Possible patterns of impairment on verb comprehension and production tests

<table>
<thead>
<tr>
<th>Patient</th>
<th>Action</th>
<th>Thematic Roles</th>
<th>Subcategorization</th>
<th>Deficit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Comp Prod</td>
<td>Comp Prod Comp Prod</td>
<td>Comp Prod</td>
<td>Comp Prod</td>
</tr>
<tr>
<td>I</td>
<td>+ +</td>
<td>+ +</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>II</td>
<td>- -</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>III</td>
<td>- -</td>
<td>+ +</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>IV</td>
<td>+ +</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>V</td>
<td>+ +</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>VI</td>
<td>+ -</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>VII</td>
<td>- +</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

Experiments 1-6

Six experiments investigating the nature of semantic verb representation will be presented. The experiments examine the verb processing abilities of seven aphasic patients. The patients’ different patterns of verb disruption have implications for models of verb semantics.

Subjects

Experimental

Seven aphasic patients were tested. The patients ranged in age from 50 to 71 years. Six of the patients were male and one was female. Each of the patients sustained brain damage as the result of a left hemisphere cerebro-vascular accident. All of the patients were at least one year post-onset of stroke at the time of testing. Each of the patients has at least
an eleventh grade education and all are native English speakers. Table 2 presents biographical information for each subject.

Table 2

**Biographical Information for Seven Aphasic Patients**

<table>
<thead>
<tr>
<th>Patient</th>
<th>Sex</th>
<th>Age</th>
<th>Years Post-Onset</th>
<th>Education (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.B.</td>
<td>M</td>
<td>71</td>
<td>11</td>
<td>19</td>
</tr>
<tr>
<td>E.E.</td>
<td>F</td>
<td>56</td>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td>W.H.</td>
<td>M</td>
<td>67</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>M.L.</td>
<td>M</td>
<td>50</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>A.P.</td>
<td>M</td>
<td>60</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>J.S.</td>
<td>M</td>
<td>58</td>
<td>13</td>
<td>16</td>
</tr>
<tr>
<td>R.W.</td>
<td>M</td>
<td>63</td>
<td>14</td>
<td>16</td>
</tr>
</tbody>
</table>

**Control**

Five subjects matched in age and education who had not suffered a stroke served as control subjects. The mean age of the controls was 64.5 years with a range from 54 to 70 years. Three of the subjects were male and two female. The mean number of years of education for the five control subjects was 15.5 with a range from 12 to 18 years. All of the subjects were native English speakers.

**Noun and Verb Naming to Pictures**

Prior to examining patients’ performance on verb comprehension and production, patients were given a noun-verb naming task developed by Zingeser and Berndt (1988).
This test looked at patients' ability to produce single nouns and verbs for pictures. Patients were given this test to determine whether any of the patients would show a dissociation between noun and verb production similar to what has been reported by Zingeser and Berndt (1988; 1990). Patients were shown line drawings one at a time. Half of the pictures depicted actions and half of the pictures depicted nouns. The nouns and verbs were matched for frequency of occurrence in the written English language. For the verb drawings, subjects were asked to name the action presented in the picture. For the noun drawings, subjects were asked to name the object shown in the picture. The results for this test are summarized in Table 3.

The control subjects tested by Zingeser and Berndt (1988) produced all of the target nouns and verbs correctly. None of the patients were at ceiling for production of either nouns or verbs. All of the patients except A.P. were worse at verb production than noun production and made some semantic errors when naming verbs. For example, M.L. when shown a picture of someone sewing responded "knitting". At times if the patient was unable to produce the verb they would list the objects in the picture. Thus, when R.W. was shown a picture of a woman drowning he responded "help...boat...sea".
Table 3

Percent Correct for Naming Pictures

<table>
<thead>
<tr>
<th>Subject</th>
<th>Nouns</th>
<th>Verbs</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.B.</td>
<td>95</td>
<td>83</td>
<td>12</td>
</tr>
<tr>
<td>E.E.</td>
<td>88</td>
<td>83</td>
<td>5</td>
</tr>
<tr>
<td>W.H.</td>
<td>97</td>
<td>87</td>
<td>10</td>
</tr>
<tr>
<td>M.L.</td>
<td>93</td>
<td>63</td>
<td>30</td>
</tr>
<tr>
<td>A.P.</td>
<td>83</td>
<td>83</td>
<td>0</td>
</tr>
<tr>
<td>J.S.</td>
<td>52</td>
<td>33</td>
<td>19</td>
</tr>
<tr>
<td>R.W.</td>
<td>65</td>
<td>33</td>
<td>32</td>
</tr>
</tbody>
</table>

The Verbs

The six experiments that follow employed either all or some subset of 97 verbs\(^2\). The 97 verbs were selected such that there were verbs which differed in meaning, role assignment, and subcategorization frame. Five semantic categories were chosen and five verbs from each category were selected. The five semantic categories were: 1) sensation; 2) movement; 3) cleaning; 4) handicraft; and 5) categorization. The same semantic category verbs were employed for the purpose of testing whether patients were clear about the actions specified by verbs. For example, both "dusting" and "sweeping" are verbs which describe types of cleaning; however, "dusting" is typically done to furniture and small objects whereas "sweeping" is typically done to floors and involves a broom. If

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\(^2\)Two of the verbs were tested for two meanings. The verb "listen" was tested as a sensation verb and also as a thematically reversible verb. The verb "catch" was tested as a thematically reversible verb paired with the verb "throw" and also as a semantically related verb for the verb "chase". Thus, there were only 95 phonemically and graphemically distinct verbs, but 97 different actions.
Johnson-Laird's (1983) verb complexity model is correct, then one would expect to find that patients with impaired verb meaning representations should perform differently on sets of verbs as a function of semantic complexity. Sensation and movement verbs should be less complex semantically than cleaning, handicraft, or organization verbs because all of the verbs within the cleaning, handicraft, and organization categories require an understanding of movement and sensation. Thus, one might expect patients to demonstrate preserved representations for sensation and movement verbs, but impaired representations for cleaning, handicraft, and organization verbs.

A second verb distinction involved thematic role assignment. To test thematic role assignment a set of verbs which consisted of 12 pairs of reverse-role verbs was used. These verbs were selected because they imply similar actions but differ in the thematic roles that they assign to specific grammatical positions in the sentence. For example, both the verb "sell" and the verb "buy" involve some item being transferred from one person to another as the result of the recipient of the item giving the original owner of the item money. The two verbs differ, however, in the roles that are assigned to the nouns in the sentence (see Sentences 5 and 6).

(5) Mary sold the book to John.

(agent/source) (theme) (goal)

(6) John bought the book from Mary.

(agent/goal) (theme) (source)

If a patient has difficulty with reverse-role verbs, but does not have problems with the same semantic category verbs there are two possible explanations: 1) the patient is unable to assign thematic roles properly; or 2) the reverse-role verbs are more similar in meaning to one another than the verbs within the same semantic category sets. In order to distinguish between these two hypotheses two other types of verbs were included: 1) opposite meaning verbs; and 2) semantically related to reverse-role verbs.
Byng (1988) suggested using opposite meaning verbs to control for semantic similarity. She notes that the verbs within a reverse-role pair are very similar to one another in meaning (e.g., sell-buy). The semantic relationship between reverse-role pairs is different from the semantic relationship of the same semantic category verbs. The same semantic category verbs involve different objects (e.g., a rag and furniture for "dusting" and a broom and floor for "sweeping") while the reverse-role verbs often involve the same objects (e.g., a seller and buyer and some object which is being exchanged for money in the case of the verbs "sell" and "buy"). To control for this type of semantic relationship, Byng (1988) used opposite meaning verbs which maintained the same thematic role relationship compared to the reverse-role verbs which differ in thematic roles. For example, the verbs "lift" and "drop" differ in their spatial relationship to an object, the verb "lift" specifies that the object is moving upward while the verb "drop" specifies that the object is moving downward, but, it can be the same object. At the same time, the verbs "lift" and "drop" involve the same thematic role assignments (see Sentences 7 and 8).

(7) Cathy lifted the ball.

(agent)     (theme)

(8) Cathy dropped the ball.

(agent)     (theme)

To address the issue of semantic similarity three sets of opposite meaning verbs which each contained five pairs of verbs were selected. The three opposite dimensions were: 1) action; 2) direction; and 3) abstract. If patients are unimpaired on the same semantic category verbs but have difficulty with the reverse-role verbs and the opposite meaning verbs then their problem would be attributed to semantic similarity. On the other hand, if patients are unimpaired on the same semantic category verbs and the opposite meaning verbs but have problems with the reverse-role verbs then their pattern of performance would be attributed to an impairment of the representation of thematic roles.
While opposite meaning verbs do address certain aspects of semantic similarity it is not clear that they address all of them. It may be that reverse-role verbs are semantically complex in a different way than the opposite meaning verbs. Gentner (1975, 1981) has argued that a verb's semantic complexity depends on the number and strength of relationships between nouns. She claims that verbs with a greater number of relationships to the nouns in a sentence are more connective. Conceivably, the opposite meaning verbs are less connective than the reverse-role verbs. For example, the verb "to sell" can involve someone owning an item that they wish to exchange with someone else for money. In contrast, the verb "to lift" requires only a single person and object. To control for this type of semantic relationship each of the 24 reverse-role verbs was paired with a semantically related verb to create a set of 24 verbs. For example, "sell" and "trade" both involve two people exchanging two objects. In the case of "sell," one of the objects is money, while typically in the case of "trade" neither object is money. If patients show impaired performance for both semantically related to reverse-role verbs and reverse-role verbs then their deficit would be attributed to semantic similarity, whereas, if they were unimpaired on the semantically related to reverse-role verbs but have difficulty with the reverse-role verbs then their performance would be the result of impaired thematic role representation.

Similarity of meaning ratings were collected for each of the verb sets to make sure that verb sets were similar in meaning. Twenty Rice University graduate and undergraduate students rated pairs of verbs for similarity of meaning. The rating scale was from 0 to 7 where a rating of 0 indicated that the two items were not at all similar, a rating of 1 indicated that the items were dissimilar, and a rating of 7 indicated that the items were very similar.\textsuperscript{3} The similarity of meaning rating data revealed that the reverse-role verbs were rated as more similar in meaning (5.39) than either the opposite action (4.97), direction (4.85), abstract (4.14) verbs, or the semantically related to reverse-role verbs (4.39).

\textsuperscript{3} The procedure and method for collecting similarity of meaning ratings is described in greater detail in the Materials section of Experiment 4.
In order to equate the overall similarity between the reverse-role verbs and the semantically related to reverse-role verbs, the semantically related pair that was rated as most similar for each reverse-role pair was used for comparison with the reverse-role verbs. For example, "sell" and "buy" were one of the reverse-role pairs and the pairs "sell-trade" and "buy-steal" were semantically related to the reverse-role pair "sell-buy." Because "sell-trade" was rated as more similar in meaning than "buy-steal," "sell-trade" was included in the revised semantically related to reverse-role verb set. The mean similarity rating for the revised semantically related to reverse-role verb set was 5.35.

A third aspect of verb representation, other than meaning and thematic roles, which was investigated was syntax or the subcategorization frames into which a verb can be placed. The same 97 verbs were used because within each set (same semantic category, opposite action, opposite direction, opposite abstract, reverse-role, and semantically related to reverse-role) a variety of subcategorization frames were appropriate.

The written frequencies of occurrence for the verbs were obtained from Francis and Kucera's (1982) corpus. Familiarity and abstractness ratings for the list of verbs were collected as well. This information was collected in order to determine if patients were impaired on certain sets of verbs because the verbs are less frequent, familiar or more abstract than verbs in other sets rather than being impaired as a result of the semantic complexity of the verb set. A distinction is made between frequency and familiarity because written word frequency is not always an accurate measure of people's exposure to a word. Written word frequency, for example, does not allow for differences in frequency of occurrence between written and spoken language usage. Germbacher (1984) presented research indicating that familiarity ratings are a more sensitive measure than frequency for some tests. Twelve Rice University graduate and undergraduate students rated the verbs on familiarity. Subjects were instructed to rate each verb from 1 to 7 on how familiar they were with the verb. A rating of 1 was very unfamiliar and a rating of 7 was very familiar.
A second group of twenty Rice University undergraduates rated the list of verbs on abstractness. Subjects were given the following dictionary definition for abstract - "considered apart from concrete existence or a specification thereof; theoretical-not applied or practical; not easily understood; thought of or stated without reference to a specific instance." Subjects were instructed to rate each verb from 1 to 5 on its abstractness, where a rating of 1 was very concrete and a rating of 5 was very abstract. For both tasks the verbs were presented in different random orders for each subject. Appendix A contains a list of the 95 verbs along with the verbs' frequency (Francis and Kucera, 1982), mean familiarity rating, and mean abstractness rating.

Experiment 1 - Verb Repetition

In this experiment, subjects were asked to repeat the 95 verbs. Patients' repetition was tested in order to make sure that any production problems were not the result of an articulation problem. Patients could have difficulty producing verbs because of a central semantic deficit, a lexical output deficit or an articulation deficit. If patients can repeat the verbs, we should be able to rule out articulation deficits.

Method

Materials

The 95 verbs were recorded on tape by a female speech pathologist in a random order.

Procedure

The subjects were told that they would hear a list of verbs and that they should repeat each verb after hearing it. The verbs were presented in the soundfield from one tape recorder and subjects' responses were recorded on a separate tape recorder. The loudness of presentation was adjusted to a comfortable listening level for each subject. After each verb was presented, subjects were given as much time as necessary to repeat the verb or indicate that they were unable to repeat the verb. Control subjects were not tested because they were assumed to be at or near 100% on this task.
Results

Table 4 summarizes patients' verb repetition. The results indicate that all but one of the patients (J.S.) are able to articulate the verbs fairly well. Most of the patients were able to repeat at least 92% of the verbs accurately.

Table 4

Percent Correct for Verb Repetition

<table>
<thead>
<tr>
<th>Subject</th>
<th>Repetition</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.B.</td>
<td>96</td>
</tr>
<tr>
<td>E.E.</td>
<td>98</td>
</tr>
<tr>
<td>W.H.</td>
<td>92</td>
</tr>
<tr>
<td>M.L.</td>
<td>94</td>
</tr>
<tr>
<td>A.P.</td>
<td>94</td>
</tr>
<tr>
<td>J.S.</td>
<td>26 (52)(^a)</td>
</tr>
<tr>
<td>R.W.</td>
<td>92</td>
</tr>
</tbody>
</table>

\(^a\) The value in parentheses is J.S.'s repetition scored leniently.

Patients' errors were classified into one of five categories. A response was recorded as a phonemic error if the subject produced something that differed from the target item by only one or two phonetic features (e.g., if the target was feed and the response was "seed" or "veed"). A response was recorded as a semantic error when the patient responded with a word that was semantically related to the target word (e.g., if the target was touch and the response was "kick"). A "neologism" occurred if the response was unrecognizable as any
word. An "unrelated word" error occurred when the patient responded with an unrelated word (e.g., if the target was weave and the response was "orange"). And finally, "no response" was recorded if the patient made no response or indicated that he or she did not know what the word was or was unable to say the word.

The few errors that the patients (other than J.S.) made were predominantly phonemic (see Table 5). This pattern of errors suggests that the patients sometimes misheard the stimulus or had a very slight problem articulating the stimulus. For example, A.B. responded "sleeping" to the target sweeping. In contrast to the other patients, J.S.'s repetition was very poor (only 26% correct). Because J.S.'s production was so poor and he exhibited articulatory difficulties, his responses were scored with two different criteria. The first criterion was the same as that used for all the other subjects, where any mistake was treated as an error. The second criterion was more lenient, if J.S.'s repetition was only one phoneme away from the target word it was scored as correct (e.g., J.S. responded "fising" to the target fixing). Using a lenient scoring, J.S.'s repetition was at 52%. Clearly, J.S. has difficulty with oral verb production. It is unclear how much of his difficulty with production should be attributed to articulation and how much should be attributed to central language based problems. Due to J.S.'s articulation impairment, unless otherwise specified, discussion of J.S.'s oral production in this and later tasks will focus on how he performed using the second criterion although scores from both criteria will be reported.
Table 5  
Number of Errors on Verb Repetition (proportion)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>phonemic</td>
<td>4 (.04)</td>
<td>2 (.02)</td>
<td>7 (.07)</td>
<td>6 (.06)</td>
<td>5 (.05)</td>
<td>31 (.33)</td>
<td>8 (.08)</td>
</tr>
<tr>
<td>semantic</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>2 (.02)</td>
<td>--</td>
</tr>
<tr>
<td>neologism</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>11 (.11)</td>
<td>--</td>
</tr>
<tr>
<td>unrelated word</td>
<td>--</td>
<td>--</td>
<td>1 (.01)</td>
<td>--</td>
<td>1 (.01)</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>no response</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>2 (.02)</td>
<td>--</td>
</tr>
</tbody>
</table>

*This score does not include phonemic errors that differed by only one phoneme from the target.

Experiment 2 - Verb Reading

Patients' were tested on their ability to read the set of 95 verbs. The purpose of asking patients to read the verbs was two-fold. First, patients with preserved grapheme-to-phoneme conversion abilities should be able to read verbs even if they are unable to produce verbs in a picture naming task. Thus, for those patients with preserved grapheme-to-phoneme conversion abilities this task, like repetition, provides another means of testing patients' production abilities without necessarily testing semantics. Second, for those patients who are unable to use grapheme-to-phoneme conversion, this test may provide a means of testing semantic information. According to two-route models of reading, reading occurs either through grapheme-to-phoneme conversion, or through activation of the semantic system via the visual representation of the word (see Coltheart, 1987 for review).
Evidence for the visual route in reading has been provided by patients who are unable to read nonwords but who can read many words. It is hypothesized that these patients are unable to read nonwords because of a disruption of grapheme-to-phoneme conversion abilities. Patients with this type of deficit must rely on the semantic system in order to pronounce a visually presented word and consequently, should show impaired reading of items which have an impaired representation within the semantic system or lexicon. Thus, if such a patient has difficulty naming verbs to pictures then the patient should also have difficulty reading the same verbs. In order to test for preserved grapheme-to-phoneme conversion abilities, the seven patients were tested on their ability to read pronounceable nonwords.

**Method**

**Materials**

Forty pronounceable nonwords and 95 verbs were printed in large typeface on 3 x 5 index cards.

**Procedure**

Subjects were shown printed nonwords and verbs one at a time and asked to read each word. After each item was presented, subjects were given as much time as necessary to read the item aloud or indicate that they were unable to read the item. Subjects' responses were recorded on audio tape. Subjects were tested on the nonwords and verbs in separate sessions. Control subjects were not tested on verb reading because they were assumed to be at 100% on this task.

**Results**

Nonword reading performance is presented in Table 6. Patients W.H., M.L., J.S., and R.W. have impaired nonword reading. Thus, one would expect these patients to be unable to read verbs for which they have disrupted semantics. Patients A.B., E.E., and A.P. exhibited some difficulties with nonword reading as well. However, their nonword
reading scores of 58% (A.B.), 88% (E.E.), and 80% (A.P.) suggest some preservation of grapheme-to-phoneme conversion abilities. Presumably, A.B., E.E., and A.P. would be able to use grapheme-to-phoneme conversion when reading verbs for which they have impaired semantic representations.

Table 6

<table>
<thead>
<tr>
<th>Subject</th>
<th>Nonword Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.B.</td>
<td>58</td>
</tr>
<tr>
<td>E.E.</td>
<td>88</td>
</tr>
<tr>
<td>W.H.</td>
<td>35</td>
</tr>
<tr>
<td>M.L.</td>
<td>13</td>
</tr>
<tr>
<td>A.P.</td>
<td>80</td>
</tr>
<tr>
<td>J.S.</td>
<td>3</td>
</tr>
<tr>
<td>R.W.</td>
<td>0</td>
</tr>
<tr>
<td>Controls</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>97</td>
</tr>
<tr>
<td>Range</td>
<td>93-100</td>
</tr>
</tbody>
</table>

Table 7 summarizes patients' verb reading. The results indicate that five of the subjects were able to read verbs at a normal level. In fact all five of them were better at verb reading than verb repetition. These results support the hypothesis that patients' verb repetition errors were primarily due to difficulty processing the verb auditorily rather than difficulty
with articulation. W.H. and M.L., two of the patients who were impaired at nonword reading, were able to read all of the verbs. This suggests that they are able to access enough semantic and phonetic information to read the verbs correctly. The other two patients who were impaired at nonword reading, J.S. and R.W., were quite impaired at verb reading. J.S. read 37% of the verbs correctly and R.W. read 24% correctly. Again, J.S. was scored somewhat leniently, in that, if his response was only one phoneme away from the target item, the response was scored as correct.

Table 7

Percent Correct for Verb Reading and Repetition

<table>
<thead>
<tr>
<th>Subject</th>
<th>Reading</th>
<th>Repetition</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.B.</td>
<td>100</td>
<td>96</td>
</tr>
<tr>
<td>E.E.</td>
<td>100</td>
<td>98</td>
</tr>
<tr>
<td>W.H.</td>
<td>100</td>
<td>92</td>
</tr>
<tr>
<td>M.L.</td>
<td>100</td>
<td>94</td>
</tr>
<tr>
<td>A.P.</td>
<td>100</td>
<td>94</td>
</tr>
<tr>
<td>J.S.</td>
<td>16(37)</td>
<td>26(52)</td>
</tr>
<tr>
<td>R.W.</td>
<td>24</td>
<td>92</td>
</tr>
</tbody>
</table>

* The value in parentheses is J.S.'s production scored leniently.

Although J.S. and R.W. were both poor at verb reading, they differed in the types of errors that they made on the reading task. Table 8 summarizes the errors made by J.S. and R.W. J.S. and R.W. are very similar in that they make a large number of phonemic/visual
errors and quite a few "no response" type errors. In the reading task, it is unclear whether a phonemic error is the result of mispronouncing the correct item or rather that a visually similar item was activated. The two patients differ, however, with respect to neologisms and unrelated word errors. Almost half of J.S.'s errors, 47%, were neologisms and he never substituted an unrelated word. In contrast, only 11% of R.W.'s errors were neologisms while 35% of his errors involved substituting an unrelated word. It may be that many of J.S.'s errors are due to articulation difficulty. It is unlikely that R.W.'s errors could be attributed to poor articulation since he was very good at verb repetition.

Table 8
Percent Errors in Verb Reading made by J.S. and R.W.

<table>
<thead>
<tr>
<th>Error Type</th>
<th>J.S.</th>
<th>R.W.</th>
</tr>
</thead>
<tbody>
<tr>
<td>phonemic/visual</td>
<td>25a</td>
<td>21</td>
</tr>
<tr>
<td>semantic</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>neologism</td>
<td>47</td>
<td>11</td>
</tr>
<tr>
<td>unrelated word</td>
<td>0</td>
<td>35</td>
</tr>
<tr>
<td>no response</td>
<td>27</td>
<td>25</td>
</tr>
</tbody>
</table>

aThis score does not include phonemic errors that differed by only one phoneme from the target.

To investigate whether or not verb frequency could explain J.S.'s and R.W.'s errors in reading, their reading performance for each verb was correlated with the natural log of each verb's frequency of occurrence in written English. For J.S. there was a significant correlation between verb reading and verb frequency (r= - .23, p < .05), but for R.W. this
correlation was small and non-significant ($r=.05, p<.62$). For both patients, verb reading correlated more highly with verb familiarity ratings (J.S., $r=.43, p<.0001$; R.W., $r=.34, p<.0007$). Abstractness was not a factor in either J.S.'s or R.W.'s verb reading (J.S., $r= -.08, p<.43$; R.W.,$r=.02, p<.84$).

Discussion of Verb Repetition and Reading

The results from the verb repetition task indicate that six of the patients have intact articulation abilities. One of the patients, J.S., was very poor at verb repetition, suggesting that he has some impairments with respect to articulation.

Results from the verb reading task are more complicated. Three of the patients (A.B., E.E., and A.P.) show fairly normal reading processes as well as good articulation. The remaining four patients (W.H., M.L., J.S., R.W.) were found to have impaired grapheme-to-phoneme conversion abilities as evidenced by their inability to read pronounceable nonwords. Two of these patients (W.H. and M.L.) were able to read all of the verbs correctly. According to two-route models of reading (Coltheart, 1987), these results suggest that W.H. and M.L. have intact semantic representations for the 95 verbs tested because two-route models of reading hypothesize that patients with impaired grapheme-to-phoneme conversion read via direct access of the semantic system. In contrast to W.H. and M.L., J.S. and R.W. displayed difficulty reading verbs as well as pronounceable nonwords. Thus, J.S. and R.W.'s reading errors may be the result of impaired semantic representation of the verbs that they were unable to read. A distinction, however, needs to be made between J.S. and R.W. J.S. was impaired at verb repetition as well as reading, consequently, a large proportion of J.S.'s reading errors may be due to an inability to articulate the verb rather than impaired semantic representation. In addition, J.S.'s verb reading correlated significantly with verb frequency and verb familiarity ratings. Consequently, his reading errors may also be attributed to difficulty activating the correct phonological representation for low frequency and low familiarity verbs. On the other
hand, while R.W.'s verb reading also correlated significantly with verb familiarity his verb repetition was good, showing no signs of an articulation deficit, and therefore his reading errors may be the result of impaired semantics. Thus, R.W.'s performance on verb reading (and to a more limited extent J.S.'s) provides preliminary evidence for a semantic problem with verbs which requires further investigation.

Experiment 3 - Single Verb Production

The first two experiments have established that all of the patients except J.S. are able to articulate the 95 verbs correctly. Referring back to the model of word comprehension and production presented in the introduction (see Figure 3), there is evidence that patients other than J.S. do not have impairments on the output side from the phoneme level down or on the input side from the heard word through the auditory analysis system. In this next experiment, patients were tested on their ability to produce verbs to pictures. The patients had to use the appropriate verb without the benefit of prior acoustic or visual input. This task is useful for detecting possible impairments within the speech output lexicon or the central semantic system.

One problem that occurs when asking people to produce words for actions portrayed in pictures is that there can be more than one appropriate word to describe the action. Preliminary testing of verb production with control subjects revealed a great deal of variability in the verbs selected to describe the actions represented in the photographs. For example, a picture might show a girl running away from someone with the desired target verb being "to flee" but people might use the verb "to run" instead. In order to elicit the desired target verb from subjects, the verbs were divided into sets of four or five items and subjects were given a list of verbs to use. Subjects were also given practice at the beginning of each set in order to familiarize them with the set of verbs.
Method

Materials

Photographs were taken of a girl named Elizabeth, performing the 97 actions. Examples of the photographs can be found in Appendix B. Also, 97 line drawings depicting the actions were pasted onto index cards to be used for practice trials. The verbs were divided into 31 sets containing four or five verbs. Sets varied in size so that all five verbs within a same semantic category set could be tested at the same time. The opposite verbs and reverse-role verbs were divided into sets of four so that there would be two opposite pairs or two reverse-role pairs in a test set. The semantically related to reverse-role pairs and the reverse-role pairs were divided into sets so that each reverse-role verb would appear with its semantically related verb. Thus the reverse-role verbs were tested twice, once in sets containing reverse-role pairs and once in sets containing semantically related to reverse-role verbs.

Procedure

Initially, patients were shown a picture of Elizabeth and told that her name was "Elizabeth." Patients were told that they would be seeing photographs of Elizabeth and that their task was to say what Elizabeth was doing in each picture. Patients were tested on verb sets one at a time. For each set, patients were first given practice trials with feedback and then test trials. For a given verb set, the experimenter read aloud the list of verbs for the set and then presented the patient with line drawings of the verbs one at a time for practice. The patient's task was to use one of the verbs from the list to describe what was going on in the picture. If the patient used an incorrect verb they were corrected by the experimenter. Then the experimenter read the same verbs again and showed the patient photographs of Elizabeth performing the actions. The patient had to use one of the verbs to describe what Elizabeth was doing in the photograph. If there were two people in the picture, patients were reminded to say what Elizabeth was doing. No feedback was given
during the photograph trials. After each photograph was presented, subjects were given as much time as necessary to produce a verb or indicate that they were unable to respond to the photograph. Patients' responses were recorded on audio tape. For the control subjects and some of the patients, the test required two sessions, but some of the patients had difficulty with speech production or simply tired easily and therefore required four sessions (A.B., M.L., J.S., and R.W.). The reverse-role sets and the semantically related to reverse-role sets were tested in different sessions. There was at least one month between sessions. This helped to prevent any inclination the patient might have to try and use the same verb for the same picture. That is, if the patient had been given both sets of verbs close together and saw the picture depicting "borrow" in the reverse-role set and responded "lend," then when he or she saw the same picture in the semantically related to reverse-role set he or she might have tried to be consistent and thereby produce the same error. By leaving a month between sessions, it was hoped that this problem could be avoided.

Results

The percentage of verbs correctly produced to pictures was calculated for each subject (see Table 9). All of the patients with the exception of E.E. were below the control subjects on verb production to pictures. It is surprising that four of the five patients who were at 100% on the verb reading task were below the normal range for verb production to pictures. Not so surprising given their poor verb reading, J.S. and R.W. were the most impaired at verb production obtaining scores of 38% (R.W.) and 19% (J.S.).

An examination of patients' errors shows a different pattern of errors in the production to picture task than in the verb repetition task (see Table 10). On the repetition task most of the errors were phonemic; in contrast, on the production to pictures task, the majority of the errors were semantic. In Table 10, the semantic errors are divided into two groups: 1) errors that came from within the same set of verbs (e.g., if the patient produced the verb "lend" when the photograph depicted the verb "borrow"); and 2) errors from outside of the
set either verbs from other sets (e.g., if the patient produced the verb "listen" to the photograph depicting "attend") or words that were not included in any set (e.g., if the patient produced the verb "clean" when the photograph depicted "sweep"). The majority of patients' semantic errors were "within set" errors. A.P. was the only patient who made more "outside set" errors than "within set" errors (19 outside set errors and 17 within set errors).

Table 9

<table>
<thead>
<tr>
<th>Subject</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.B.</td>
<td>76</td>
</tr>
<tr>
<td>E.E.</td>
<td>95</td>
</tr>
<tr>
<td>W.H.</td>
<td>86</td>
</tr>
<tr>
<td>M.L.</td>
<td>76</td>
</tr>
<tr>
<td>A.P.</td>
<td>70</td>
</tr>
<tr>
<td>J.S.</td>
<td>19(47)a</td>
</tr>
<tr>
<td>R.W.</td>
<td>38</td>
</tr>
</tbody>
</table>

Controls

| Mean    | 95         |
| Range   | 94-98      |

aThe value in parentheses is J.S.'s production scored leniently.
Table 10

Number and Type of Errors made in Single Verb Production Task (proportion)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>phonemic</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>14a(.11)</td>
<td>--</td>
</tr>
<tr>
<td>semantic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>within set</td>
<td>18(.14)</td>
<td>3(.02)</td>
<td>13(.10)</td>
<td>22(.17)</td>
<td>17(.13)</td>
<td>18(.14)</td>
<td>29(.23)</td>
</tr>
<tr>
<td>outside set</td>
<td>4(.03)</td>
<td>3(.02)</td>
<td>3(.02)</td>
<td>8(.06)</td>
<td>19(.15)</td>
<td>5(.04)</td>
<td>13(.10)</td>
</tr>
<tr>
<td>neologism</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>12(.09)</td>
<td>--</td>
</tr>
<tr>
<td>unrelated word</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>10(.08)</td>
<td></td>
</tr>
<tr>
<td>no response</td>
<td>9(.07)</td>
<td>--</td>
<td>2(.01)</td>
<td>1(.01)</td>
<td>2(.01)</td>
<td>18(.14)</td>
<td>27(.21)</td>
</tr>
</tbody>
</table>

aThis score does not include phonemic errors that differed by only one phoneme from the target.

Before examining patients' verb production by verb sets it is necessary to establish that patients' errors are not due to general variables like verb frequency, familiarity, or abstractness. E.E., W.H., and R.W.'s verb production did not correlate significantly with any of the three variables. It is somewhat surprising that R.W.'s production failed to correlate with familiarity given that his verb reading did correlate with verb familiarity. A.P. and M.L. produced more verbs which were rated as concrete and made more errors on verbs which were rated as abstract (A.P., r=.31, p<.0003; M.L., r=.23, p<.008).

J.S.'s verb production correlated positively with both the natural log of verb frequency (r=.24, p<.02) and verb familiarity ratings (r=.25, p<.005). A.B. and M.L.'s production correlated negatively with the natural log frequencies of the verbs (A.B., r=.22, p<.01; M.L., r=.25, p<.004). Because it is counterintuitive to find subjects who are able to
produce low frequency verbs but are unable to produce high frequency verbs, A.B.'s and M.L.'s production data were re-examined. It appears that a few outliers can account for the negative frequency effect. There were a few very low frequency verbs that were very picturable (e.g., embroider, erase) and a few very high frequency verbs that were very difficult to portray (e.g., have, do). A.B. and M.L. were able to produce the low frequency verbs and made errors on the high frequency verbs but their production on the verbs that fell between these two extremes did not show a consistent negative frequency effect.

In general, it does not appear that patients' verb production to pictures (with the exception of J.S.) can be explained in terms of frequency or familiarity. Therefore, verb production will be re-examined in terms of the different verb sets. The percentage of verbs correctly produced to pictures was calculated for each subject and each set of verbs (see Table 11). E.E.'s performance was within the normal range for all the different types of verbs. W.H. was in the normal range for all of the verb types except the reverse-role verbs and the semantically related to reverse-role verbs. M.L.'s verb production was within the normal range for the same semantic category verbs and the opposite direction verbs. M.L.'s production was somewhat impaired on all the other verb sets. A.B. and A.P. were similar in that their verb production was slightly outside the range of performance of the control subjects for all the different types of verbs (A.P. was in the normal range for the opposite direction verbs). J.S. and R.W. were similar in that their production was well below the minimum level of performance obtained from the control subjects for all the verb types.
### Table 11

**Percent Correct for Single Verb Production by Verb Type**

<table>
<thead>
<tr>
<th>Verb Type</th>
<th>A.B.</th>
<th>E.E.</th>
<th>W.H.</th>
<th>M.L.</th>
<th>A.P.</th>
<th>J.S.(^a)</th>
<th>R.W.</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semantic</td>
<td>80</td>
<td>100</td>
<td>88</td>
<td>92</td>
<td>84</td>
<td>12(36)</td>
<td>32</td>
<td>97 (88-100)</td>
</tr>
<tr>
<td>Opposite Action</td>
<td>80</td>
<td>100</td>
<td>100</td>
<td>70</td>
<td>90</td>
<td>20(70)</td>
<td>40</td>
<td>100</td>
</tr>
<tr>
<td>Opposite Direction</td>
<td>80</td>
<td>100</td>
<td>100</td>
<td>90</td>
<td>90</td>
<td>0(30)</td>
<td>20</td>
<td>98 (90-100)</td>
</tr>
<tr>
<td>Opposite Abstract</td>
<td>50</td>
<td>90</td>
<td>100</td>
<td>60</td>
<td>50</td>
<td>30(50)</td>
<td>10</td>
<td>94 (80-100)</td>
</tr>
<tr>
<td>Reverse Role</td>
<td>79</td>
<td>92</td>
<td>67</td>
<td>58</td>
<td>50</td>
<td>21(46)</td>
<td>54</td>
<td>97 (92-100)</td>
</tr>
<tr>
<td>Related to Reverse Role(^b)</td>
<td>79</td>
<td>96</td>
<td>83</td>
<td>75</td>
<td>54</td>
<td>17(54)</td>
<td>38</td>
<td>91 (88-92)</td>
</tr>
</tbody>
</table>

\(^a\) The value in parentheses is J.S.'s production scored leniently.

\(^b\) The numbers presented here are for the revised set of semantically related to reverse-role verbs which were rated as the most similar.

A note should be made about the opposite abstract verb set. It is very difficult to find pictures which will consistently elicit abstract verbs like "do," "have," etc. Consequently, all of the subjects including the control subjects had difficulty with this set of verbs. The control subjects showed the widest range of performance with the opposite abstract verb set, performing between 80% and 100%. If we disregard the abstract opposite stimuli, three of the patients are most impaired on reverse-role verbs (W.H., M.L., and A.P.). It should be noted, however, that M.L.'s and A.P.'s verb production correlated significantly with verb abstractness ratings; they made more production errors on abstract verbs than concrete verbs. The mean abstractness ratings for the reverse-role (2.55) and semantically related to reverse-role (2.62) verbs indicate that these sets were more abstract than any of the other verb sets aside from the opposite abstract verbs (3.85). Thus, it appears that M.L.'s and A.P.'s verb production errors can be attributed to the abstractness of the verbs.
However, if abstractness is the primary variable involved in M.L.'s and A.P.'s verb deficits then there should be no difference in performance for reverse-role and semantically related to reverse-role verbs since they were matched in level of abstractness.

To determine whether poor performance on reverse-role verbs might be attributed to impaired thematic role assignment a chi-square test was done comparing verb production performance for reverse-role verbs to performance on semantically related to reverse-role verbs. A.B., E.E., A.P., J.S., and R.W. showed no significant difference in verb production between the reverse-role sets and the semantically related to reverse-role sets with $X^2$ close to zero. While W.H. and M.L. did not show statistically significant differences between the reverse-role verbs and the semantically related to reverse-role verbs, they obtained $X^2$ values that were suggestive of a difference (W.H., $X^2(24, 24)=1.78$, $p<.25$; M.L., $X^2(24, 24)=1.50$, $p<.25$).

**Discussion of Single Verb Production**

The purpose of testing patients on verb production to pictures was to see whether patients had verb deficits located within the output lexicon or central semantic system. The seven patients show very different patterns of performance on verb production therefore each patient’s performance will be reviewed individually.

**A.B.**

A.B. was unimpaired on verb repetition and reading. His verb production to pictures, however, was slightly below the normal range for all the different verb sets. Verb production errors did not correlate significantly with verb frequency, familiarity, or abstractness. A.B. also showed no difference in production of reverse-role verbs and semantically related to reverse-role verbs. These results suggest that A.B. might have a mildly degraded semantic representation for some verbs within the central semantic system or there might be some kind of activation impairment between the central semantic system
and the output lexicon such that semantically related words are being activated more strongly than the target word.

**E.E.**

E.E. was within the normal range for verb production to pictures for all the different verb types. She was also unimpaired on verb repetition and reading. It therefore, does not appear that E.E. has any deficits in verb representation on the output side of verb processing.

**W.H.**

W.H. was within the normal range on verb production to pictures for all the verb types except the reverse-role and semantically related to reverse-role verbs. His verb repetition and reading were normal and his production performance did not correlate significantly with frequency, familiarity, or abstractness. Because there was no significant difference between W.H.'s production of reverse-role verbs and semantically related to reverse-role verbs it is not possible to attribute W.H.'s production difficulty to a deficit in thematic role assignment. It may be that the two sets of verbs are more complex or similar semantically than the other sets and that W.H. has some central semantic problem that is causing poor performance on both sets of verbs. Another interesting aspect of W.H.'s performance was that he had difficulty producing verbs to pictures that he had no trouble reading. These results are problematic for models of reading that would attribute W.H.'s good reading in spite of impaired grapheme-to-phoneme conversion to direct semantic access. W.H.'s understanding of reverse-role and semantically related to reverse-role verbs needs to be investigated further.

**M.L.**

M.L. was within the normal range for production of the same semantic set verbs and the opposite direction verbs. He was below the normal range for production of opposite action, abstract, reverse-role and semantically related to reverse-role verbs. His poor
production cannot be attributed to articulation difficulties because his verb repetition was
good. M.L. did show a significant correlation between verb production and abstractness
ratings. M.L.'s verb production was impaired on the verb sets which contained the most
abstract verbs. M.L., like W.H., was at 100% on the verb reading task in spite of
impaired grapheme-to-phoneme conversion abilities and it is therefore surprising that he
was impaired on verb production to pictures for some verb sets. It is unclear whether
M.L.'s production deficit should be located at the level of the output lexicon or rather
within the central semantic system. Clearly further investigation of M.L.'s comprehension
of the various verb sets is necessary.

A.P.

A.P.'s performance is very similar to A.B.'s. A.P. was unimpaired on verb repetition
and reading. His verb production to pictures was below the normal range for all the
different verb sets except the opposite direction verbs. A.P. showed no significant
difference in production of reverse-role verbs and semantically related to reverse-role
verbs. A.P., like M.L., showed an abstractness effect in production; but, A.P.'s verb
production cannot be explained in terms of abstractness alone. A.P. was impaired at
production of same semantic category verbs which were rated as the most concrete set of
verbs. If A.P.'s production performance were due to abstractness effects alone then his
production should have been the best on the same semantic category verbs. Abstractness,
however, can explain his performance on the remaining verb sets. Overall, the results
suggest that A.P. has an impairment either within the central semantic system or in the
output lexicon.

J.S.

J.S. is impaired at both verb repetition and reading; therefore, it is not surprising that he
was impaired at verb production for all the different sets of verbs. He exhibits articulatory
difficulties. Also, J.S.'s verb production correlated significantly with verb frequency and
familiarity which suggests that J.S. has difficulty retrieving the correct phonological form for verb production in addition to articulatory difficulties. In view of J.S.'s articulation deficit, it is necessary to test the nature of J.S.'s verb representations without requiring oral production.

R.W.

R.W. was outside of the normal range of performance for verb production for all the different verb sets. Because his verb repetition was normal his errors cannot be attributed to poor articulation. He showed no significant difference in performance on the reverse-role verbs and semantically related to reverse-role verbs. Therefore, it seems likely that R.W. has either a general semantic deficit of verb representation localized in the central semantic system or a deficit within the output lexicon.

Experiment 4 - Verb Comprehension

The previous experiment, investigated patients' abilities to produce verbs to pictures in order to see whether patients might have a deficit for verb representations either in the central semantic system or the output lexicon. The data collected from the production experiment alone are not enough to distinguish between a deficit in the central semantic system and a deficit at the level of the output lexicon. The present experiment attempts to separate these two deficits. If a patient has impaired representations at the level of the central semantic system, then he or she should be impaired on both production and comprehension tasks. If a patient is impaired at the level of the output lexicon, then he or she should still have good comprehension of items but simply be unable to produce those items due to an impairment either between the central semantic system and the output lexicon or between the output lexicon and articulatory codes. This experiment investigated whether patients comprehend semantic and thematic distinctions between verbs. In other words, do patients associate the correct actions to given verbs and are they able to assign the arguments of particular actions to the correct thematic role?
Method

Materials

The photographs of Elizabeth performing the 97 verbs were used. Pairs of photographs were matched to create 205 pairs. Examples of the photographs are presented in Appendix B.

Same semantic category pairs. As described earlier, there were five verbs from each of five semantic categories: 1) sensation (e.g., smell); 2) movement (e.g., walk); 3) cleaning (e.g., sweep); 4) handicraft (e.g., sew); and 5) categorization (e.g., sort). Thus, there were a total of 25 photographs. Each photograph in a set was paired with each of the other photographs in the same set resulting in 10 related pairs of verbs for each semantic category for a total of 50 same semantic category pairs. Each of the same semantic category verbs was also paired with two verbs that were semantically unrelated resulting in 50 unrelated pairs. Thus, there were 100 pairs of stimuli for the same semantic category verbs.

Opposite meaning pairs. There were three sets of opposites: 1) action (e.g., laugh-cry); 2) direction (e.g., lift-drop); and 3) abstract (e.g., have-want). Within each of these three sets there were five pairs of opposites resulting in 15 opposite pairs. Each of the verbs in an opposite pair was also paired with an unrelated verb to create 30 unrelated pairs. There were a total of 45 pairs of stimuli for the opposite verbs.

Reverse-role and semantically related to reverse-role pairs. There were 12 pairs of reverse-role verbs (e.g., buy-sell). Each of the verbs was also paired with a semantically unrelated verb to create 24 unrelated pairs. The reverse role verbs were also paired with semantically related verbs resulting in 24 related pairs (e.g., sell-trade). There were 60 pairs of stimuli for the reverse-role verbs.

Similarity ratings. Similarity of meaning ratings were collected for the 205 verb pairs. Twenty Rice University graduate and undergraduate students were given a written list of the 205 pairs of verbs and asked to rate the pairs of verbs for similarity of meaning. The
rating scale was from 0 to 7 where a rating of 0 indicated that the two items were not at all similar, a rating of 1 indicated that the items were very dissimilar, and a rating of 7 indicated that the items were very similar. The order in which the verb pairs were presented was random across subjects. Table 12 contains the mean similarity rating for each of the verb sets. It should be noted that the pairs of verbs which were semantically related to the reverse-role verbs had a somewhat lower mean similarity rating (4.39) than the reverse-role pairs (5.39). As was described earlier, in order to better equate the reverse-role verbs and semantically related to reverse-role verbs in terms of similarity of meaning ratings, for each reverse-role pair the item that was rated as most similar in meaning to its semantically related pair was used for comparison with performance on reverse-role verbs. The semantically related verbs that were rated as most similar in meaning to reverse-role verbs are marked with an asterisk in Appendix A.
Table 12

Mean Similarity Ratings for Verb Comprehension Pairs

<table>
<thead>
<tr>
<th>Pairs</th>
<th>Semantic</th>
<th>Action</th>
<th>Direction</th>
<th>Abstract</th>
<th>Reverse-Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related</td>
<td>4.55</td>
<td>4.97</td>
<td>4.85</td>
<td>4.14</td>
<td>4.39 (5.35)*</td>
</tr>
<tr>
<td>Unrelated</td>
<td>1.09</td>
<td>.89</td>
<td>1.33</td>
<td>1.86</td>
<td>.88</td>
</tr>
<tr>
<td>Thematically Related</td>
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<td></td>
<td></td>
<td></td>
<td>5.39</td>
</tr>
</tbody>
</table>

* The number in parentheses is the similarity rating for the revised set of semantically related to reverse-role verbs.

Procedure

Subjects were first shown a picture of Elizabeth and told her name. They were then told that they would see two pictures of Elizabeth doing different things. Subjects then heard or read a verb and were instructed to point to the picture in which Elizabeth was performing the specified action. Subjects were told that sometimes someone other than Elizabeth would be performing the action and consequently they needed to be very careful to point to the photograph in which Elizabeth was performing the action. Subjects were shown pairs of photographs depicting verbs which were semantically related, thematically related, or unrelated. Two photographs were presented adjacent to one another on the same page of a photograph album. The photographs were arranged so that on half of the trials the correct picture was on the left side and on half of the trials the correct picture was on the
right side. Patients were tested on the 205 pairs of stimuli four times with an interval of at least one week between sessions. They were tested four times in order to test their knowledge of both verbs in a pair (e.g., the patient might see pictures representing "taste" and "smell" and in one session be asked to point to "taste" and in the second session be asked to point to "smell") and also to test them in both the auditory and visual modalities. The order in which the four conditions were presented was determined randomly for each subject. In the auditory condition, the experimenter said the verb and in the visual condition the verb was printed on an index card and the subject read it. Subjects were given as much time to respond as they needed.

The 205 trials were presented in a different random order for each of the four sessions.

**Results**

**Auditory Presentation**

The percentage of correct responses were calculated for each subject for each set of verbs. Patients’ performance and that of the control subjects is presented in Table 13. Most of the patients performed within the normal range on the auditory verb comprehension task for same semantic category verbs and opposite meaning verbs. R.W. was slightly below the normal range on all the verb sets and A.P. was slightly outside of the normal range on the abstract opposite verbs. Note that all of the patients except A.P. and R.W. showed good comprehension for the opposite abstract pairs. These results lend support to the hypothesis that poor production on the opposite abstract stimuli was in part due to the stimuli rather than a patient deficit. All of the patients, with the exception of E.E., had difficulty comprehending reverse role verbs. M.L. did the worst of all the patients scoring only 54% where a score of 50% would be chance. Patients’ poor performance on reverse role verbs is surprising given the normal performance or near normal performance on the same semantic category pairs and the opposite meaning pairs.
In general, patients' comprehension was better when the reverse-role verbs were paired with semantic distractors than when paired with thematic distractors. Patients, however, did make errors on the reverse-role verbs paired with semantic distractors. A.B. was the only patient who performed within the range of the control subjects for the semantic distractors. To determine whether poor performance on reverse-role verbs could be attributed to impaired thematic role assignment rather than increased semantic similarity a chi-square analysis was performed comparing patients' comprehension performance on the reverse-role verbs to their performance on the semantically related to reverse-role verbs (see Table 13). M.L. was significantly worse at auditory comprehension of the reverse-role verbs than the semantically related to reverse-role stimuli ($\chi^2 (24, 24)=8.55$, $p<.005$).
Table 13

Percent Correct for Auditory Verb Comprehension

<table>
<thead>
<tr>
<th>Verb Type</th>
<th>A.B.</th>
<th>E.E.</th>
<th>W.H.</th>
<th>M.L.</th>
<th>A.P.</th>
<th>J.S.</th>
<th>R.W.</th>
<th>Controls&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semantic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Related</td>
<td>98</td>
<td>97</td>
<td>99</td>
<td>100</td>
<td>98</td>
<td>99</td>
<td>93</td>
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<tr>
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<td>100</td>
<td>99</td>
<td>100</td>
<td>98</td>
<td>95</td>
<td>100</td>
</tr>
<tr>
<td>Opposite Action</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>100</td>
<td>100</td>
<td>90</td>
<td>100</td>
<td>100</td>
<td>90</td>
<td>100</td>
</tr>
<tr>
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<td>100</td>
<td>100</td>
<td>100</td>
<td>95</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Opposite Direction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>100</td>
<td>95</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>90</td>
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</tr>
<tr>
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<td>100</td>
<td>85</td>
<td>100</td>
<td>85</td>
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<tr>
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<td>98 (92-100)</td>
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<td>100</td>
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<td>92</td>
<td>92</td>
<td>92</td>
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<td>1.23</td>
<td>.51</td>
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</tbody>
</table>

<sup>a</sup> Control subjects were tested on visual verb comprehension only. There was no reason to expect normal subjects to differ in performance on visual and auditory presentation. Thus, the control data presented here were obtained with visual presentation rather than auditory.

<sup>b</sup>The numbers presented here are for the revised set of semantically related to reverse-role verbs which were rated as the most similar.

* $p<.005$
Visual Presentation

The percentage of correct responses were calculated for each subject for each set of verbs. Patients' performance and that of the controls is presented in Table 14. Once again all of the patients, with the exception of E.E., had difficulty comprehending reverse role verbs. In addition, J.S., who has difficulty reading verbs was at 50% on opposite direction verbs while similar on the reverse-role verbs and semantically related to reverse-role verbs. R.W.'s performance was impaired on all of the verbs.

Once again it is possible that patients' poor comprehension of reverse role verbs is due to greater semantic complexity or similarity between the reverse role verbs. To test this hypothesis, performance on the reverse-role verbs and semantically related to reverse-role verbs was submitted to a chi-square test (see Table 14). With visual presentation, M.L. continued to be significantly worse at comprehension for reverse-role verbs than semantically related to reverse-role verbs ($X^2(24, 24)=7.85, p<.005$). In addition, A.B., who did not show a significant difference with auditory presentation, was significantly worse on the reverse-role verbs with visual presentation ($X^2(24, 24)=8.20, p<.005$). Given that A.B., W.H., and A.P. were 100% at verb reading and that their comprehension performance with auditory presentation was in the same direction as their visual performance, their visual and auditory performance were combined and chi-squares were calculated comparing their performance on reverse-role verbs and semantically related to reverse-role verbs. With this reanalysis, two of the patients, A.B., and A.P., were significantly worse at comprehension of reverse-role verbs (A.B., $X^2(48, 48)=8.32, p<.005$; A.P., $X^2(48, 48)=4.38, p<.05$) while W.H.'s comprehension of reverse-role verbs was not significantly worse than his comprehension of semantically related to reverse-role verbs ($X^2(48, 48)=2.57, p<.20$).
Table 14
Percent Correct for Visual Verb Comprehension

<table>
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<tr>
<th></th>
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<td>.34</td>
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</tbody>
</table>

*The numbers presented here are for the revised set of semantically related to reverse-role verbs which were rated as the most similar.

*p<.005
Discussion of Verb Comprehension

This experiment focused on whether patients comprehended the verbs within the various sets. If patients had difficulty with same semantic set verbs, opposite action verbs, or semantically related to reverse-role verbs, it would suggest an impaired semantic representation for verbs. If patients were worse at comprehending reverse-role verbs than semantically related to reverse-role verbs it would provide support for a selective deficit for thematic role assignment. Once again patients were very different in their performance and therefore each will be examined individually.

A.B.

A.B.'s verb comprehension was better than his verb production. On the verb production task, A.B. was slightly below the normal range for all the verb sets. On verb comprehension, A.B. was within the normal range for all the verb sets except the reverse-role verbs. Because A.B.'s comprehension for verbs that he had difficulty producing was unimpaired, the hypothesis that A.B. has a central semantic deficit for the semantic representation of verbs is not supported. It seems more plausible that A.B. comprehends what is happening in a picture but when he tries to produce the verb, a semantically related verb gets activated within the output lexicon. Consequently, A.B. makes semantic errors on production. A.B. was impaired on reverse-role verbs in both production and comprehension. Therefore, it appears that A.B. has some kind of central deficit related to the representation of thematic roles.

E.E.

E.E. was within the normal range on verb comprehension for all the different verb types. This is not very surprising given her normal verb production.

W.H.

W.H. was within the normal range on verb production to pictures for all the verb types except the reverse-role and semantically related to reverse-role. On auditory verb
comprehension, he was within the normal range on all the verb sets except the reverse-role and semantically related to reverse-role. With visual presentation, he was within the normal range for all the verb types except the reverse-role. W.H. did not show a significant difference between reverse-role verbs and semantically related to reverse-role verbs. In production, he showed the same pattern of performance, that is, impaired on both reverse-role and semantically related to reverse-role verbs. It therefore seems plausible that W.H. has a central semantic deficit for verbs that are very similar in meaning.

M.L.

M.L.'s verb comprehension was similar to A.B.'s. His comprehension was within the normal range for all the verbs except the reverse-role and semantically related to reverse-role. Although, he was slightly below the normal range for semantically related to reverse-role verbs, he was near chance on the reverse-role verbs. M.L. who had difficulty with opposite action and opposite abstract verbs in the production experiment was unimpaired on comprehension for these same verbs. Although, verb abstractness seemed to be a viable explanation for M.L.'s verb production, it cannot account for M.L.'s verb comprehension because he was more impaired on reverse-role verbs than semantically related to reverse-role verbs in spite of these two verb sets being equivalent in abstractness. Therefore, it appears that M.L. has a central thematic role assignment deficit and an additional deficit involving the retrieval of phonological forms from the output lexicon for abstract verbs.

A.P.

A.P.'s performance is very similar to A.B. His verb production to pictures was outside of the normal range for all the different verb sets. He was within the normal range for verb comprehension for all the verb sets except the reverse-role and semantically related to reverse-role, and his comprehension was significantly worse for the reverse-role verbs. He was also outside of the normal range for the opposite abstract verbs. It appears that
A.P., like M.L., has a central deficit for thematic role assignment and an additional deficit at the level of the output lexicon for abstract verbs.

**J.S.**

J.S. was within the normal range for auditory verb comprehension on all the verb sets except the reverse-role and semantically related to reverse role verbs. He did not show any difference in performance between the reverse-role verbs and the semantically related to reverse-role verbs. Because J.S.'s impaired verb reading suggested disrupted semantic representations for verbs, it is not surprising that his visual verb comprehension was outside of the normal range for opposite direction verbs as well as reverse-role and semantically related to reverse-role verbs. However, J.S. was good at visual verb comprehension for the remaining verb sets suggesting that some component of his impaired reading abilities is due to difficulty accessing phonological forms within the output lexicon and to articulation impairments. Again, he showed no significant difference between the reverse-role or semantically related to reverse-role verbs. Because J.S. did not have to orally produce the verbs in the comprehension task, his errors cannot be attributed to impaired access of output phonology or articulatory deficits. Consequently, it appears that J.S., like W.H., has an impaired representation within the central semantic system for some items that are semantically very similar.

**R.W.**

R.W.'s auditory verb comprehension was slightly below the normal range for same semantic set verbs, opposite direction verbs, and opposite abstract verbs. His auditory verb comprehension was even worse for the reverse-role and semantically related to reverse-role verbs although there was no significant difference in his performance on the two sets. For visual verb comprehension, R.W. was below the normal range for all of the verb types. He was also impaired at verb production for all the different verb types. Therefore, it seems likely that R.W. has a general semantic deficit for verbs localized in the
central semantic system. He has more difficulty accessing the semantic system through the visual modality than the auditory modality.

**Experiment 5 - Sentence Production**

The previous two experiments investigated semantic and thematic aspects of verb representation. The results for A.B., M.L., and A.P. indicate a dissociation between semantic and thematic representation. The next two experiments explore the nature of verbs' syntactic representation. In Experiment 5, patients were tested on their ability to produce sentences describing pictures. In order to produce an acceptable sentence, one must have an intact representation of the subcategorization frames into which a verb can be placed. This experiment helps to address the issue of whether or not syntactic structure and thematic role assignment are linked. If these two processes are connected then one would expect patients who had selective difficulty with production and comprehension of reverse-role verbs to also have difficulty in using reverse-role verbs in appropriate sentences. If these two processes are separate, however, one would expect to find patients who have difficulty with comprehension and production of reverse-role verbs but are able to use these verbs in syntactically acceptable frames. Similarly, one might expect to find patients who do not have difficulty with comprehension and production of reverse-role verbs but are unable to produce grammatically correct sentences.

**Method**

**Materials**

The materials were the same as those used in Experiment 3.

**Procedure**

The experimenter read the list of verbs for the set and then presented the patient with line drawings of the verbs one at a time for practice. The patient's task was to use one of the verbs from the list to describe what was going on in the picture. If the patient used an incorrect verb they were corrected by the experimenter. Then the experimenter read the
verbs again and showed the patient photographs of Elizabeth performing the actions. The patient had to produce a sentence starting with "Elizabeth is." Patients were reminded repeatedly to be sure to say what Elizabeth was doing. Also, patients were instructed to be as descriptive as possible. No feedback was given during the photograph trials. Patients' were given as much time as necessary to respond. Patients' responses were recorded on audio tape.

Results

Initially, sentence production was scored in the same manner as single verb production. Table 15 presents patients' percent correct for producing the target verb. The scores presented in Table 15 do not reflect patients' performance on portions of the sentence other than the verb. In general, patients' verb production in the sentence task was similar to the verb production task.

Patients' verb production in the sentence production task broken down by verb set is presented in Table 16. All of the patients, except E.E., basically showed the same pattern of verb production in the sentence production task as they did in the single verb production task. A.B. and A.P. who were slightly below the normal range for all the verb sets in the single verb production task were within the normal range for several of the verb sets in the sentence production task. W.H. was slightly below the normal range for same semantic category verbs and opposite abstract verbs in the sentence production task whereas his performance was normal for these sets in the single verb production task.

E.E. who was within the normal range for all the verb types in the single verb production task was below the normal range on abstract opposites and semantically related to reverse-role verbs for sentence production. In fact, E.E. was significantly worse on semantically related to reverse-role verbs than the reverse-role verbs.

4 Some of the patients had difficulty saying "Elizabeth" and they were allowed to begin the sentence with "The girl is" or "She is".
Table 15

Percent Correct for Verb Production in Sentence Production to Pictures

<table>
<thead>
<tr>
<th>Subject</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.B.</td>
<td>83</td>
</tr>
<tr>
<td>E.E.</td>
<td>90</td>
</tr>
<tr>
<td>W.H.</td>
<td>81</td>
</tr>
<tr>
<td>M.L.</td>
<td>77</td>
</tr>
<tr>
<td>A.P.</td>
<td>80</td>
</tr>
<tr>
<td>J.S.</td>
<td>13(46)\textsuperscript{a}</td>
</tr>
<tr>
<td>R.W.</td>
<td>35</td>
</tr>
</tbody>
</table>

Controls

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>96</td>
</tr>
<tr>
<td>Range</td>
<td>95-98</td>
</tr>
</tbody>
</table>

\textsuperscript{a}The value in parentheses is J.S.'s production scored leniently.
Table 16

Percent Correct for Verb Production in Sentence Task for Different Verb Sets

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Semantic</td>
<td>92</td>
<td>96</td>
<td>88</td>
<td>96</td>
<td>88</td>
<td>16(44)</td>
<td>44</td>
<td>97 (92-100)</td>
</tr>
<tr>
<td>Opposite Action</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>70</td>
<td>100</td>
<td>0(50)</td>
<td>80</td>
<td>98 (90-100)</td>
</tr>
<tr>
<td>Opposite Direction</td>
<td>100</td>
<td>100</td>
<td>90</td>
<td>90</td>
<td>100</td>
<td>30(30)</td>
<td>40</td>
<td>100</td>
</tr>
<tr>
<td>Opposite Abstract</td>
<td>60</td>
<td>70</td>
<td>60</td>
<td>50</td>
<td>20</td>
<td>0(10)</td>
<td>20</td>
<td>98 (90-100)</td>
</tr>
<tr>
<td>Reverse Role</td>
<td>71</td>
<td>100</td>
<td>63</td>
<td>71</td>
<td>88</td>
<td>13(42)</td>
<td>33</td>
<td>98 (96-100)</td>
</tr>
<tr>
<td>Related to Reverse Role</td>
<td>75</td>
<td>79</td>
<td>83</td>
<td>79</td>
<td>67</td>
<td>21(42)</td>
<td>25</td>
<td>91 (88-92)</td>
</tr>
<tr>
<td>$X^2$</td>
<td>.11</td>
<td>5.58*</td>
<td>2.64</td>
<td>.44</td>
<td>2.95</td>
<td>0.00</td>
<td>.40</td>
<td></td>
</tr>
</tbody>
</table>

$^a$The value in parentheses is J.S.’s production scored leniently.

$^b$The numbers presented here are for the revised set of semantically related to reverse-role verbs which were rated as the most similar.

$^{*p<.025}$

As was noted earlier, the reason for asking patients to produce sentences describing photographs was to see if patients have intact syntactic representations for the various verbs within the various verb sets. Appropriate syntactic frames for each photograph were defined as any syntactic frame produced by the five control subjects for a given photograph. For example, if the photograph was of the verb "to catch" and the patient responded "Elizabeth is catching the ball" the response would be scored as correct because control subjects produced sentences with the subcategorization frame NP aux Ving NP for the verb "to catch." In contrast, if the patient responded "Elizabeth is catching" the response would be scored as incorrect since none of the control subjects produced the subcategorization frame NP aux Ving to the photograph for the verb "to catch." If a patient
produced a sentence in which the subcategorization frame matched that of the control subjects but the patient changed the tense of the verb, the sentence was scored as correct (e.g., "Elizabeth caught the ball" or "Elizabeth will catch the ball"). Because the question of interest was whether patients knew what elements of the sentence were required by the verb, scoring was lenient with respect to the nouns used by the patients within the sentence. For example, if the patient produced the sentence "Elizabeth is catching the balloon" or "Elizabeth is catching the I can't remember this word" when the photograph shows Elizabeth catching a ball, the sentence was scored as syntactically correct because the patient followed the verb with a noun phrase even though the noun was not correct or the patient was unable to produce the noun while indicating that a noun was needed by providing the article for the noun. Appendix C contains examples of each patient's sentence production.

Patients' sentences were categorized into four groups: 1) a correct verb and a correct syntactic frame (e.g., Elizabeth is catching the ball); 2) an incorrect verb with a correct syntactic frame (e.g., Elizabeth is throwing the ball or Elizabeth is holding the ball); 3) a correct verb with an incorrect syntactic frame (e.g., Elizabeth catch); and 4) an incorrect verb with an incorrect syntactic frame (Elizabeth throw). Table 17 presents patients' performance on sentence production using subcategorization frame as the dependent measure. The data presented in Table 17 are collapsed across the different verb sets and do not distinguish whether the patient used the correct verb, but just whether the patient produced an acceptable syntactic frame for the verb used.
Table 17

Percent Correct for Subcategorization Frames in Sentence Production Task

<table>
<thead>
<tr>
<th>Subject</th>
<th>Subcategorization</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.B.</td>
<td>93</td>
</tr>
<tr>
<td>E.E.</td>
<td>91</td>
</tr>
<tr>
<td>W.H.</td>
<td>92</td>
</tr>
<tr>
<td>M.L.</td>
<td>88</td>
</tr>
<tr>
<td>A.P.</td>
<td>82</td>
</tr>
<tr>
<td>J.S.</td>
<td>1</td>
</tr>
<tr>
<td>R.W.</td>
<td>56</td>
</tr>
</tbody>
</table>

With the exception of J.S., patients' performance on subcategorization frame production was as good as and often better than their performance on verb production for the sentence production task. All of the patients except for J.S. and perhaps R.W. seem to have fairly intact syntactic representations for verbs. However, performance was also examined taking into consideration the various verb sets (see Table 18). It could be that patients had good syntactic representations for some verb sets but were impaired on others.

In general, patients' subcategorization frame production did not vary much across the different verb sets. However, an examination of Table 18 reveals that patients made more incorrect verb with the correct syntactic frame errors for abstract opposite verbs, reverse-role verbs, and semantically related to reverse-role verbs than any of the other verb sets.
Table 18
Percent Correct for Subcategorization Frame Production by Verb Set

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Semantic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correct frame</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>correct verb</td>
<td>88</td>
<td>94</td>
<td>81</td>
<td>96</td>
<td>80</td>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>incorrect verb</td>
<td>8</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>32</td>
</tr>
<tr>
<td>Incorrect frame</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>correct verb</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>8</td>
<td>44</td>
<td>4</td>
</tr>
<tr>
<td>incorrect verb</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>24</td>
<td>16</td>
</tr>
<tr>
<td>Opposite Action</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correct frame</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>correct verb</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>70</td>
<td>90</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>incorrect verb</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Incorrect frame</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>correct verb</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>10</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>incorrect verb</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Opposite Direction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correct frame</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>correct verb</td>
<td>100</td>
<td>100</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>incorrect verb</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>Incorrect frame</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>correct verb</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td>incorrect verb</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>0</td>
</tr>
</tbody>
</table>
### Opposite Abstract

#### Correct frame
- **Correct verb**: 60 70 50 50 20 10 20
- **Incorrect verb**: 40 20 20 20 70 0 30

#### Incorrect frame
- **Correct verb**: 0 0 10 10 10 10 0
- **Incorrect verb**: 0 0 0 0 0 30 10

### Reverse Role

#### Correct frame
- **Correct verb**: 63 92 54 67 79 0 25
- **Incorrect verb**: 25 0 42 25 13 0 17

#### Incorrect frame
- **Correct verb**: 8 8 4 8 8 46 8
- **Incorrect verb**: 0 0 0 0 0 38 12

### Related to

#### Reverse Role

#### Correct frame
- **Correct verb**: 75 68 81 71 56 0 17
- **Incorrect verb**: 15 13 13 13 13 0 35

#### Incorrect frame
- **Correct verb**: 6 13 4 4 21 50 8
- **Incorrect verb**: 2 6 0 4 2 19 17

---

1The percentages in this table do not always add up to 100% because "no response" errors were not included in this analysis.
For the abstract opposite verbs, the problem of the photographs not being explicit enough to elicit the target verb continued. Patients tended to produce related verbs or to randomly assign verbs from the list to the photographs. For the reverse-role verbs, when patients produced an incorrect verb it tended to be the verbs' thematically reversible pair (e.g., if the target was "borrow" they would say "lend") used in the correct syntactic frame. Table 19 presents the percentage of patients' incorrect verb errors on the reverse-role verbs categorized as either reverse-role errors (e.g., "send" for "receive") or semantically related errors (e.g., "get" for "receive"). Notice that the majority of patients' errors, with the exception of A.P., were reverse-role errors. Patients also made reverse-role and semantically related errors for the semantically related to reverse-role verbs.

Table 19
Percent Incorrect Verb Errors in Sentence Task for the Reverse-Role Verbs

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse-Role</td>
<td>71</td>
<td>--</td>
<td>67</td>
<td>71</td>
<td>0</td>
<td>78</td>
<td>67</td>
</tr>
<tr>
<td>Semantic</td>
<td>29</td>
<td>--</td>
<td>33</td>
<td>29</td>
<td>100</td>
<td>22</td>
<td>33</td>
</tr>
</tbody>
</table>

Because patients had difficulty producing the target verb in the sentence task, it is difficult to compare performance on reverse-role verbs with performance on semantically related to reverse-role verbs. Therefore, the percent of correctly produced subcategorization frames was calculated for only the sentences in which the correct target verb was produced (see Table 20). A chi-square analysis was done comparing performance on reverse-role verbs to performance on semantically related to reverse-role
verbs. Patients did not show any significant difference in subcategorization frame production for the reverse-role verbs and the semantically related to reverse-role verbs. In fact, the patients’ who show the largest difference in performance on the two verb groups, E.E., A.P., and R.W., are worse at producing sentences for the semantically related to reverse-role verbs than the reverse-role verbs.

Table 20

Percent Correct Verb Performance in Sentence Task for the Reverse-Role Verbs and Semantically Related to Reverse-Role Verbs

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse-Role</td>
<td>89</td>
<td>92</td>
<td>93</td>
<td>94</td>
<td>91</td>
<td>0</td>
<td>75</td>
</tr>
<tr>
<td>Related to</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse-Role</td>
<td>93</td>
<td>83</td>
<td>95</td>
<td>95</td>
<td>72</td>
<td>0</td>
<td>54</td>
</tr>
<tr>
<td>$X^2$</td>
<td>.23</td>
<td>.97</td>
<td>.01</td>
<td>.01</td>
<td>3.06</td>
<td>0.00</td>
<td>.94</td>
</tr>
</tbody>
</table>

Discussion of Sentence Production

In general, patients other than J.S. and R.W. were good at producing syntactically correct sentences. Unfortunately, it is difficult to make inferences about patients’ syntactic representation for the verbs that they did not produce. The next experiment will help to address this problem for the reverse-role verbs. Before presenting the next experiment, individual patients' performance on sentence production will be reviewed.

A.B.
A.B.'s sentence production was similar to his single verb production in terms of the verbs that he was able to produce. His sentence production scored in terms of syntactic acceptability was better than his production of single verbs. These results suggest that A.B. has an intact syntactic representation for verbs in spite of his deficit for production and comprehension of reverse-role verbs. Such results imply that syntactic and thematic role representations are separable.

E.E.

E.E.'s sentence production was a little bit worse than her single verb production. This may have been due to the fact that E.E. had some word finding difficulties. In other words, in the process of producing a sentence she would have trouble producing the desired word for an object in the photograph. These word finding difficulties may have resulted in an overall increase in cognitive load which resulted in slightly poorer performance on this task than the single verb task. E.E.'s sentence production scored in terms of subcategorization frame was generally good although she did have some trouble with the reverse-role verbs and semantically related to reverse-role verbs. However, it should be remembered that E.E. was unimpaired on both of these verb sets for single verb production and comprehension. Therefore, E.E.'s performance suggests a dissociation between subcategorization frame and thematic role representation.

W.H.

The previous experiments indicated that W.H. has an impairment for items which are semantically very similar. His sentence production suggests intact syntactic representations for verbs. But as in the case of A.B., he failed to produce some of the verbs, therefore, further testing of W.H.'s syntactic representation is required.

M.L.

M.L.'s performance was very similar to A.B.'s performance. The sentences he produced were syntactically well-formed, but there were some verbs that he did not
produce. But like A.B., M.L. was impaired in production and comprehension for reverse-role verbs.

A.P.

A.P.'s performance was mixed. He was impaired at subcategorization frame production for abstract opposites, reverse-role, and semantically related to reverse-role verbs. His sentence production was fairly good for the other verb sets. But as in the case of A.B. and M.L., A.P. failed to produce sentences for quite a few of the verbs. Therefore, his syntactic representation for verbs needs to be examined further.

J.S.

J.S. was the poorest of the patients on sentence production. He produced only one syntactically well-formed sentence. Unlike the other patients, who generally produced syntactically correct sentences if they produced the correct verb, J.S. often used the correct verb but was unable to embed it properly in a sentence. J.S. showed a central semantic deficit for verbs that were very similar in meaning but his comprehension was good for same semantic category verbs and opposite meaning verbs. Thus, J.S.'s poor sentence production on same semantic category and opposite meaning verbs indicates a dissociation between verb meaning and syntax.

R.W.

R.W.'s sentence production indicated slightly impaired syntactic representations for all the different verb sets. However, R.W. had slightly impaired semantic representations for all the different verb sets. Therefore, it is difficult to know whether R.W.'s semantic problem might be causing his sentence production problem.
Experiment 6 - Grammaticality Judgments

In the previous experiment, patients' ability to produce correct subcategorization frames was examined. However, a patient might have an intact representation of a verb's syntactic constraints but have some deficit between the syntactic representation and the mechanisms involved in assigning lexical items to the appropriate slots. Consequently, a patient could be unable to produce a grammatically correct sentence, but be able to distinguish between grammatically correct and incorrect sentences. Also, patients did not produce all of the verbs in the sentence production task, therefore, it is unclear whether the syntactic representations for the verbs which were not produced are intact. In the present experiment, all the verbs were tested. This experiment examined patients' comprehension of the verbs' subcategorization frames. For example, the verbs "buy" and "sell" both fit into sentence frames with 3NPs. However, the verbs differ in their prepositions. Thus, "sell" takes the preposition "to" in the sentence "Mary sold the book to John" while "buy" takes the preposition "from" in the sentence "John bought the book from Mary."

Subjects were tested on their comprehension of the subcategorization constraints of 78 of the verbs. Subjects heard sentences using verbs like "buy" and "sell" which were either in an acceptable sentence frame or an unacceptable sentence frame. For example, "Mary bought the book from John" is acceptable while "Mary bought the book to John" is not. The subjects' task was to indicate which sentences were grammatically correct and which were not.

Method

Materials

For each of the 78 verbs in the same semantic category set, the three opposite sets, and the reverse role set, four sentences were created. For each verb two of the sentences had acceptable subcategorization frames and two had unacceptable subcategorization frames. There were a total of 312 sentences. The sentences were divided into two sets such that
one correct sentence and one incorrect sentence for each verb appeared in each set. The two sets of sentences were presented during different test sessions with at least one week between sessions. The sentences were recorded by a female speech pathologist at a normal speaking rate on tape. The sentences were recorded in a random order.

There were several types of incorrect frames that were used. First, an intransitive verb could appear in a transitive frame (e.g., He sleeps the soft pillow). Similarly, a transitive verb could appear in an intransitive frame (e.g., They fed every morning). Secondly, verbs could appear in frames which were correct except for an incorrect preposition (e.g., Greg bought the card to the clerk). Another type of error involved whether or not the verb could take a sentence complement (e.g., The girl embroidered that the doll's dress was pretty).

Procedure

Subjects were seated in front of a tape recorder and told that they would hear sentences and that they should indicate whether the sentence was grammatically acceptable or not. The loudness was adjusted to a comfortable listening level for each subject. Subjects were told that they should not try and create a context for a sentence in order to make it acceptable and that a sentence should be able to stand by itself. Subjects who did not have difficulty articulating simply said "yes" if they thought the sentence was grammatically correct and "no" if they thought the sentence was grammatically incorrect. Subjects who had difficulty articulating pointed to cards with the words "yes" and "no" printed on them. Each sentence was played twice so that subjects could be sure about the sentence they heard. After the sentence had been presented twice, subjects were given as long as necessary to make a response.

Results

The percentage of correct grammaticality judgments was calculated for each subject (see Table 21). A.B., W.H., and M.L. were all within or very near the normal range for
grammaticality judgments. E.E., A.P., J.S., and R.W. were below the normal range for grammaticality judgments.

Table 21
Percent Correct for Grammaticality Judgments

<table>
<thead>
<tr>
<th>Subject</th>
<th>Grammaticality</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.B.</td>
<td>94</td>
</tr>
<tr>
<td>E.E.</td>
<td>85</td>
</tr>
<tr>
<td>W.H.</td>
<td>95</td>
</tr>
<tr>
<td>M.L.</td>
<td>96</td>
</tr>
<tr>
<td>A.P.</td>
<td>76</td>
</tr>
<tr>
<td>J.S.</td>
<td>70</td>
</tr>
<tr>
<td>R.W.</td>
<td>88</td>
</tr>
<tr>
<td>Controls</td>
<td>97.4 (95-100)</td>
</tr>
</tbody>
</table>

The percentage of correct responses was calculated for each subject for each set of verbs (see Table 22). In general, the patients who were impaired at grammaticality judgments do not show much variation in performance across the different verb types. E.E., A.P., and J.S. were best at the opposite action verbs. It may be that the syntactic frames that were selected for these verbs were easier than those used for other verb sets rather than the overall semantics or syntax of opposite action verbs. Also note that two of the patients who had difficulty with the reverse-role verbs in the production and comprehension tasks (A.B. and M.L.) were within the normal range of performance for
grammaticality judgments involving reverse-role verbs. In addition, two of the patients who did not have selective difficulty with reverse-role verbs in the comprehension task (E.E. and J.S.) were impaired on grammaticality judgments across the different verb sets.

Table 22

Percent Correct for Grammaticality Judgments by Verb Types

<table>
<thead>
<tr>
<th>Verb Type</th>
<th>A.B</th>
<th>E.E</th>
<th>W.H</th>
<th>M.L</th>
<th>A.P</th>
<th>J.S</th>
<th>R.W</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semantic</td>
<td>92</td>
<td>84</td>
<td>91</td>
<td>96</td>
<td>72</td>
<td>72</td>
<td>83</td>
<td>97 (95-98)</td>
</tr>
<tr>
<td>Opposite Action</td>
<td>95</td>
<td>93</td>
<td>93</td>
<td>95</td>
<td>95</td>
<td>80</td>
<td>95</td>
<td>99.5 (97.5-100)</td>
</tr>
<tr>
<td>Opposite Direction</td>
<td>98</td>
<td>90</td>
<td>100</td>
<td>98</td>
<td>73</td>
<td>70</td>
<td>95</td>
<td>99 (95-100)</td>
</tr>
<tr>
<td>Opposite Abstract</td>
<td>93</td>
<td>90</td>
<td>98</td>
<td>100</td>
<td>78</td>
<td>75</td>
<td>95</td>
<td>98.5 (95-100)</td>
</tr>
<tr>
<td>Reverse Role</td>
<td>95</td>
<td>81</td>
<td>97</td>
<td>96</td>
<td>73</td>
<td>65</td>
<td>86</td>
<td>96.4 (93-99)</td>
</tr>
</tbody>
</table>

Because there was no clear relationship between verb set and performance on grammaticality judgments, patients' performance was examined in terms of syntactic frame. It may be that patients who were impaired at the grammaticality task were impaired for specific subcategorization frames rather than for all subcategorization frames. Note that the sentences were designed to test several syntactic frames across the different verbs, but the verbs varied in the types of frames into which they could be placed, therefore, the number of exemplars for a particular syntactic frame varied. The sentences from the grammaticality judgment task were divided into five groups by syntactic frame: 1) intransitive (27 correct, 66 incorrect); 2) transitive (95 correct, 34 incorrect); 3) intransitive sentence complement (17 correct, 35 incorrect); 4) transitive sentence complement (10 correct, 0 incorrect); and
5) transfer (6 correct, 20 incorrect). Table 23 presents patients' percent correct performance on the grammaticality judgment task broken down by subcategorization frame and response type.

Table 23
Percent Correct for Grammaticality Judgments by Subcategorization Frame

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Intransitive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correct</td>
<td>93</td>
<td>100</td>
<td>96</td>
<td>96</td>
<td>93</td>
<td>96</td>
<td>93</td>
<td>100</td>
</tr>
<tr>
<td>Incorrect</td>
<td>86</td>
<td>67</td>
<td>89</td>
<td>91</td>
<td>59</td>
<td>52</td>
<td>79</td>
<td>94(86-98)</td>
</tr>
<tr>
<td>Transitive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correct</td>
<td>98</td>
<td>96</td>
<td>98</td>
<td>99</td>
<td>96</td>
<td>87</td>
<td>92</td>
<td>98(97-100)</td>
</tr>
<tr>
<td>Incorrect</td>
<td>88</td>
<td>85</td>
<td>94</td>
<td>94</td>
<td>62</td>
<td>41</td>
<td>88</td>
<td>94(88-100)</td>
</tr>
<tr>
<td>Intransitive Sentence Complement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correct</td>
<td>100</td>
<td>88</td>
<td>88</td>
<td>94</td>
<td>100</td>
<td>82</td>
<td>94</td>
<td>96(88-100)</td>
</tr>
<tr>
<td>Incorrect</td>
<td>94</td>
<td>77</td>
<td>97</td>
<td>100</td>
<td>34</td>
<td>54</td>
<td>88</td>
<td>99(97-100)</td>
</tr>
<tr>
<td>Transitive Sentence Complement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correct</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>80</td>
<td>90</td>
<td>90</td>
<td>100</td>
</tr>
<tr>
<td>Transfer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correct</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>83</td>
<td>iū̂̂</td>
<td>iū̂̂</td>
<td>100</td>
</tr>
<tr>
<td>Incorrect</td>
<td>100</td>
<td>90</td>
<td>95</td>
<td>100</td>
<td>80</td>
<td>95</td>
<td>95</td>
<td>100</td>
</tr>
</tbody>
</table>

5 There were four other sentences which did not fit into a clear category and therefore were omitted from the analysis.
A.B., W.H., and M.L. who performed within the normal range on the overall test were basically in the normal range for all the different subcategorization frames. E.E.'s performance appears fairly normal for transitive frames and transfer frames but she was impaired on intransitive and intransitive sentence complement frames. R.W. was only slightly impaired on all the different frames; there was no particular frame on which he was far below the range of the control subjects. A.P. and J.S. were very impaired on all the different subcategorization frames and both tended to make more errors on incorrect sentences; in other words, they tended to accept all of the sentences as grammatically correct.

Discussion of Grammaticality Judgments

This experiment addressed the question of whether patients could discriminate between grammatically correct and incorrect sentences. The results have implications for the relationship of a verb's semantic representation, thematic role representation, and syntactic representation. Two of the patients appear to show a dissociation between thematic role knowledge and syntactic knowledge. Because the patients are quite different each will be reviewed separately.

A.B.

A.B.'s performance on the grammaticality judgment task was close to the normal range (the minimum score for the control subjects was 95% and A.B. achieved a score of 94%). Given that A.B.'s sentence production was also quite good, it appears that A.B. does not have any deficits with respect to the syntactic representation of verbs. However, A.B. was impaired at production and comprehension of reverse-role verbs. These results suggest that syntactic processing and production can be intact despite an impairment to thematic role assignment mechanisms.

E.E.
E.E. was surprisingly poor at the grammaticality judgment task. Although, E.E. had some difficulty in the sentence production task for semantically related to reverse-role verbs she was below the range of the normal control subjects for all of the verb sets except the opposite direction verbs on the grammaticality judgment task. When the sentences were examined in terms of syntactic frame, she showed the greatest difficulty with the intransitive frames. One possibility for E.E.'s poor performance on grammaticality judgments may involve difficulty with processing rapidly presented auditory material. Most of the other comprehension experiments have involved single word processing and it may be that E.E. has difficulty when sentences are longer and more complex as in the case of sentences containing a sentence complement.

W.H.

W.H. was within the normal range of performance for the grammaticality judgment task. These results along with his good sentence production performance indicate an intact syntactic representation for verbs. The verb production and comprehension experiments suggested that W.H. has an impairment for items which are semantically very similar. Therefore, W.H.'s performance provides evidence of a dissociation between semantic similarity and syntax for verbs.

M.L.

M.L. performed within the normal range for grammaticality judgments. Like A.B., M.L. was impaired at production and comprehension for reverse-role verbs. M.L.'s performance provides additional support for the hypothesis of separate mechanisms being involved for thematic role assignment and syntax.

A.P.

A.P. did very poorly on the grammaticality judgment task. Given that he was also impaired at sentence production for several of the verb sets it seems plausible that A.P. has
an impairment for the syntactic representation of verbs. A.P. was also impaired on the reverse-role verbs for both production and comprehension.

**J.S.**

J.S. was impaired on both the grammaticality judgment test and the sentence production test. His performance on the grammaticality test was impaired for all the different verb sets and all the different subcategorization frames. J.S. showed a central semantic deficit for verbs that were very similar in meaning but his comprehension was good for same semantic category verbs and opposite meaning verbs. Thus, J.S.'s performance indicates a dissociation between verb meaning and syntax.

**R.W.**

R.W.'s was below the normal range of performance on the grammaticality judgment task. His sentence production was slightly impaired for all the different verb sets. R.W.'s performance on single verb production and comprehension indicated a central semantic deficit for some verbs. It is difficult to determine what the relationship between R.W.'s syntactic and semantic impairments might be.

**Review and Discussion of Patients' Performance**

Up to this point, patients' performance has been presented within the context of all the patients on each experiment. In this section, each patients' performance will be reviewed overall and individually for all the experiments. In addition, the implications of each subjects' performance for models of verb representation and processing will be discussed.

Patients' performance on the production tasks is summarized in Table 24. A.B. had difficulty producing all the different sets of verbs; however, he was able to place verbs into the correct subcategorization frames. These results indicate an impairment of the semantic aspects of verb representation, but intact syntactic representations for verbs. E.E. was normal at verb production for all the verb tasks indicating intact semantic and syntactic verb representation. W.H. and M.L. were impaired at production of verbs that were very
similar semantically. They were normal at production of same semantic category verbs. They were also able to insert verbs into appropriate subcategorization frames. A.P., J.S., and R.W. were impaired at production of all the different verb sets.

Table 24
Summary of patients' performance on verb production tasks

<table>
<thead>
<tr>
<th>Patient</th>
<th>Same Semantic Category</th>
<th>Related to Reverse-Role</th>
<th>Reverse-Role</th>
<th>Subcategorization</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.B.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>E.E.</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>W.H.</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>M.L.</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>A.P.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>J.S.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>R.W.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

1 A + indicates normal performance and a - indicates impaired performance

Patients' performance on the comprehension tasks is summarized in Table 25. A.B.'s comprehension was normal for all the verbs except the reverse-role verbs. E.E.'s performance was normal on all the verb sets, but she was impaired at making grammaticality judgments. W.H. and M.L. appear to be similar, in that, both of them were impaired at comprehension of reverse-role and semantically related to reverse-role verbs. Note, however, that M.L.'s performance was significantly worse on the reverse-role verbs compared to the semantically related to reverse-role verbs. A.P. was impaired at
comprehending reverse-role verbs and making grammaticality judgments. J.S. was normal at comprehending same semantic category verbs, but he was impaired on all the other comprehension tasks. Finally, R.W. was impaired on all the verb comprehension tasks.

Table 25

Summary of patients' performance on verb comprehension tasks

<table>
<thead>
<tr>
<th>Patient</th>
<th>Same Semantic Category</th>
<th>Related to Reverse-Role</th>
<th>Reverse-Role</th>
<th>Subcategorization</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.B.</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>E.E.</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>W.H.</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>M.L.</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>A.P.</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>J.S.</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>R.W.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

1 A + indicates normal performance and a - indicates impaired performance

Examining patients' overall performance, there are several interesting patterns of performance. A.B. and M.L. have a fairly specific deficit for thematic role representation with relatively preserved semantic and subcategorization frame representations. This provides support for the hypothesis that thematic role information is separable from more general semantic information and subcategorization frame information. W.H. appears to have difficulty producing and comprehending items that are very similar semantically, but
his knowledge of subcategorization frame restrictions is preserved. These results indicate a separation between semantic and syntactic information. One pattern that was not found was preserved thematic role information with impaired semantic and subcategorization frame representations. Perhaps other patients would demonstrate a dissociation in the other direction, that is preserved thematic role information but impaired general semantics. However, it is difficult to know how this might be tested because semantic information would be needed to make the thematic role judgments.

This overview of patients' performance may give the false impression that the patients' performance could be adequately described as either normal or impaired. Actually, the results for each patient were quite complex in terms of the patterns of errors and relations across tasks, consequently, each patients' performance will now be examined individually in greater detail.

A.B.

A.B.'s performance on all of the experiments for the reverse-role and semantically related to reverse-role verbs is summarized in Table 26. A.B. was able to repeat and read both sets of verbs perfectly, indicating intact articulation. Although A.B. was able to repeat and read the verbs, he was impaired at producing both sets of verbs to pictures. For single verb production, he did not show any difference between reverse-role and semantically related to reverse-role verbs; he correctly produced 79% of the verbs in each set. A.B.'s verb production in the sentence production task was similar to his performance on single verb production; he produced 71% of the reverse-role verbs correctly and 75% of the semantically related to reverse-role verbs correctly. Although A.B.'s verb production in the sentence task was slightly better for the semantically related to reverse-role verbs than the reverse-role verbs, the difference was not statistically significant. Notice that A.B.'s verb production in the sentence production task was not as good as in the single verb production task. A.B. exhibited some word finding difficulty in the sentence task which
probably accounts for the slight decrease in A.B.'s performance on the sentence task. On
the verb comprehension task collapsed across modalities, A.B. was significantly worse at
comprehending the reverse-role verbs (80%) than the semantically related to reverse-role
verbs (97%).

Given that A.B. was below the normal range of performance for both the production
and comprehension tasks for the reverse-role verbs, it seems likely that A.B. has some
central deficit that is causing his impaired performance on reverse-role verbs. Presumably
the deficit involves thematic role information within the central semantic system. It should
be remembered that A.B. was also impaired at production of semantically related verbs.
Because A.B.'s comprehension was intact for the semantically related verbs that he had
difficulty producing, it appears that A.B. has an additional deficit on the production side of
verb processing involving semantically related items. Previous research with aphasic
patients has suggested that the output lexicon is organized in terms of semantic and
syntactic dimensions. Semenza and Zettin (1988) reported a patient who had difficulty
producing proper names; however, the patient was able to comprehend proper names.
These results led Semenza and Zettin to hypothesize that the output lexicon is organized
according to categories. Yaffee (1990) reported a patient who had difficulty producing
function words that he did not have difficulty comprehending. These results led Yaffee
(1990) to hypothesize that the output lexicon may need to be organized along the lines of
word class. Thus, it may be that A.B. has a deficit in the output lexicon involving
semantically related verbs.

An alternative explanation for A.B.'s poor production of semantically related to
reverse-role verbs involves the thematic role complexity of the semantically related to
reverse-role verbs. It may be that A.B. has difficulty producing these verbs for the same
reason that he has difficulty producing the reverse-role verbs. Both sets of verbs require
more thematic role assignments than the other verb sets. If A.B. is having difficulty with
thematic role assignment, then it is not surprising that he has difficulty producing both sets of verbs that require the assignment of several thematic roles.

Finally, A.B. was able to produce well-formed sentences for both reverse-role verbs and semantically related to reverse-role verbs and he performed within the normal range of performance for grammaticality judgements. These results indicate intact syntactic representations for verbs. Therefore, it appears that knowledge of thematic roles is separate from knowledge of the subcategorization frames into which a verb can fit.
Table 26
A.B.'s Percent Correct Performance on Experiments 1-5 for Reverse-Role and Semantically Related to Reverse-Role Verbs

<table>
<thead>
<tr>
<th>Test</th>
<th>Verbs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reverse-Role</td>
</tr>
<tr>
<td>Articulation</td>
<td></td>
</tr>
<tr>
<td>Repetition</td>
<td>100 (+)</td>
</tr>
<tr>
<td>Reading</td>
<td>100 (+)</td>
</tr>
<tr>
<td>Production</td>
<td></td>
</tr>
<tr>
<td>Single Verb</td>
<td>79 (-)</td>
</tr>
<tr>
<td>Sentence</td>
<td>71 (-)</td>
</tr>
<tr>
<td>Comprehension</td>
<td></td>
</tr>
<tr>
<td>Auditory</td>
<td>88 (-)</td>
</tr>
<tr>
<td>Visual</td>
<td>71 (-)</td>
</tr>
<tr>
<td>Auditory + Visual</td>
<td>80 (-)</td>
</tr>
<tr>
<td>Subcategorization</td>
<td></td>
</tr>
<tr>
<td>Production</td>
<td>89</td>
</tr>
<tr>
<td>Grammaticality</td>
<td></td>
</tr>
<tr>
<td>Judgment</td>
<td>95 (+)</td>
</tr>
</tbody>
</table>

1 A + indicates that performance was within the normal range of control subjects and a - indicates that performance was below the range of normal performance.

* p<.005
E.E.

Table 27 summarizes E.E.'s performance on all of the experiments for reverse-role verbs and semantically related to reverse-role verbs. E.E. was able to repeat and read verbs indicating that she does not have an articulation deficit. E.E. was within the normal range of performance for single verb production for both reverse-role verbs (92%) and semantically related to reverse-role verbs (96%). On the sentence production task, her verb production was within the normal range for reverse-role verbs (100%) but impaired for the semantically related to reverse-role verbs (79%). E.E. exhibited word finding difficulties for nouns during the sentence production task. This may be partly responsible for her poor performance on the semantically related to reverse-role verbs. E.E. was within the normal range of performance for verb comprehension for all the verbs. Thus, it appears that E.E. has intact semantic and thematic role representations for verbs.

E.E.'s performance on the grammaticality judgment task was below the normal range of performance. She was particularly impaired at making judgments about intransitive and intransitive sentence complement frames. She was also impaired at sentence production when sentences were scored for the appropriateness of subcategorization frames. It seems likely that E.E. has some deficits related to the syntactic representation of verbs but further research is required to determine specific details about the nature of these deficits.
Table 27

E.E.'s Percent Correct Performance on Experiments 1-5 for Reverse-Role and Semantically Related to Reverse-Role Verbs

<table>
<thead>
<tr>
<th>Test</th>
<th>Verbs</th>
<th></th>
<th></th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reverse-Role</td>
<td>Semantically Related</td>
<td>(Semantic - Reverse-Role)</td>
<td>to Reverse-Role</td>
</tr>
<tr>
<td>Articulation</td>
<td>Repetition</td>
<td>96 (+)</td>
<td>100 (+)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Reading</td>
<td>100 (+)</td>
<td>100 (+)</td>
<td>0</td>
</tr>
<tr>
<td>Production</td>
<td>Single Verb</td>
<td>92 (+)</td>
<td>96 (+)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Sentence</td>
<td>100 (+)</td>
<td>79 (-)</td>
<td>-21*</td>
</tr>
<tr>
<td>Comprehension</td>
<td>Auditory</td>
<td>96 (+)</td>
<td>92 (-)</td>
<td>-4</td>
</tr>
<tr>
<td></td>
<td>Visual</td>
<td>100 (+)</td>
<td>100 (+)</td>
<td>0</td>
</tr>
<tr>
<td>Subcategorization</td>
<td>Production</td>
<td>92</td>
<td>83</td>
<td>-9</td>
</tr>
<tr>
<td>Grammaticality</td>
<td>Judgment</td>
<td>81 (-)</td>
<td>--</td>
<td></td>
</tr>
</tbody>
</table>

1 A + indicates that performance was within the normal range of control subjects and a - indicates that performance was below the range of normal performance.

* p<.025
W.H.

W.H.'s performance on all of the experiments for reverse-role verbs and semantically related to reverse-role verbs is summarized in Table 28. W.H. was able to repeat and read the verbs indicating intact articulation. W.H.'s single verb production was impaired for both reverse-role verbs (67%) and semantically related to reverse-role verbs (83%). His production was worse for reverse-role verbs than semantically related to reverse-role verbs but the difference was not statistically significant. His verb production in the sentence task was basically the same as his single verb production (reverse-role verbs, 63%; semantically related to reverse-role verbs, 83%). On auditory verb comprehension, W.H. was below the normal range of performance for both reverse-role verbs (83%) and semantically related to reverse-role verbs (92%) and the difference between the reverse-role verbs and semantically related to reverse-role verbs was not significant. On visual verb comprehension, W.H. was below the normal range of performance for reverse-role verbs (83%) but was within the normal range of performance for the semantically related to reverse-role verbs (98%) but again the difference in performance for the two sets of verbs was not statistically significant. W.H.'s performance on the two tests of syntactic representation (subcategorization production and grammaticality judgments) was normal.

The pattern of performance shown by W.H. is similar to A.B.'s except that there was never a significant difference between reverse-role verbs and semantically related to reverse-role verbs for W.H. However, W.H.'s level of performance was always worse on the reverse-role verbs. In addition, on visual comprehension he was within the normal range of performance for the semantically related to reverse-role verbs while below the normal range for reverse-role. These results suggest that W.H. has a mild deficit for reverse-role verbs and that perhaps there was not enough statistical power to show a significant effect for W.H.
An additional issue that arises from W.H.'s performance relates to models of reading. W.H. appears to be impaired at grapheme-to-phoneme conversion as evidenced by his poor nonword reading (35%). As was discussed previously, two-route models of reading claim that if grapheme-to-phoneme conversion mechanisms are impaired then the individual must rely on a semantic route for reading. The semantic route involves a visual word form of the word directly triggering the semantic representation of the word which can then be used to access a phonological representation on the output side of processing. Once an individual has access to the output phonology the word can be said aloud. According to the two-route model, however, if a patient has an impaired semantic representation for certain words then he or she should make semantic errors when reading those words. W.H. was able to read all of the verbs correctly, even the ones on which he was impaired in verb production and comprehension. These results argue for modifications to the two-route model by allowing for a third route which would travel directly from the visual representation of the word to output phonology without having to go through the semantic system (Schwartz, Saffran, and Marin, 1980). The existence of such a third route could account for W.H.'s good reading of verbs for which he has a impaired semantic representations.
Table 28

W.H.'s Percent Correct Performance on Experiments 1-5 for Reverse-Role and Semantically Related to Reverse-Role Verbs

<table>
<thead>
<tr>
<th>Test</th>
<th>Verbs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reverse-Role</td>
<td>Semantically Related</td>
</tr>
<tr>
<td>Articulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repetition</td>
<td>92 (+)</td>
<td>96 (+)</td>
</tr>
<tr>
<td>Reading</td>
<td>100 (+)</td>
<td>100 (+)</td>
</tr>
<tr>
<td>Production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Verb</td>
<td>67 (-)</td>
<td>83 (-)</td>
</tr>
<tr>
<td>Sentence</td>
<td>63 (-)</td>
<td>83 (-)</td>
</tr>
<tr>
<td>Comprehension</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auditory</td>
<td>83 (-)</td>
<td>92 (-)</td>
</tr>
<tr>
<td>Visual</td>
<td>83 (-)</td>
<td>98 (+)</td>
</tr>
<tr>
<td>Subcategorization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production</td>
<td>93</td>
<td>95</td>
</tr>
<tr>
<td>Grammaticality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Judgment</td>
<td>97 (+)</td>
<td>--</td>
</tr>
</tbody>
</table>

1 A + indicates that performance was within the normal range of control subjects and a - indicates that performance was below the range of normal performance.

* p<.025
M.L.

M.L.'s performance on all of the experiments for reverse-role and semantically related to reverse-role verbs is presented in Table 29. His normal performance on repetition and reading for reverse-role and semantically related to reverse-role verbs indicates that his articulation is intact. On the single verb production task, M.L. was below the normal range of performance for both reverse-role verbs (58%) and semantically related to reverse-role verbs (75%). Although M.L. was worse at producing the reverse-role verbs than the semantically related to reverse-role verbs, the difference was not statistically significant. M.L. was also impaired at verb production in the sentence task for both reverse-role verbs (71%) and semantically related to reverse-role verbs (79%). On both auditory and visual verb comprehension tests, M.L. was below the normal range of performance for both reverse-role verbs (auditory, 54%; visual, 50%) and semantically related to reverse-role verbs (auditory, 92%; and visual, 90%). M.L.'s comprehension was significantly worse for the reverse-role verbs than the semantically related to reverse-role verbs; in fact, M.L. was at chance with visual presentation and near chance with auditory presentation. In general, M.L.'s comprehension of the other verb sets was quite good. During testing M.L. seemed to take longer to respond to reverse-role pairs than other pairs and he often commented when a reverse-role pair was presented that these were trials for which he was unsure of his answer. On the sentence production task, M.L. produced syntactically acceptable sentences for both the reverse-role verbs (94%) and the semantically related to reverse-role verbs (96%). He was also within the normal range of performance on the grammaticality judgment task.

M.L.'s pattern of performance is similar to that of A.B. Like A.B., it appears that M.L. has a deficit within the output lexicon which results in semantic errors in verb production. Given that M.L.'s verb production correlated with abstractness ratings, it may be that M.L. has difficulty activating the phonological forms for abstract verbs. In
addition, M.L. seems to have a central semantic impairment for thematic role relationships as evidenced by his poor production and comprehension of reverse-role verbs. Like A.B., M.L.'s syntactic representation for the verbs seems to be unimpaired arguing in favor of a separation in the representation of syntactic and thematic role information.

There are two other issues that are noteworthy about M.L.'s performance. First, M.L.'s reading is very similar to W.H.'s reading. M.L.'s nonword reading was poor (13%) but he was able to read all of the verbs correctly, even the ones for which he has a poor semantic representation. Thus M.L.'s reading provides additional support for three-route models of reading (Schwartz, Saffran, and Marin, 1980). Second, M.L.'s sentence production was interesting. When M.L. had difficulty finding a word he would often produce lower frequency words or more specific words that were semantically related to the more common responses. Table 30 contains several examples of M.L.'s sentences along with more common responses. It is unclear why M.L. is producing these low frequency, specific words, but it points to the need for further research.
Table 29

M.L.'s Percent Correct Performance on Experiments 1-5 for Reverse-Role and Semantically Related to Reverse-Role Verbs

<table>
<thead>
<tr>
<th>Test</th>
<th>Reverse-Role</th>
<th>Semantically Related (Semantic - Reverse-Role) to Reverse-Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repetition</td>
<td>92 (+)</td>
<td>100 (+)</td>
</tr>
<tr>
<td>Reading</td>
<td>100 (+)</td>
<td>100 (+)</td>
</tr>
<tr>
<td>Production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Verb</td>
<td>58 (-)</td>
<td>75 (-)</td>
</tr>
<tr>
<td>Sentence</td>
<td>71 (-)</td>
<td>79 (-)</td>
</tr>
<tr>
<td>Comprehension</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auditory</td>
<td>54 (-)</td>
<td>92 (-)</td>
</tr>
<tr>
<td>Visual</td>
<td>50 (-)</td>
<td>90 (-)</td>
</tr>
<tr>
<td>Subcategorization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production</td>
<td>94</td>
<td>95</td>
</tr>
<tr>
<td>Grammaticality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Judgment</td>
<td>96 (+)</td>
<td>--</td>
</tr>
</tbody>
</table>

1 A + indicates that performance was within the normal range of control subjects and a - indicates that performance was below the range of normal performance.

* p<.005
Table 30

Examples of M.L.'s Sentence Production

Elizabeth is following her adversary. (woman or girl)
Elizabeth is catching the culprit. (woman or girl)
Elizabeth is drinking her soda pop. (water or something)
Elizabeth is examining the artifacts. (picture)
Elizabeth is watching with anticipation. (boy or girl)

1 The words in parentheses are what the control subjects and other patients tended to say.

A.P.

Table 31 summarizes A.P.'s performance on all of the experiments for the reverse-role verbs and semantically related to reverse-role verbs. A.P. was able to repeat and read the verbs, therefore, he does not have an articulation impairment. A.P. was well below the normal control subjects for single verb production of reverse-role verbs (50%) and semantically related to reverse-role verbs (54%). On the sentence production task, he produced 88% of the reverse-role verbs correctly and 67% of the semantically related to reverse-role verbs correctly. The difference between his performance on the reverse-role verbs and semantically related to reverse-role verbs was not statistically significant. On the verb comprehension tests collapsed across modality, A.P.'s performance was slightly below the range of the normal control subjects for the semantically related to reverse-role verbs (91%), whereas his comprehension of the reverse-role verbs was significantly worse (73%). On the tests of syntactic representation, A.P. was impaired at using the semantically related to reverse-role verbs in the correct subcategorization frame (71%) and he was below the normal range of performance for the grammaticality judgment task.
(73%). A.P.'s auditory processing of words and sentences has been tested extensively and A.P. is impaired at processing words in sentences (see Breedin and Martin, 1990). Because the grammaticality judgment task was presented auditorily, A.P. was also given the test visually a few weeks later to see if his poor performance could be attributed to his auditory processing deficit rather than to impaired syntactic representation. With visual presentation, A.P. was able to make 71% of the grammaticality judgments correctly for the reverse-role verbs. Therefore, his poor performance on the grammaticality judgment task does not seem to be the result of an auditory processing problem.

A.P.'s performance on the verb production and comprehension tests is similar to M.L.'s. He has difficulty producing abstract verbs. Presumably this impairment is localized within the output lexicon. A.P. was also impaired at comprehension of the reverse-role verbs indicating that he has a central semantic deficit for assigning thematic roles. Unlike M.L., however, A.P. is impaired for the syntactic representation of verbs as well as the thematic role representation.
### Table 31

A.P.'s Percent Correct Performance on Experiments 1-5 for Reverse-Role and Semantically Related to Reverse-Role Verbs

<table>
<thead>
<tr>
<th>Test</th>
<th>Verbs</th>
<th>Reverse-Role</th>
<th>Semantically Related (Semantic - Reverse-Role) to Reverse-Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Articulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repetition</td>
<td>92 (+)</td>
<td>100 (+)</td>
<td>8</td>
</tr>
<tr>
<td>Reading</td>
<td>100 (+)</td>
<td>100 (+)</td>
<td>0</td>
</tr>
<tr>
<td>Production</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Verb</td>
<td>50 (-)</td>
<td>54 (-)</td>
<td>4</td>
</tr>
<tr>
<td>Sentence</td>
<td>88 (-)</td>
<td>67 (-)</td>
<td>-21</td>
</tr>
<tr>
<td>Comprehension</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auditory</td>
<td>75 (-)</td>
<td>92 (-)</td>
<td>17</td>
</tr>
<tr>
<td>Visual</td>
<td>71 (-)</td>
<td>90 (-)</td>
<td>19</td>
</tr>
<tr>
<td>Auditory + Visual</td>
<td>73 (-)</td>
<td>91 (-)</td>
<td>18*</td>
</tr>
<tr>
<td>Subcategorization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production</td>
<td>91</td>
<td>72</td>
<td>-19</td>
</tr>
<tr>
<td>Grammaticality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Judgment</td>
<td>73 (-)</td>
<td>--</td>
<td></td>
</tr>
</tbody>
</table>

1 A + indicates that performance was within the normal range of control subjects and a - indicates that performance was below the range of normal performance.

* p<.05
J.S. 

J.S.'s performance on all of the experiments for the reverse-role verbs and the semantically related to reverse-role verbs is presented in Table 32. J.S., unlike any of the patients discussed thus far, was impaired at both verb repetition and reading. J.S.'s poor repetition indicates impaired articulation mechanisms. J.S.'s reading correlated significantly with verb frequency and familiarity ratings. Frequency effects in reading indicate that the patient has difficulty retrieving the phonological forms of words. J.S.'s single verb production was below the normal range for both reverse-role verbs (46%) and semantically related to reverse-role verbs (54%). His single verb production correlated significantly with verb frequency and familiarity ratings. J.S.'s verb production in the sentence production task was similar to his production in the single verb production task (reverse-role verbs, 42%; semantically related to reverse-role verbs, 42%). On the verb comprehension tasks, J.S. was impaired on reverse-role verbs (auditory, 75%; visual, 83%) and semantically related to reverse-role verbs (auditory, 88%; visual, 85%). His comprehension of most of the other verb sets was within the normal range. J.S. was not able to use the reverse-role verbs (0%) or the semantically related to reverse-role verbs (0%) in acceptable subcategorization frames and he was impaired at the grammaticality judgment task (65%).

J.S. seems to have several impairments affecting his performance on verb tests. First, his poor repetition, reading, and production indicate articulation impairments and difficulty retrieving the phonological form of the words he wishes to produce. His impaired comprehension and production of both reverse-role verbs and semantically related to reverse-role verbs suggests an impaired representation for items which are very similar semantically. His good comprehension of same semantic set verbs and opposite meaning verbs argues against an overall semantic representation deficit. His poor performance on
tests of syntactic representation indicate that his representation for the syntax of verbs is disrupted.
<table>
<thead>
<tr>
<th>Test</th>
<th>Verbs</th>
<th>(Semantic - Reverse-Role) to Reverse-Role</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reverse-Role</td>
<td>Semantically Related</td>
</tr>
<tr>
<td>Articulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repetition</td>
<td>71 (-)</td>
<td>17 (-)</td>
</tr>
<tr>
<td>Reading</td>
<td>33 (-)</td>
<td>8 (-)</td>
</tr>
<tr>
<td>Production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Verb</td>
<td>46 (-)</td>
<td>54 (-)</td>
</tr>
<tr>
<td>Sentence</td>
<td>42 (-)</td>
<td>42 (-)</td>
</tr>
<tr>
<td>Comprehension</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auditory</td>
<td>75 (-)</td>
<td>88 (-)</td>
</tr>
<tr>
<td>Visual</td>
<td>83 (-)</td>
<td>85 (-)</td>
</tr>
<tr>
<td>Subcategorization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Grammaticality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Judgment</td>
<td>65 (-)</td>
<td>--</td>
</tr>
</tbody>
</table>

1 A + indicates that performance was within the normal range of control subjects and a - indicates that performance was below the range of normal performance.
R.W.

Table 33 presents R.W.'s performance on reverse-role verbs and semantically related to reverse-role verbs for all of the different experiments. R.W. was normal at repeating the verbs indicating that he does not have articulation difficulties for the verbs. His verb reading was very impaired, he read 25% of the reverse-role verbs correctly and 8% of the semantically related to reverse-role verbs correctly. His reading correlated significantly with verb familiarity. R.W. was impaired at verb production for both the single verb production test and the sentence production test for both reverse-role verbs (single verb, 54%; sentence, 33%) and semantically related to reverse-role verbs (single verb, 38%; sentence, 25%). His verb production did not correlate significantly with verb frequency or familiarity ratings. On the auditory verb comprehension test, R.W. was slightly below the normal range of performance for all the verb sets. On the visual verb comprehension test, he was well below the normal range of performance for all of the verb sets. On tests of syntactic knowledge of verbs, R.W. was impaired for both subcategorization frame production and grammaticality judgments.
Table 33

R. W.'s Percent Correct Performance on Experiments 1-5 for Reverse-Role and Semantically Related to Reverse-Role Verbs¹

<table>
<thead>
<tr>
<th>Test</th>
<th>Reverse-Role</th>
<th>Semantically Related (Semantic - Reverse-Role) to Reverse-Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Articulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repetition</td>
<td>96 (+)</td>
<td>96+ (-)</td>
</tr>
<tr>
<td>Reading</td>
<td>25 (-)</td>
<td>8 (-)</td>
</tr>
<tr>
<td>Production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Verb</td>
<td>54 (-)</td>
<td>38 (-)</td>
</tr>
<tr>
<td>Sentence</td>
<td>33 (-)</td>
<td>25 (-)</td>
</tr>
<tr>
<td>Comprehension</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auditory</td>
<td>75 (-)</td>
<td>83 (-)</td>
</tr>
<tr>
<td>Visual</td>
<td>63 (-)</td>
<td>67 (-)</td>
</tr>
<tr>
<td>Subcategorization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production</td>
<td>75</td>
<td>54</td>
</tr>
<tr>
<td>Grammaticality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Judgment</td>
<td>86 (-)</td>
<td>--</td>
</tr>
</tbody>
</table>

¹ A + indicates that performance was within the normal range of control subjects and a - indicates that performance was below the range of normal performance.
R.W.'s poor performance on both production and comprehension tests is evidence for a central impairment of verb semantics. R.W. was the only patient who was impaired on all of the verb sets, not just the sets which were rated as most similar in meaning. Given R.W.'s poor semantic representation for verbs it is difficult to know how to interpret his performance on tests of verb syntax. He was able to judge the syntactic acceptability of 86% of the reverse-role verb sentences correctly. This is somewhat surprising if one compares R.W.'s performance with J.S. who scored 65% and showed better comprehension of the reverse-role verbs than R.W. It may be that R.W.'s errors on the grammaticality judgment task are due to assigning the wrong meaning to the sentence and consequently making an error about the grammaticality of the sentence. Similarly, on the sentence production task, R.W. would produce sentences that were syntactically well-formed but were incorrect or empty semantically (see Table 34). Therefore, it seems plausible that R.W.'s syntactic representation for verbs is intact but appears impaired during testing due to his semantic representation impairment. It may be that when trying to produce a sentence, R.W. accesses the wrong word due to his impaired semantic system but activates the correct syntax for that word, however, the syntax may be incorrect for the target sentence context.
Table 34

Examples of R. W.'s Sentence Production

The girl is penciler. (breaking the pencil)
The girl is buying the boy. (buying the crayons)
The girl is stealing the friend. (grabbing the book from her friend)
The girl is dusting the broom. (sweeping the floor)
The girl is chocolate. (tasting the chocolate bar)

---

1 The words in parentheses are what the control subjects and other patients tended to say.

General Discussion of Experiments 1-6

Six experiments were carried out which investigated the nature of verb representation by examining patterns of verb representation impairment in seven aphasic patients. The implications of the results for the two models of verb semantics reviewed earlier will now be discussed.

The first model presented was Johnson-Laird's semantic complexity model. According to this model, verbs differ in semantic complexity as a function of the number of definitional components needed to establish the verb's meaning. He suggests that verbs within the lexicon are organized along the lines of semantic complexity. Thus, semantically primitive verbs should be at the center with semantically complex verbs radiating outward. If this theory is correct, then one would expect to find patients demonstrating damage to the lexicon by losing the representations of verbs further away from the center. Kohn et al. (1989) found that patients tended to use semantically empty verbs in sentence generation tasks. However, Kohn et al. only tested patients on verb production. In the present research, patients were tested on both comprehension and production of verbs. It was hypothesized that if patients had a central semantic deficit for the meaning of verbs, then...
they should show a better level of performance on the semantically primitive verbs (e.g., sensation and movement) than the semantically complex verbs (e.g., handicraft, cleaning, and organization). Most of the patients did not have difficulty producing and comprehending any of the same semantic category verbs. J.S. was very impaired at production of same semantic category verbs; however, his comprehension was normal for the same semantic category verbs. Also, J.S.'s production correlated with both verb frequency and familiarity suggesting that J.S. has damage involving activation of the phonological form of words. R.W. was the only patient whose verb production and comprehension were impaired for the same semantic category verbs. However, his performance was at the same level for all five of the semantic categories tested. Although the patients in the present study failed to provide evidence of a hierarchical organization of verbs in the lexicon based upon semantic complexity, there may be patients who would provide such evidence. The present study, however, does point to the importance of testing both verb production and comprehension before making inferences about the central semantic system.

The second model to be discussed is Pinker's conceptual constituent model of verb representation (Pinker, 1989). Pinker claims that thematic role information is part of a verb's semantic representation, while lexical and linking rules determine how those thematic roles get mapped onto the appropriate syntax. The results obtained from patients A.B. and M.L. support the idea of thematic roles being represented within the verbs' semantic structure. When shown a picture of Elizabeth selling a book to a boy, A.B. and M.L. were unable to decide whether Elizabeth was selling the book or buying the book. If the representation of thematic roles within the semantic system is impaired then one cannot distinguish between the verbs "sell" and "buy." Thus, A.B. and M.L. often select the reverse-role verb in production and comprehension tasks. However, A.B.'s and M.L.'s good performance on the sentence production and grammaticality judgment tasks suggests
that they are not impaired at mapping semantic information onto syntax. Once they have selected a verb whether it be "sell" or "buy" they are able to produce a correct sentence using that verb. Thus, it does not appear that these patients difficulty linking semantic information with the appropriate syntactic structures. It should also be noted that the pattern of performance exhibited by A.B. and M.L. is different from that of patients reported by Saffran et al. (1985) and Byng (1988). These patients produced sentences that were syntactically ill-formed and showed confusion about the thematic roles played by a verb's objects. It may be that other patients have impairments related to linking rules or lexical rules as well as impairments connected to the representation of thematic roles within the semantic system.

It is also noteworthy that J.S. and R.W. provide a double dissociation for semantic and syntactic aspects of verb representation. J.S. showed intact comprehension of semantically related items, while R.W. was impaired. At the same time, J.S.'s performance on tasks requiring subcategorization frame knowledge was very poor, while R.W.'s was relatively intact.

A second methodological issue which was raised by the present set of experiments involved the importance of collecting measures of semantic similarity. As was discussed previously, Byng (1986) compared patients' performance on reverse-direction and reverse-action to their performance on reverse-role verbs to control for possible similarity of meaning effects. Similarity of meaning ratings collected in the present study, however, did not indicate that reverse-direction and reverse-action verbs were as similar in meaning as reverse-role verbs. If reverse-direction and reverse-action verbs had been the only similarity control in the present study, then almost all of the patients would have been seen as impaired at comprehension of reverse-role verbs as a result of thematic rather than semantic similarity.
The results from the present study also point to the need for a better specified model of the speech output lexicon. Previous research has suggested that the output lexicon might be organized according to grammatical classes (Yaffee, 1990; Zingesser & Berndt, 1988; Caramazza & Hillis, 1991). The present findings suggest that the output lexicon might also be organized according to word abstractness (M.L. and A.P. were worse at producing abstract words than concrete words but did not show the same effect in comprehension) or semantic similarity (A.B. made semantic errors in verb production that he did not make in verb comprehension). Alternatively, A.B.'s errors in production for semantically related to reverse-role verbs may be the result of increased thematic role complexity rather than semantic similarity to the reverse-role verbs. Both sets of verbs require complex thematic role assignments.

Finally, the results from these six experiments suggest some interesting directions for future research. First, further study of M.L.'s and W.H.'s reading seems worthwhile. Both patients were unable to read nonwords but could read words perfectly, even the words for which they had impaired semantic representations. More extensive testing of these two patients' reading might provide additional support for the three-route model of reading. Second, M.L.'s sentence production was interesting because he tended to substitute low frequency, abstract words for high frequency, concrete words. Therefore, M.L.'s noun production warrants further investigation. Third, R.W. was the only patient who showed semantic impairments for verbs. He also has difficulty with the semantic representation of nouns (Jonsdottir, 1990), although he seems worse on verbs. It would be interesting to investigate possible relationships between R.W.'s noun and verb impairments. Finally, recent research in aphasia has tried to develop therapy programs using cognitive models developed from neuropsychological testing. Recent studies have focused on trying to rehabilitate the sentence production of patients using cognitive neuropsychological models (Byng, 1988; Mitchum & Berndt, 1988; in press; Fink, Martin,

The Effects of Verb Representation on Sentence Processing

In the first part of this paper, models of verb representation were reviewed and several experiments were presented which examined the claims made by these models. Thus far, the question of interest has involved how verbs are represented in the central semantic and syntactic system. Continuing from this point, the last experiment deals with the relationship between verb representation and sentence processing. More specifically, the final experiment investigates the effect of thematic roles on sentence processing. Before presenting Experiment 7, previous research on the effect of verb representation on sentence processing will be reviewed.
The Effects of Verb Semantics on Sentence Processing

Most of the research on how semantic aspects of verb representation affect sentence processing have focused on the Semantic Complexity Model with the assumption that the greater the number of components in a verb's definition the more difficult it will be to comprehend.

Kintsch (1974) tested whether or not semantic complexity plays a role in language processing. He found that semantically complex words did not: 1) take any longer to process than semantically simple words; 2) have a detrimental effect on distracting tests; 3) or result in poorer memory for sentences in which they appeared.

More recently, Rayner and Duffy (1986) looked at the effect of meaning complexity on lexical access of verbs. Subjects read sentences and their eye movements were recorded by an eye-tracking machine. The hypothesis was that subjects would spend more time looking at words that are more difficult to access from the lexicon. They hypothesized that verbs with more complex meaning representations would take longer to access. They selected verbs which varied in complexity in three ways: 1) whether or not the verb was causative (e.g., the verb "kill" can be defined as "cause to die" while the verb "die" does not contain a causal element; 2) whether or not the verb was factive (e.g., factive verbs contain an assumption that what follows in the sentences is true as in "The girl noticed that the dog was hurt" versus "The girl insisted that the dog was hurt"); and 3) whether or not the verb was negative (e.g. the verb "dislike" might be defined as "not to like" whereas the verb "help" does not contain a negative component in its definition). The verbs were matched for length, syllables, and frequency. They found no effect for verb complexity on length of eye gaze. Not surprisingly, they did find an effect for word frequency. Low frequency verbs took longer to access than high frequency verbs. These findings (Kintsch, 1974; Rayner & Duffy, 1986) would seem to put an end to the traditional view of how semantic complexity affects language processing.
The Effects of Verb Syntax on Sentence Processing

Earlier, it was noted that verbs can differ from one another syntactically as well as semantically. Two syntactic distinctions for verbs were made: 1) subcategorization; and 2) argument structure. Both of these distinctions have been used to make predictions about sentence processing. The Verb Complexity Hypothesis (Fodor, Garrett, & Bever, 1968) predicts that the number of subcategorization frames into which a verb can be placed determines the amount of time needed to process the verb. Other researchers (Shapiro, Zurif, & Grimshaw, 1987; Tanenhaus, Carlson, & Trueswell, 1989) hypothesize that the number of different argument structures into which a verb can be placed will determine processing time. Verbs which allow many different arguments structures should require more processing time. Do these syntactic distinctions actually affect sentence processing?

The Effect of Subcategorization Complexity on Sentence Processing

Fodor et al. (1968) developed a theory of sentence comprehension, the Verb Complexity Hypothesis, in which verb subcategorization properties were of central importance. They claimed that each word in a sentence is associated with information in the lexicon that can be used to construct the meaning of the sentence. They claimed that verbs were of particular importance. Verbs that can appear in more than one type of sentence, (e.g., the verb "knew" can take a sentential complement or not) are considered to be more complex than verbs that can appear in only one kind of sentence structure (e.g., the verb "met" does not take a sentence complement).

The Verb Complexity Hypothesis proposed that when the listener reaches the verb in a sentence, all possible sentence frames are generated at that moment. To return to an earlier example, when the listener hears "Valerie bought" the sentence processing mechanism recognizes "bought" as an alternating dative which has three possible sentence frames (V_NP; V_NP PP; V_NP NP). When the verb was reached, Fodor et al. (1968) argued that the central syntactic system generates all three possible sentence frames. Therefore, a
verb which has three possible syntactic structures (alternating datives) should take longer to process than a verb that has only one possible syntactic structure (simple transitives, V_NP) because it will take longer to generate three syntactic structures than one.

Support for this theory was found by having subjects paraphrase center-embedded sentences. The researchers timed how long it took subjects to paraphrase the sentences. They found that subjects took longer when the sentence's verb could fit into more than one subcategorization frame. However, later research (Hakes, 1971) failed to replicate Fodor et al. (1968). Hakes (1971) pointed out that the paraphrase task is not a good measure of what the subject is doing while actually processing the sentence. He also noted that center-embedded sentences are very difficult for subjects to comprehend. He tested the Verb Complexity Hypothesis using a phoneme monitoring task. Subjects listened to sentences and at the same time, listened for a word in the sentence that began with a specific phoneme. When the subject heard the target phoneme they were to hit a response key as quickly as possible. Presumably, subjects are slower to respond to the target phoneme if the comprehension task requires more effort. Hakes (1971) looked at how long it took subjects to respond to the target phoneme when it followed the verb. He found no difference for verbs that fit into one subcategorization frame and verbs that fit into more than one subcategorization frame. Consequently, there seems to be little support for the claim that subcategorization properties determine processing complexity.

The Effect of Argument Structure Complexity on Sentence Processing

Tanenhaus et al. (1989) have argued that verb-based thematic roles help to guide parsing decisions and incorporate discourse information, general knowledge, and actual parsing information. They also believe that thematic structures allow people to make an early commitment to a given interpretation of a sentence and to recover quickly when that commitment was incorrect.
Tanenhaus et al. (1989) propose that when the verb of a sentence is recognized four types of information becomes available: 1) the semantic representation of the verb; 2) the thematic roles connected to the verb; 3) the types of complements the verb can take; and 4) how the thematic roles and syntactic constituents of the complements are connected. These hypotheses about verb recognition fit into a more general language processing model proposed by Tanenhaus, Carlson, and Seidenberg (1985):

a model of language processing in which there are at least two distinct systems: a general cognitive system, which contains a general problem solver, and a linguistic system consisting of one or more linguistic modules. The general problem solver has access either to the output of the linguistic system or, quite plausibly, to the output of each of the modules. It also has access to the knowledge base stored in the cognitive system in what psychologists commonly refer to as the episodic and semantic memory systems. The general problem solver operates on the output of the linguistic modules to develop a constructed representation. (p. 365)

Shapiro, Zurif, & Grimshaw (1987) hypothesized that sentence processing is affected by the number of different argument structures (or thematic roles) that a verb can take in a sentence. To return to our earlier discussion of argument structure, a simple transitive verb has one argument structure (agent, theme) whereas nonalternating datives have two argument structures (agent, theme; agent, theme, and goal). According to Shapiro et al. (1987) it should take longer to process sentences with alternating datives than simple transitives because the central syntactic system initiates all possible argument structures for a given verb. To test this hypothesis, they used a cross-modal lexical decision task. Subjects listened to sentences for comprehension and at the same time made lexical decisions to visually presented items. Shapiro et al. used verbs that were matched in subcategorization frame complexity but differed in argument structure complexity. They also examined verbs which were matched in argument structure complexity but differed in subcategorization complexity in order to test the Verb Complexity Hypothesis. Shapiro et al. (1987) found that it took subjects longer to make a lexical decision when the sentence's verb had more possible argument structures. Subcategorization complexity had no effect
on lexical decision time. They concluded that all possible argument structures for the verb are activated when the verb is reached in the sentence. Therefore, verbs with a greater number of possible argument structures will take longer to process than verbs with fewer argument structures.

Recently, Schmauder (1991) attempted to replicate Shapiro et al.'s (1987) findings. She used the same verbs as Shapiro et al. and presented subjects with sentences varying in argument structure complexity. She recorded subjects' eye movements while they read the sentences. She found no effect for argument structure complexity although she did find effects of verb length and frequency. Longer and lower frequency verbs took longer to process. Schmauder also tried to replicate Shapiro et al.'s results using the cross-modal lexical decision task. She again failed to replicate Shapiro et al.'s results.

Schmauder (1991) suggests that her failure to replicate Shapiro et al. (1987) is due to a difference in experimental design. Shapiro et al. presented subjects with each of the verbs five times over the course of the experiment while Schmauder presented each verb only once. Perhaps subjects adopted a special processing strategy in Shapiro et al.'s experiment as a result of seeing the same verbs repeatedly.

An Alternative to the Verb Complexity Hypothesis

Neither subcategorization complexity nor argument structure complexity appear to have much of an effect during sentence processing. Frazier and others (Frazier, 1978, 1987; Frazier & Fodor, 1978; Frazier & Rayner, 1982) have developed a different conceptualization of the sentence processing mechanism. They agree that listeners structure utterances syntactically during comprehension. However, Frazier (1987) does not view the central syntactic system as generating all possible subcategorization frames or all possible argument structures upon reaching the verb of the sentence. Rather, she views the central syntactic system as generating the most simplistic possible syntactic structure for the sentence as each additional word is perceived based solely on word class. When the most
simplistic structure does not fit the rest of the sentence, the subject is seen as being led
down a "garden-path." In other words, the subject has constructed an incorrect analysis
and at some point realizes that the chosen analysis is not sensible and therefore must go
back and reanalyze the sentence.

Frazier (1987) has proposed a set of rules that the central syntactic system uses to
generate the most simplistic syntactic structure. Some of these rules are: 1) minimal
attachment - which states that the central syntactic system should postulate the most
simplistic syntactic structure (e.g., when presented with "She knew the man" the central
syntactic system initially assigns "the man" to the direct object position and does not
generate the possibility that "the man" is the subject of an embedded clause, such as, "She
knew the man was her father" until "was" is presented); 2) late closure - which states that,
if possible, assign each new item of the sentence to the clause presently being processed; 3)
most recent filler - when there is a gap in a sentence assign the most recent possible filler to
the gap (e.g., in the sentence "The girl begged ___ to sing for the woman" there is a gap
before the infinitive "to sing" according to Frazier, the gap should be filled by the most
recent object "the girl").

Frazier and Rayner (1982) had subjects read sentences which contained verbs which
could accept sentence complements (e.g., "knew"). Subjects' eye movements were
recorded. They found that subjects' reading times increased when they reached the verb of
the embedded clause (e.g., "She knew the man was"). They interpreted these findings as
evidence for the minimal attachment hypothesis. Subjects took longer to process embedded
clauses because the noun phrase following the verb was initially parsed as a direct object
rather than as the subject of an embedded clause.

Frazier (1987) postulates that the central syntactic system uses these parsing strategies
without taking advantage of potential lexical information from the verb which at times
indicates that these strategies will not work. A recent study by Ferreira and Henderson
(1990) provides support for Frazier's view. It has been noted that some verbs can take either a direct object or a sentential complement (e.g. "know"), however, there are verbs which take a sentence complement but rarely take a direct object (e.g. "realize" is acceptable in the sentence "Mary realized that the child was hurt" while it is not acceptable in the sentence "Mary realized the child"). If the central syntactic system is able to use lexical information, such as, appropriate subcategorization frames then subjects should be faster when reading sentences containing sentence complements for verbs like "realize" than for verbs like "know." Ferreira and Henderson (1990) recorded subjects eye movements. They found no difference in reading times for verbs which do not take direct objects and verbs which do take direct objects. They concluded that if subcategorization information is made available to the lexicon, the central syntactic system does not use this information. A potential problem with this study is that they used a relatively low proportion of filler sentences. Therefore, on more than half of the trials, subjects were presented with sentences containing sentence complements. It may be that subjects began to expect all sentences to contain sentence complements and therefore no difference was seen between the verbs which only fit into sentences with sentence complements and verbs which can take sentence complements or direct objects.

Frazier's (1987) views have been opposed by Tanenhaus et al. (1989). As was noted earlier, Tanenhaus et al. (1989) believe that a substantial amount of information is made available when the reader reaches the verb in a sentence. Recently, Boland, Tanenhaus, and Garnsey (1990) presented evidence that verb information is used during sentence processing. They looked at verbs which can be followed by an infinitival complement (e.g., "John promised Mary to wash"). In some cases the subject of the sentence is also the subject of the infinitive verb, whereas, in other cases, the object of the sentence is the subject of the infinitive verb (e.g., "John persuaded Mary to wash"). Boland et al. (1990) argue that readers are aware of the lexical representations of these verbs and use this
information during parsing. Therefore, subjects should not use strategies like Frazier’s "most recent filler" when parsing these sentences if lexical information about the verb indicates that the most recent filler is inappropriate. To test their hypothesis, Boland et al. had subjects read sentences one word at a time. Subjects controlled the rate at which words were presented by pressing a key to get the next word. Subjects were instructed to press a second key if the sentence became semantically implausible. If subjects have verb information, subjects should be fast at making implausibility judgments regardless of whether or not the verb is controlled by the most recent filler. They found that subjects were aware of lexical information about the verb and used it to make fast and accurate implausibility judgements. However, one problem with this study was that subjects controlled the word presentation rate. Reading times were slow for this task compared to other studies. It may be that subjects were reading too slowly for effects of the "most recent filler" strategy to be detected.

It should be apparent from the review of recent research on sentence processing that the role verb information (subcategorization and argument structure) plays in sentence processing remains under dispute. Researchers like Tanenhaus et al. (1989) argue that subcategorization and thematic role information is activated simultaneously at the point of verb recognition. Frazier (1987) argues that the central syntactic system uses a set of strategies to insure the simplest and quickest analysis of the sentence. Lexical information about the verb is activated only if the simplest and quickest parse of the sentence is semantically unacceptable.

What is apparent from the present review of how syntactic information is used during sentence processing is that the research is riddled with methodological problems. Researchers need to be very careful in their selection of stimuli, because the stimulus set can induce strategic or semantic bias in the subject separate from the issue being tested.
Similarly, testing procedures need to be carefully inspected to insure that they are accessing on-line processing.

Experiment 7 - Thematic Roles and On-line Processing

Experiments 1-6 involved an investigation into the nature of verb representation within the semantic and syntactic systems. The results indicated that thematic roles play an important part in verb representation and are separate from syntactic representations. Given that thematic roles are an important component of verb representation, a final experiment examined whether or not thematic roles affect on-line processing. Fillmore (1968b) noted that the lexicon for a verb entry should specify which positions in a sentence can be filled by which thematic roles. For example, the verb "to open" allows three thematic roles to appear in the subject position of the sentence (see Sentences 9-11).

(9) The door opened.
   (theme)

(10) John opened the door.
    (agent)

(11) The key opened the door.
    (instrument)

In contrast, the verb "to kill" allows only two thematic roles to appear in the subject position of the sentence (see Sentences 12 and 13).

(12) The man killed the girl.
    (agent)

(13) The bullet killed the girl.
    (instrument)

Although it is apparent that one needs thematic information to properly use verbs, it is unclear how differences in the thematic role that appears in a particular syntactic position affect sentence processing.
Early theories of syntactic parsing (Bever, 1970) proposed parsing strategies which incorporated thematic role information. Bever hypothesized a strategy which initially assigned any N-V-N sequence to the roles Agent-Action-Theme. If this strategy is correct then one would expect processing time to be longer for sentences like (9) and (11) than for sentences like (12). This type of strategy is similar to the linking rules that Pinker (1989) proposed for mapping thematic roles onto appropriate argument structures. For example, Pinker hypothesized that one rule was to assign the agent to the subject position and if there is no agent then assign the theme to the subject position.

Frazier (1978) noted that a strategy such as the one proposed by Bever (1970) would result in the misanalysis of many sentences. She points out that many sentences do not have an agent. Frazier has argued in favor of syntactic parsing strategies which do not use semantic and thematic role information during initial processing except in the case of misanalysis (garden-path sentences). Frazier would therefore predict no difference in the processing time of sentences which differ in the thematic role of the subject noun. Unfortunately, Frazier's theory of sentence processing does not specify at what point thematic role assignment occurs.

Although Bever (1970) argues in favor of agent as the preferred thematic role for the subject position, some linguists might argue otherwise. Talmy (1976) looked at thematic roles with respect to their semantic causal complexity. In other words, how much information do specific thematic roles imply? For example, in the case of Sentence (9) no causal inference needs to be made. In contrast, in the case of Sentence (10) one infers that John used some instrument or body part to open the door and that he did it volitionally. Thus, when the agent appears in the subject position the sentence is semantically more complex. If one believes that semantic complexity has an effect on overall sentence processing time, then one would expect sentences like (9) to be processed more quickly than sentences like (10).
In this last experiment, the issue of whether or not the thematic role of the subject noun affects sentence processing time in a self-paced word by word reading task was explored. In this experiment, there were two dependent measures: 1) the time to process each part of the sentence, especially the verb; and 2) the time to process the entire sentence. The thematic role of the subject noun was chosen for manipulation because in the English language it cannot be assigned a definite thematic role until after the verb has been processed.

A word by word reading task was used to measure on-line sentence processing. Ferreira and Henderson (1990) demonstrated that reliable on-line sentence processing effects can be found with a word by word reading task. Typically in self-paced word by word reading tasks, subjects read sentences presented one word at a time. After reading a word, subjects press a key to indicate that they are ready to read the next word in the sentence. When a new word is presented, the previous word is no longer visible. It is assumed that the time between key presses is a measure of the time spent reading the displayed word. Mitchell (1984) noted that subjects can develop a key pressing rhythm which masks timing effects during a word by word reading task. Mitchell recommended randomly varying the number of words that appear after each key press to prevent subjects from automatically pressing a key before they have read the words on the screen. Thus, in the present experiment, sentences were presented in segments that varied from one to five words.

Two types of verbs were used in the sentences: 1) change-of-state verbs; and 2) theme-experiencer verbs. Change-of-state verbs act to change the state of the theme of the sentence. For example in the sentence "The log split in half," the verb "split" changes the theme (the log) from a log to two halves of a log. Theme-experiencer verbs indicate something about the state of mind of the theme in the sentence, consequently, they require an animate theme. For example in the sentence "The general embarrassed the soldier," the
theme, the soldier, is experiencing a state of embarrassment. Previous research has demonstrated that different types of verbs are processed differently. MacDonald (1989) found that subjects took longer to answer questions about sentences which contained theme-experiencer verbs than sentences which contained change-of-state verbs. Both types of verbs were tested in the present experiment to explore whether thematic role effects would generalize to different verb types.

It should also be noted that in most cases, agents are animate entities and themes and instruments are inanimate entities. Stowe (1989) reported that animacy can effect the speed with which subjects make ambiguity judgments about sentences. Subjects took longer to make grammaticality judgements about ambiguous sentences when the disambiguating information was animate. Thus, differences in sentence processing time as a function of the thematic role of the subject of the sentence could actually be due to animacy rather than thematic role. To address a possible confound between animacy and thematic role, sentences were constructed with verbs which could contain either an animate or inanimate theme in the subject position. Thus, the thematic role of the item in the subject position is the same for both sets of sentences (theme), but the animacy of the item varies. If animacy is a factor in sentence processing, there should be a difference in processing time for sentences containing animate themes and sentences containing inanimate themes. If subjects expect the subject of a sentence to be the agent and then read a sentence which contains an animate theme in the subject position, they should initially assign the animate object to the role of agent rather than theme. Consequently, subjects' overall reading times for sentences with animate themes in the subject position should be longer than for inanimate themes because subjects would have to recover from making incorrect role assignments when the theme is animate.

Finally, people rarely read simple sentences like "The log split in half" in isolation. In order to create a more natural reading environment each sentence was preceded by a context
sentence. When more than one sentence is involved, discourse relationships become a factor. Malt (1985) found that different types of discourse structures effect how quickly subjects are able to answer questions about a discourse. Discourse structures vary the strength of the connections between sentences. For example, question-answer pairs are very closely connected, while interruptions or digressions are practically independent. The strength of connections between sentences can affect sentence processing times. If the reader has to expend more processing time integrating one pair of sentences than another, the effect of thematic role may be masked. Consequently, it is important to keep the discourse relationships between sentences constant. In the present experiment, the discourse structure was the same for all the test items. Each context sentence served as a background for the two or three test sentences developed for a given verb. Thus in Example 14, the context sentence provides a background in which one could find pilots (agent), aircraft (instrument), or bombs (theme).

(14) The sound of air raid sirens pierced the silence. (context sentence)

The pilot dropped the bomb swiftly. (test sentence A)

The aircraft dropped the bomb swiftly. (test sentence B)

The bomb dropped swiftly. (test sentence C)

To review, Experiment 7 examined whether the thematic role of the subject noun affects sentence processing time in a self-paced word by word reading task. If Bever (1970) is correct, then subjects should be quicker to assign the thematic role of agent to the subject noun than the thematic roles of instrument or theme. Thus, one would expect subjects to be faster at reading the verb and phrase following the verb when the subject noun plays the preferred role of agent. In contrast, Frazier (1978) does not predict any difference in processing time as a function of the thematic role of the subject noun. Therefore, subjects should spend the same amount of time reading the verb and phrase following the verb when the thematic role of the subject noun is agent, instrument, or theme.
Frazier and Bever, however, do not make predictions about overall sentence reading time. Talmy (1976) addresses the issue of overall sentence processing. Talmy argues that thematic roles differ in the number of inferences needed to integrated them into a sentence. He claims that when the agent appears in the subject position more causal inferences need to be made than when the theme or instrument appear in the subject position. If Talmy is correct, then one might expect subjects' overall sentence processing times to be slower when the agent appears in the subject position than when the instrument or theme appears in the subject position.

**Method**

**Design**

There were three types of verbs tested: 1) change-of-state verbs; 2) theme-experiencer verbs; and 3) animate-inanimate objects verbs. For each of these three types of verbs there were two within subject factors. One factor was the thematic role of subject noun (agent, instrument, or object). The second factor involved the portion of the sentence. The dependent measures were reaction time to read the verb, the word immediately following the verb, and the entire sentence.

**Subjects**

Thirty-six Rice University undergraduates were given course credit for their participation in the experiment. All of the subjects were native speakers of English. Twenty of the subjects were male and sixteen were female. The mean age for the subjects was 20 years with a range between 18 and 23 years.

**Materials**

Two hundred and sixty-six pairs of sentences were created (e.g., "War had started between the rival factions. The colonel killed the journalist by accident"). The first sentence was a context sentence followed by the test sentence. The context sentences were
added to make the target sentences more comprehensible and thus encourage reading for comprehension. The test sentences contained verbs which could take more than one thematic role in the subject position of the sentence. The verbs came from three categories: 1) change-of-state verbs which can take theme, agent, or instrument in the subject position (e.g., to open); 2) theme-experiencer verbs which can take agent or instrument in the subject position and requires an animate object as a noun phrase following the verb which experiences the action of the verb (e.g., to kill); and 3) animate or inanimate theme verbs, which can take either an inanimate or animate theme in the subject position (e.g., to freeze). Twenty-one verbs came from the first category, fourteen from the second category, and fourteen from the third category. For each verb, test sentences were created for each of the possible subject position roles that the verb could have. For example, change-of-state verbs can take three roles in the subject position so three sentences were created for each verb (e.g., to split: (1) agent - The peasant split the log in half; (2) instrument - The axe split the log in half; and (3) theme - The log split in half). Subjects saw each of the verbs from a set only once. If a subject was presented with the sentence "The peasant split the log in half" he or she did not see "The axe split the log in half." The context sentence was the same for the different thematic roles. Thus, there were 63 change-of-state verb sentences, 28 theme-experiencer verb sentences, and 28 animate-inanimate object verb sentences. The change-of-state sentences were divided into three blocks of 21 sentences such that each block contained all 21 verbs but differed in the thematic roles that appeared in the subject position for each verb. Each block contained seven sentences with the agent in the subject position, seven sentences with the instrument in the subject position, and seven sentences with the theme in the subject position. Similarly, the theme-experiencer verb sentences were divided into two blocks of 14 sentences and the animate-inanimate theme verb sentences were divided into two blocks of 14 sentences. This resulted in seven blocks of sentences. The seven blocks were divided into all possible sentence sets where
each set contained one block of change-of-state sentences, one block of theme-experiencer sentences, and one block of animate-inanimate theme sentences, resulting in 12 sentence sets.

The word frequencies for the 119 nouns that appeared in the subject position of the test sentences were equated across thematic roles. Twelve Rice University graduate and undergraduate students rated the 119 nouns for familiarity. They were instructed to rate the nouns according to how familiar they were with each noun on a seven point scale where a rating of "1" was "very unfamiliar" and a rating of "7" was "very familiar." The mean frequency and familiarity ratings for the nouns in each thematic role within each of the three verb sets appears in Table 35.

Each subject was presented with a total of 49 test sentence pairs and an additional 147 filler sentence pairs. The filler sentences were comprised of sentence types other than those used for the test sentences (e.g., passive sentences, progressive sentences, and sentence complement sentences). Thus, there were a total of 196 sentence pairs of which 25% were test sentences and 75% were filler sentences. The entire set of test sentences and several examples of the filler sentences are presented in Appendix D.

Procedure

Subjects were seated in front of a Macintosh Plus computer. They were told that they would be reading pairs of sentences which would be presented in portions varying in the number of words per portion. The number of words that appeared on the screen at a time varied from one to five words. The filler sentences and the context sentences for the test sentences were randomly divided into segments that varied in size from one to five words. The test sentences were always divided such that the initial NP was the first segment, the verb was the second segment and the second noun phrase was the third segments (e.g., The axe -- split -- the log -- in half). Appendix D shows how the words in the test sentences were segmented for presentation.
Table 35

Mean Frequency and Familiarity Ratings for Nouns used in Sentences by Verb Set and Thematic Role

<table>
<thead>
<tr>
<th>Verb Type</th>
<th>Thematic Role</th>
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Change-of State

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Theme-Experiencer

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<th>--</th>
</tr>
</thead>
<tbody>
<tr>
<td>familiarity</td>
<td>6.10</td>
<td>6.19</td>
<td>--</td>
</tr>
</tbody>
</table>

Animacy

<table>
<thead>
<tr>
<th></th>
<th>Animacy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Animate</td>
</tr>
</tbody>
</table>

Animate/Inanimate Theme

<table>
<thead>
<tr>
<th></th>
<th>frequency</th>
<th>91.14</th>
<th>91.86</th>
</tr>
</thead>
<tbody>
<tr>
<td>familiarity</td>
<td>6.15</td>
<td>6.46</td>
<td></td>
</tr>
</tbody>
</table>
A line of asterisks appeared in the center of the screen, followed by the first portion of the sentence. Subjects read the first portion of the sentence and then pressed the space bar in order to see the next portion of the sentence. Reaction times were collected for each key press in 16.6 msec intervals. Subjects were instructed to read the sentences as quickly as possible while at the same time trying to comprehend the sentence. In order to encourage reading for comprehension, 50% of the trials were immediately followed by a yes-no question about the target sentence (see Example 15). There were three practice trials followed by 196 test trials.

(15) Mrs. Farnsworth instructed the help to press her evening gown.  
The maid tore the fabric by mistake.  
Did the help sew the gown?  

The sentences were divided into blocks for presentation to ensure that subjects would not be presented with all of one sentence type in a row. For each subject, the sentences were randomly placed into one of seven blocks of 28 sentences. Each block contained: 1) three change-of-state verb sentences each with a different thematic role in the subject position; 2) two theme-experiencer sentences with different thematic roles in the subject position; 3) two animate-inanimate theme sentences, one with an animate object in the subject position and one with an inanimate object in the subject position; and 4) 21 filler sentences of which seven were passive sentences, seven were progressive sentences, and seven were sentence complement sentences.

Results

The percentage of correct responses to the "yes-no" questions that followed 50% of the trials were calculated and used as a measure of reading comprehension. The mean reading comprehension score was 96% correct with a range from 86% to 100% correct. These results indicate that subjects were reading the sentences for meaning and were comprehending what they read.
The word by word reaction time data were modified in two ways to control for outliers. First, if the reaction time for reading any portion of a test sentence was longer than 2,000 msec then all of the reaction times for that sentence were changed to missing values. Second, the mean reaction time and standard deviation were calculated for each subject for each of the possible thematic roles that appeared in the subject position of the sentences for each part of the sentence. If the reaction time to respond to any part of a sentence was greater than or less than three standard deviations from the subject's mean reaction time for that thematic role and sentence part then all of the reaction times for that sentence were treated as missing values. Missing values were then replaced with the appropriate cell mean. These two modifications resulted in 1.5% of the data being treated as outliers and therefore replaced with the appropriate cell mean.

**Change-of-State Verbs**

These verbs had three possible thematic roles that could appear in the subject position of the sentence: 1) agent; 2) instrument; 3) theme. Because the sentences containing agent and instrument roles in the subject position were longer than the sentences containing themes in the subject position two separate analyses were done using sentence part reaction times (see Sentences 16-18).

(16) The peasant \( \rightarrow \) split \( \rightarrow \) the log \( \rightarrow \) in half. (agent)

(17) The axe \( \rightarrow \) split \( \rightarrow \) the log \( \rightarrow \) in half. (instrument)

(18) The log \( \rightarrow \) split \( \rightarrow \) in half. (theme)

In the first analysis, the reaction times for the first three parts of the sentence were examined and in the second analysis the reaction times for the first four parts of the sentence were examined for the agent and instrument sentences only. The mean reaction times for the different conditions are presented in Table 36.
Table 36
Mean Reaction Time for Reading Change-of-State Verb Sentences by Part in Milliseconds

<table>
<thead>
<tr>
<th>Sentence Part</th>
<th>Agent</th>
<th>Instrument</th>
<th>Theme</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>470</td>
<td>459</td>
<td>473</td>
<td>467</td>
</tr>
<tr>
<td>2</td>
<td>395</td>
<td>386</td>
<td>393</td>
<td>391</td>
</tr>
<tr>
<td>3</td>
<td>374</td>
<td>367</td>
<td>400</td>
<td>380</td>
</tr>
<tr>
<td>4</td>
<td>409</td>
<td>405</td>
<td>--</td>
<td>407</td>
</tr>
</tbody>
</table>

In the first analysis, the effect of thematic role in the subject position of the sentence was not significant for subjects or items, $F_1(2,70) = 1.96$, $p<.14$, $MSe = 4,579$, $F_2(2,40) = .97$, $p<.39$, $MSe = 5,379$. The effect of sentence part was significant for both subjects and items, $F_1(2,70) = 49.35$, $p<.0001$, $MSe = 4,783$, $F_2(2,40) = 41.68$, $p<.0001$, $MSe = 3,365$. Subjects took the longest time to read the initial noun phrase and then progressively less time to read the verb and subsequent phrase. The effect of thematic role by sentence part was not significant for either subjects or items, $F_1(4,140) = 1.06$, $p<.38$, $MSe = 2,311$, $F_2(4,80) = 1.00$, $p<.41$, $MSe = 1,421$. For the second analysis the results were similar. The effect of thematic role was not significant for subjects or items, $F_1(1,35) = .99$, $p<.32$, $MSe = 4,325$, $F_2(1,20) = .37$, $p<.54$, $MSe = 6,689$. The effect of sentence part was significant for both subjects and items, $F_1(3,105) = 27.23$, $p<.0001$, $MSe = 4,303$, $F_2(3,60) = 35.95$, $p<.0001$, $MSe = 1,902$. As in the previous analysis, subjects took longer to read the initial noun phrase and progressively less time to read the verb and the second noun phrase and there was a slight increase in reaction time for the final part of the sentence which was probably due to subjects needing additional time to integrate the
entire sentence. The mean reaction times for each part of the sentence are presented in Table 36. The effect of thematic role by sentence part was not significant for either subjects or items, $F_1(3,105) = .15, p<.93, MSe = 1.393, F_2(3,60) = .11, p<.95, MSe = 1,028$.

The change-of-state verbs were also analyzed for overall sentence processing time as a function of thematic role for the sentences that contained either an agent or instrument in the subject position. The mean sentence reading time for the sentences with an agent in the subject position was 1,714 msec and the mean sentence reading time for sentences with an instrument in the subject position was 1,665 msec. There was no significant effect of thematic role on overall sentence processing time for either subjects or items, $F_1(1,35) = 1.60, p<.21, MSe = 26,284, F_2(1,20) = .77, p<.39, MSe = 31,849$.

**Theme Experiencer Verbs**

These verbs could have two possible thematic roles appear in the subject position of the sentence: 1) agent; 2) instrument (see Sentences 19-20).

(19) The preacher inspired the congregation to be tolerant. (agent)

(20) The sermon inspired the congregation to be tolerant. (instrument)

Reaction times were analyzed by sentence part. The mean reaction times for the different conditions are presented in Table 37. There was no significant effect of thematic role for subjects or items, $F_1(1,35) = .27, p<.61, MSe = 5,965, F_2(1,13) = .19, p<.67, MSe = 7,005$. The effect of sentence part was significant for both subjects and items, $F_1(3,105) = 16.57, p<.0001, MSe = 2,698, F_2(3,39) = 13.55, p<.0001, MSe = 2,894$. Subjects took longer to read the initial noun phrase and progressively less time to read the verb and the second noun phrase and there was a slight increase in reaction time for the final part of the sentence which was probably due to subjects needing additional time to integrate the entire sentence. The effect of thematic role by sentence part was not significant for either subjects or items, $F_1(3,105) = .13, p<.94, MSe = 1,657, F_2(3,39) = .67, p<.57, MSe = 1,202$. 


Overall sentence processing time was analyzed as a function of thematic role. The mean sentence reading time for the sentences with an agent in the subject position was 1,640 msec and the mean sentence reading time for sentences with an instrument in the subject position was 1,621 msec. There was no significant effect of thematic role on overall sentence processing time for either subjects or items, $F_{1}(1,35) = .27, p<.61$, \( \text{MSE} = 23,859 \), $F_{2}(1,13) = .27, p<.61$, \( \text{MSE} = 18,093 \).

Table 37

Mean Reaction Time for Reading Theme Experiencer Verb Sentences by Part in Milliseconds

<table>
<thead>
<tr>
<th>Sentence Part</th>
<th>Agent</th>
<th>Instrument</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>436</td>
<td>429</td>
<td>433</td>
</tr>
<tr>
<td>2</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>3</td>
<td>.378</td>
<td>374</td>
<td>376</td>
</tr>
<tr>
<td>4</td>
<td>426</td>
<td>418</td>
<td>422</td>
</tr>
</tbody>
</table>

Animate and Inanimate Theme Verbs

These sentences had either an animate or inanimate object in the subject position (see Sentences 21-22).

(21) The boy baked in the summer heat for hours. (animate)
(22) The car baked in the summer heat for hours. (inanimate)

Reaction times were analyzed by sentence part. The mean reaction times for the different conditions are presented in Table 38.
Table 38

Mean Reaction Time for Reading Animate Inanimate Object Verb Sentences by Part in Milliseconds

<table>
<thead>
<tr>
<th>Sentence Part</th>
<th>Animate</th>
<th>Inanimate</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>465</td>
<td>451</td>
<td>458</td>
</tr>
<tr>
<td>2</td>
<td>390</td>
<td>379</td>
<td>385</td>
</tr>
<tr>
<td>3</td>
<td>379</td>
<td>367</td>
<td>373</td>
</tr>
<tr>
<td>4</td>
<td>404</td>
<td>413</td>
<td>409</td>
</tr>
</tbody>
</table>

When reaction times for the different parts of the sentence were analyzed there was no significant effect of animacy for subjects or items, $F_1(1,35) = .45, p<.51, MSe = 7,522, F_2(1,13) = .11, p<.75, MSe = 5,817$. There was a significant effect of sentence part for both subjects and items, $F_1(3,105) = 21.54, p<.0001, MSe = 4,682, F_2(3,39) = 6.35, p<.0001, MSe = 2,738$. Subjects took longer to read the initial noun phrase and progressively less time to read the verb and the second noun phrase and there was a slight increase in reaction time for the final part of the sentence which was probably due to subjects needing additional time to integrate the entire sentence. The mean reaction times for each part of the sentence are presented in Table 38. The effect of animacy by sentence part was not significant for either subjects or items, $F_1(3,105) = .70, p<.56, MSe = 2,989, F_2(3,39) = .10, p<.96, MSe = 860$.

Overall sentence processing time was analyzed as a function of animacy. The mean sentence reading time for the sentences with an animate theme in the subject position was
1,637 msec and the mean sentence reading time for sentences with an inanimate theme in the subject position was 1,610 msec. There was no significant effect of animacy on overall sentence processing time for either subjects or items, $F_{1}(1,35) = .45, p<.51, MSe = 30,090, F_{2}(1,13) = .19, p<.67, MSe = 28,022.$

**Discussion**

The present experiment examined the effect of the thematic role of the subject of the sentence on sentence processing time. Research with aphasic patients has indicated the importance of thematic role knowledge for sentence comprehension. Bever (1970) hypothesized that people have thematic role preferences for syntactic positions in a sentence. Bever posited that subjects would prefer the thematic role of agent in the subject position of a sentence. Recent models of verb representation (Pinker, 1989) also suggest biases for certain thematic roles in specific syntactic positions. The results from the present experiment failed to support the hypothesis that subjects have a preference for the thematic role of the subject noun. There was no difference in the time that it took subjects to read the verb or phrase following the verb as a result of the thematic role of the subject noun. Rather, the results support Frazier’s (1978) claim that subjects do not have a bias for the thematic role of the subject noun.

Talmy (1976) postulated that thematic roles differ in the number of causal inferences that they require to be integrated into a sentence. He argued that the thematic role of agent requires more inferences than the roles of theme and instrument. The overall reading times collected in this experiment indicated that it took no longer to integrate an agent into a sentence than to integrate a theme or instrument into a sentence.

These findings indicate that during sentence processing the central semantic and syntactic system does not have a bias for particular thematic roles. The results from Experiments 1-6 indicated that thematic role information is an important part of verb representation, but can be dissociated from syntactic representation. The results of
Experiment 7 support Frazier’s (1978) assertion that thematic role information does not influence the time of normal sentence processing.

Clearly, thematic role information must be accessed to comprehend the meaning of a sentence, but the results of Experiment 7 reveal no difference in the time required to access specific thematic roles for specific syntactic positions. Perhaps thematic role information is stored rather than generated. When subjects read a verb, all aspects of a verb’s semantic representation are activated. Thus, all the thematic roles that the verb could specify and the syntactic positions that each role could fill would be available. This type of model is quite different from one in which treats comprehension as if it were production in reverse. While production models hypothesis a sequence of steps from idea generation to idea expression, the same processes may not be required for comprehension. If all the semantic information about a verb is available at once then there is no need to predict differences in processing time.

Alternatively, it may be that subjects are very good at assigning thematic roles to syntactic positions. It may be that a more demanding task is needed to reveal the on-line processes involved in thematic role assignment.

Finally, there were significant differences in processing time as a function of sentence position for all of the verb types. Subjects spent more time reading the initial and final sentence segments than the middle segments. Presumably, subjects were slower at reading sentence initial segments because they were trying to form connections between the context sentence and the test sentence. The longer reading times for the sentence final segment are probably the result of additional time being required to integrate the information presented in the sentence. These sentence position effects, however, suggest that subjects were trying to read the sentences for comprehension.
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Appendix A

List of 95 verbs used for patient testing and the frequency, mean familiarity rating, and mean abstractness rating for each.

<table>
<thead>
<tr>
<th>Verb</th>
<th>Frequency</th>
<th>Familiarity</th>
<th>Abstractness</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Sensation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. listen</td>
<td>123</td>
<td>5.42</td>
<td>3.15</td>
</tr>
<tr>
<td>2. look</td>
<td>910</td>
<td>6.00</td>
<td>2.40</td>
</tr>
<tr>
<td>3. smell</td>
<td>43</td>
<td>5.67</td>
<td>2.50</td>
</tr>
<tr>
<td>4. taste</td>
<td>22</td>
<td>6.00</td>
<td>2.25</td>
</tr>
<tr>
<td>5. touch</td>
<td>91</td>
<td>6.00</td>
<td>1.95</td>
</tr>
<tr>
<td><strong>B. Movement</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. crawl</td>
<td>37</td>
<td>4.08</td>
<td>1.40</td>
</tr>
<tr>
<td>2. jump</td>
<td>58</td>
<td>5.25</td>
<td>1.50</td>
</tr>
<tr>
<td>3. run</td>
<td>431</td>
<td>5.25</td>
<td>1.25</td>
</tr>
<tr>
<td>4. stand</td>
<td>468</td>
<td>5.58</td>
<td>1.30</td>
</tr>
<tr>
<td>5. walk</td>
<td>287</td>
<td>4.83</td>
<td>1.30</td>
</tr>
<tr>
<td><strong>C. Cleaning</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. dust</td>
<td>9</td>
<td>4.08</td>
<td>1.40</td>
</tr>
<tr>
<td>2. polish</td>
<td>20</td>
<td>2.92</td>
<td>1.55</td>
</tr>
<tr>
<td>3. scrub</td>
<td>9</td>
<td>4.42</td>
<td>1.35</td>
</tr>
<tr>
<td>4. sweep</td>
<td>54</td>
<td>4.92</td>
<td>1.55</td>
</tr>
<tr>
<td>5. wipe</td>
<td>35</td>
<td>4.25</td>
<td>1.55</td>
</tr>
<tr>
<td><strong>D. Handicraft</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. cut</td>
<td>245</td>
<td>5.58</td>
<td>1.50</td>
</tr>
<tr>
<td>2. embroider</td>
<td>5</td>
<td>1.75</td>
<td>1.40</td>
</tr>
<tr>
<td>3. knit</td>
<td>18</td>
<td>2.50</td>
<td>1.25</td>
</tr>
<tr>
<td>4. sew</td>
<td>18</td>
<td>3.67</td>
<td>1.40</td>
</tr>
<tr>
<td>5. weave</td>
<td>20</td>
<td>1.92</td>
<td>1.30</td>
</tr>
</tbody>
</table>

E. Categorization

| 1. file   | 87 | 4.50 | 1.85 |
| 2. measure | 128 | 4.08 | 1.85 |
| 3. sort   | 10 | 4.58 | 2.45 |
| 4. stack  | 11 | 4.42 | 1.45 |
| 5. weigh  | 33 | 4.00 | 2.50 |

F. Opposite Action

| 1. break- | 228 | 4.00 | 1.75 |
| fix      | 109 | 5.83 | 2.15 |
| 2. cry-   | 64  | 5.08 | 1.85 |
| laugh    | 89  | 6.50 | 2.10 |
| 3. erase- | 5   | 4.58 | 1.80 |
| write    | 561 | 5.91 | 1.80 |
| 4. find-  | 1033 | 5.33 | 2.80 |
| hide     | 61  | 4.58 | 2.30 |
| 5. sleep- | 97  | 6.75 | 2.10 |
| wake     | 45  | 4.83 | 2.90 |

G. Opposite Direction

| 1. climb- | 65  | 5.58 | 1.50 |
| fall     | 239 | 5.17 | 2.10 |
| 2. drop- | 159 | 4.58 | 1.80 |
| lift     | 69  | 4.75 | 1.45 |
| 3. enter- | 213 | 4.58 | 2.40 |
| leave    | 650 | 5.33 | 2.60 |
| 4. pull- | 145 | 4.58 | 1.60 |
|    push | 102 | 4.75 | 1.70 |
| 5. squeeze- | 30 | 4.25 | 1.45 |
|    stretch | 61 | 4.67 | 1.75 |

**H. Opposite Abstract**

| 1. attend- | 119 | 4.08 | 3.00 |
|    ignore | 57 | 4.50 | 3.45 |
| 2. do- | 4367 | 6.00 | 3.25 |
|    think | 982 | 6.58 | 4.30 |
| 3. enjoy- | 128 | 5.25 | 4.15 |
|    worry | 89 | 5.25 | 3.90 |
| 4. hate- | 66 | 4.92 | 4.30 |
|    like | 294 | 6.08 | 4.25 |
| 5. have- | 12458 | 5.00 | 3.80 |
|    want | 631 | 5.08 | 4.10 |

**I. Reverse Role**

<p>| 1. borrow- | 31 | 4.42 | 2.65 |
|    lend | 29 | 4.42 | 2.85 |
| 2. buy- | 162 | 6.08 | 2.20 |
|    sell | 128 | 4.17 | 2.25 |
| 3. catch- | 146 | 5.67 | 1.75 |
|    throw | 150 | 5.42 | 1.50 |
| 4. chase- | 7 | 4.58 | 1.90 |
|    flee | 40 | 3.17 | 2.55 |
| 5. eat- | 122 | 6.92 | 1.40 |
|    feed | 132 | 5.67 | 1.90 |</p>
<table>
<thead>
<tr>
<th>6. follow-lead</th>
<th>540</th>
<th>4.75</th>
<th>2.75</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. get-give</td>
<td>1486</td>
<td>4.58</td>
<td>3.40</td>
</tr>
<tr>
<td></td>
<td>1264</td>
<td>5.42</td>
<td>3.10</td>
</tr>
<tr>
<td>8. learn-teach</td>
<td>254</td>
<td>6.58</td>
<td>4.05</td>
</tr>
<tr>
<td></td>
<td>153</td>
<td>5.92</td>
<td>2.95</td>
</tr>
<tr>
<td>9. listen-tell</td>
<td>123</td>
<td>5.42</td>
<td>3.15</td>
</tr>
<tr>
<td></td>
<td>759</td>
<td>4.42</td>
<td>2.45</td>
</tr>
<tr>
<td>10. receive-send-</td>
<td>294</td>
<td>4.33</td>
<td>2.90</td>
</tr>
<tr>
<td></td>
<td>253</td>
<td>5.00</td>
<td>2.70</td>
</tr>
<tr>
<td>11. seat-sit</td>
<td>31</td>
<td>3.83</td>
<td>2.55</td>
</tr>
<tr>
<td></td>
<td>314</td>
<td>5.75</td>
<td>1.55</td>
</tr>
<tr>
<td>12. show-watch</td>
<td>640</td>
<td>5.42</td>
<td>2.75</td>
</tr>
<tr>
<td></td>
<td>209</td>
<td>5.58</td>
<td>2.60</td>
</tr>
</tbody>
</table>

J. Semantically Related to Reverse Role

<p>| 1. act (teach) | 159 | 5.00 | 2.70 |
|               |    |      |      |
| *2. bounce (throw) | 28  | 4.50 | 1.55 |
| 3. catch (chase)  | 146 | 5.67 | 1.75 |
| 4. cook (feed)    | 50  | 6.08 | 1.50 |
| *5. distribute (lend) | 39  | 2.92 | 2.75 |
| *6. drink (eat)   | 93  | 6.67 | 1.40 |
| *7. escape (flee)  | 69  | 4.00 | 3.15 |
| *8. examine (watch) | 70  | 4.42 | 2.45 |
| *9. grab (get)    | 37  | 3.83 | 1.60 |
| *10. help (lead)   | 352 | 5.75 | 3.10 |
| 11. hold (give)    | 509 | 4.58 | 1.80 |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>12. lift (catch)</td>
<td>69</td>
<td>4.75</td>
<td>1.45</td>
</tr>
<tr>
<td>13. meet (follow)</td>
<td>339</td>
<td>5.50</td>
<td>2.65</td>
</tr>
<tr>
<td>14. read (borrow)</td>
<td>274</td>
<td>6.33</td>
<td>1.85</td>
</tr>
<tr>
<td>15. read (receive)</td>
<td>274</td>
<td>6.33</td>
<td>1.85</td>
</tr>
<tr>
<td>16. serve (seat)</td>
<td>300</td>
<td>4.58</td>
<td>2.50</td>
</tr>
<tr>
<td>*17. squat (sit)</td>
<td>12</td>
<td>2.83</td>
<td>1.45</td>
</tr>
<tr>
<td>18. steal (buy)</td>
<td>39</td>
<td>4.17</td>
<td>1.80</td>
</tr>
<tr>
<td>*19. study (learn)</td>
<td>163</td>
<td>6.25</td>
<td>2.85</td>
</tr>
<tr>
<td>20. tell (show)</td>
<td>759</td>
<td>4.42</td>
<td>2.45</td>
</tr>
<tr>
<td>*21. trade (sell)</td>
<td>47</td>
<td>3.92</td>
<td>2.55</td>
</tr>
<tr>
<td>*22. look (listen)</td>
<td>209</td>
<td>5.58</td>
<td>2.60</td>
</tr>
<tr>
<td>*23. write (send)</td>
<td>561</td>
<td>1.88</td>
<td>1.80</td>
</tr>
<tr>
<td>24. write (tell)</td>
<td>561</td>
<td>1.88</td>
<td>1.80</td>
</tr>
</tbody>
</table>

* Items marked by an asterisk were included in the revised set of semantically related to reverse-role verbs.
Appendix B

Same semantic category verbs - polish (top) and scrub (bottom)
Opposite action verbs - laugh (left) and cry (right)
Opposite direction verbs - drop (left) and lift (right)
Opposite abstract verbs - have (top) and want (bottom)
Reverse-role verbs - sell (top) and buy (bottom)
Semantically related to reverse-role verbs - sell (left) and trade (right)
Appendix C

Examples of patients' sentence production collected in Experiment 5.

A.B.

Correct verb/Correct Syntactic Frame - Target verb - teach
  Elizabeth is teaching a lesson to the boy.

Incorrect Verb/Correct Syntactic Frame - Target verb - lend
  She is borrowing a book.

Correct verb/Incorrect Syntactic Frame - Target verb - learn
  Elizabeth is learning the boy from the book.

Incorrect Verb/Incorrect Syntactic Frame - Target verb - show
  Elizabeth is explaining to the girl her lessons.

E.E.

Correct verb/Correct Syntactic Frame - Target verb - hide
  Elizabeth is hiding behind the statue.

Incorrect Verb/Correct Syntactic Frame - Target verb - serve
  Elizabeth will give the boy something to eat.

Correct verb/Incorrect Syntactic Frame - Target verb - buy
  Elizabeth is buying some crayon.

Incorrect Verb/Incorrect Syntactic Frame - Target verb - trade
  Elizabeth is selling uhm balloon.

W.H.

Correct verb/Correct Syntactic Frame - Target verb - give
  Elizabeth is giving the book to the girl.

Incorrect Verb/Correct Syntactic Frame - Target verb - borrow
  Elizabeth is borrowing the book.

Correct verb/Incorrect Syntactic Frame - Target verb - listen
Elizabeth is listening uh the radio.

Incorrect Verb/Incorrect Syntactic Frame

--none of this type of error made--

M.L.

Correct verb/Correct Syntactic Frame - Target verb - fall

Elizabeth is falling from the tree.

Incorrect Verb/Correct Syntactic Frame - Target verb - sell

Elizabeth is trading money for the Crayolas.

Correct verb/Incorrect Syntactic Frame - Target verb - show

Elizabeth is showing.

Incorrect Verb/Incorrect Syntactic Frame - Target verb - listen

Elizabeth is looking.

A.P.

Correct verb/Correct Syntactic Frame - Target verb - drop

Elizabeth is dropping the bucket.

Incorrect Verb/Correct Syntactic Frame - Target verb - knit

Elizabeth is weaving.

Correct verb/Incorrect Syntactic Frame - Target verb - sell

Elizabeth selling.

Incorrect Verb/Incorrect Syntactic Frame - Target verb - distribute

Elizabeth she exchanging.

J.S.

Correct verb/Correct Syntactic Frame - Target verb - attend

The girl attending a talk.

Incorrect Verb/Correct Syntactic Frame

--none of this type of error made--
Correct verb/Incorrect Syntactic Frame - Target verb - feed
    feed - feed - I don't know boy.
Incorrect Verb/Incorrect Syntactic Frame - Target verb - receive
    The girl ah send boy.
R.W.
Correct verb/Correct Syntactic Frame - Target verb - write
    The girl is writing a letter.
Incorrect Verb/Correct Syntactic Frame - Target verb - lift
    The girl is dropping the basketball.
Correct verb/Incorrect Syntactic Frame - Target verb - find
    The girl is finding.
Incorrect Verb/Incorrect Syntactic Frame - Target verb - drink
    The girl is water and a glass.
Appendix D

Test sentences and example filler sentences used in Experiment 7.

<table>
<thead>
<tr>
<th>Sentence</th>
<th>Frequency</th>
<th>Familiarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change of State Verb Stimuli</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The</td>
<td>saleswoman</td>
<td>in the</td>
</tr>
<tr>
<td>The</td>
<td>clerk</td>
<td>broke</td>
</tr>
<tr>
<td>The</td>
<td>accident</td>
<td>broke</td>
</tr>
<tr>
<td>The</td>
<td>plate</td>
<td>broke</td>
</tr>
<tr>
<td>The takeover</td>
<td>of the hospital</td>
<td>resulted</td>
</tr>
<tr>
<td>The</td>
<td>doctor</td>
<td>closed</td>
</tr>
<tr>
<td>The</td>
<td>policy</td>
<td>closed</td>
</tr>
<tr>
<td>The</td>
<td>department</td>
<td>closed</td>
</tr>
<tr>
<td>The</td>
<td>children</td>
<td>were</td>
</tr>
<tr>
<td>The</td>
<td>youngster</td>
<td>cracked</td>
</tr>
<tr>
<td>The</td>
<td>boot</td>
<td>cracked</td>
</tr>
<tr>
<td>The</td>
<td>mirror</td>
<td>cracked</td>
</tr>
<tr>
<td>The shelter</td>
<td>for the homeless</td>
<td>was</td>
</tr>
<tr>
<td>The</td>
<td>volunteer</td>
<td>dissolved</td>
</tr>
<tr>
<td>The</td>
<td>detergent</td>
<td>dissolved</td>
</tr>
<tr>
<td>The</td>
<td>dirt</td>
<td>dissolved</td>
</tr>
<tr>
<td>The sound</td>
<td>of</td>
<td>air raid sirens</td>
</tr>
<tr>
<td>The</td>
<td>pilot</td>
<td>dropped</td>
</tr>
</tbody>
</table>
The aircraft dropped the bomb swiftly. 71 5.60
The bomb dropped swiftly. 68 6.13

There was a roaring fire in the artist's studio.
The painter ignited the canvas rapidly. 35 6.27
The flame ignited the canvas rapidly. 27 6.13
The canvas ignited rapidly. 27 5.73

The cows roamed across the prairie trying to stay free from the lasso.
The rancher jerked the rope sharply. 22 5.87
The twist jerked the rope sharply. 19 5.67
The rope jerked sharply. 19 6.33

Many experiments were carried out in the laboratory.
The scientist melted the ice quickly. 53 6.73
The salt melted the ice quickly. 52 6.67
The ice melted quickly. 45 6.87

For security reasons all luggage had to be inspected.
The official opened the box easily. 82 6.20
The key opened the box easily. 71 6.80
The box opened easily. 82 6.47

It was a wonderful day to be on the lake.
The couple raced the boat across the water. 136 6.53
The motor raced the boat across the water. 109 6.27
The boat raced across the water.  

It was lunchtime at the Catholic school.

The monk rang the bell loudly.  23  5.07
The clock rang the bell loudly.  28  6.73
The bell rang loudly.  23  6.40

The manuscript was being printed.

The editor ripped the page in two.  100  6.27
The press ripped the page in two.  107  6.20
The page ripped in two.  102  6.73

The automotive shop was filled with vehicles which were being repaired.

The mechanic rolled the tire across the floor.  22  6.07
The gear rolled the tire across the floor.  28  5.53
The tire rolled across the floor.  31  6.53

During the hurricane the store's seed was damaged.

The merchant scattered the grain from the bag when it began.  40  5.47
The storm scattered the grain from the bag when it began.  31  6.53
The grain scattered from the bag when it began.  47  5.87

After the team had left the custodian cleaned the locker-room.

The worker shattered the glass completely.  123  6.40
The ball shattered the glass completely.  123  6.80
The glass shattered completely.  128  6.60
It was a windy day and the Congressman needed some papers from his desk.
The aide shut the drawer suddenly after the Congressman left.
The breeze shut the drawer suddenly after the Congressman left.
The drawer shut suddenly after the Congressman left.

The floor of the art gallery was a mess after the opening and was being cleaned.
The proprietor soaked the carpet in the bathroom.
The steam soaked the carpet in the bathroom.
The carpet soaked in the bathroom.

The university cafeteria was very crowded and people were always knocking into each other.
The undergraduate spilled the juice onto the floor.
The collision spilled the juice onto the floor.
The juice spilled onto the floor.

The forest was filled with trees which were being cut.
The peasant split the log in half.
The axe split the log in half.
The log split in half.

The aroma of freshly toasted bread permeated through the kitchen.
The cook spread the butter onto the toast.
The blade spread the butter onto the toast.
The butter spread onto the toast.
Mrs. Farnsworth instructed the help to press her evening gown.

The maid tore the fabric by mistake.  
44 6.20

The iron tore the fabric by mistake.  
46 6.20

The fabric tore by mistake.  
44 5.67

Theme-Experiencer Verbs

The spotlight lit the stage.

The performer amazed the crowd immediately.  
20 5.67

The magic amazed the crowd immediately.  
16 6.33

It was a cold night in the castle.

The servant covered the king against the chill.  
41 5.73

The blanket covered the king against the chill.  
39 6.47

The young woman had been ill most of her life.

The physician cured the invalid of the disease.  
22 6.20

The dose cured the invalid of the disease.  
24 5.53

The soldier was awarded the medal for his bravery.

The general embarrassed him greatly.  
158 5.87

The attention embarrassed him greatly.  
180 6.27

Wortham Center presents many cultural events.

The dancer entertained the audience enormously.  
63 6.33
The concert entertained the audience enormously.

The visiting theater was one of the school's most popular events.

The prince fascinated everyone in the class.

The tale fascinated everyone in the class.

The school offered many educational opportunities.

The philosopher impressed the students completely.

The exhibition impressed the students completely.

Sunlight streamed through the stained glass.

The preacher inspired the congregation to be tolerant.

The sermon inspired the congregation to be tolerant.

War had started between the rival factions.

The colonel killed the journalist by accident.

The bullet killed the journalist by accident.

Margaret went to her first wedding yesterday.

The bride pleased her very much.

The ring pleased her very much.

Martha fell to the floor in a faint.

The nurse revived her after a short time.

The gin revived her after a short time.
The hospital was one of the best in the country.

The specialist saved the patient from certain death. 35 5.87
The medicine saved the patient from certain death. 35 6.47

The lights in the theater had gone out and it was very quiet.
The actor startled the audience out of its stupor. 40 6.33
The noise startled the audience out of its stupor. 43 6.60

It was a beautiful Saturday afternoon.
The mother surprised the little girl on her birthday. 280 6.87
The party surprised the little girl on her birthday. 283 6.67

Animate Inanimate Theme Verbs

August in Houston is very hot.
The boy baked in the summer heat for hours. 409 6.87
The car baked in the summer heat for hours. 393 6.80

Lightning from the storm struck the house.
The family burned in the fire unfortunately. 405 6.60
The room burned in the fire unfortunately. 439 6.87

Police chases are not uncommon in the city.
The detective crashed into the wall of the building. 72 5.73
The automobile crashed into the wall of the building. 74 6.60

Short rainstorms occur frequently in Paris during the summer.
The tourist dried out in the sun during the afternoon. 31 6.27
The shirt dried out in the sun during the afternoon. 29 7.00

The museum had hired the best security advisors to safeguard the exhibit of priceless jewels.
The criminal fell to the ground quickly. 15 5.93
The diamond fell to the ground quickly. 15 6.40

The pirate ship was wrecked in the typhoon.
The survivor floated in the water for days. 15 5.67
The treasure floated in the water for days. 10 5.80

The city was experiencing record low temperatures.
The salesman froze during the winter. 32 6.27
The pond froze during the winter. 32 6.20

The expedition involved crossing a deep cavern using a rope.
The hunter hung over the abyss. 17 6.20
The pack hung over the abyss. 17 5.67

The road was very bumpy.
The driver rocked back and forth. 79 6.47
The truck rocked back and forth. 80 6.53

The city was holding an Easter celebration.
The mayor rolled down the hill. 47 6.20
The egg rolled down the hill.  

Many people have gone diving for stones in the Gordon's swimming pool.  
The youth sank to the bottom of the pool.  
The rock sank to the bottom of the pool.  

The sidewalk in front of the bank was icy.  
The investor skidded across the pavement.  
The coin skidded across the pavement.  

The teams were engaged in a vigorous game of baseball.  
The athlete slammed into the fence.  
The bat slammed into the fence.  

The rain was pouring down and the hikers were lost.  
The guide slid across the wet path.  
The map slid across the wet path.  

Filler Sentences  
Passives  
The house had a window seat that faced the street.  
The cat was held by the girl.  

Space is filled with debris.  
The farm was hit by a meteor.
Progressive Sentences
The drought has lasted two months.
The community is conserving water.

Christmas vacation will be busy for the seniors.
They are applying to colleges.

Sentence Complements
The will left all the money to a raccoon orphanage.
Grandmother trusted that her wishes would be carried out.

Some cafeterias are filthy.
The inspector inferred that the kitchen was a health hazard.