The Misinterpretation of Passive Sentences

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Abstract

A fundamental task of the language comprehension system is to assign thematic roles to concepts in sentences and then maintain them. The comprehension system has access to two sources of information for thematic roles: one is the syntactic structure, and the other is information in long-term memory. In a sentence such as *the dog was bitten by the man*, the syntactic source specifies that the concept DOG is the patient and MAN is the agent; the schematic source provides the opposite role assignments, because it is far more plausible that a dog would bite a person than that a person would bite a dog. The studies reported here were motivated by two hypotheses: First, syntactic assignment of thematic roles is easier in canonical syntactic structures such as the active than in noncanonical structures such as the passive. Second, schematic information influences syntactically vulnerable thematic role assignments. If the syntactic and schematic sources are consistent, thematic assignments tend to stay bound to concepts. If they are inconsistent, syntactically based assignments will loosen, and misinterpretations are likely to occur. These hypotheses were explored in three experiments. In the first experiment, participants were presented active and passive sentences that were either plausible or implausible. Participants tend to label a sentence such as *the dog was bitten by the man* as grammatical. For the second experiment, the same sentences were presented aurally, and the participants' task was to identify the thematic roles in the sentence. Participants had difficulty keeping track of implausible roles in the passive, especially the agent. The third experiment showed that the active-cleft is no harder than an ordinary active sentence, suggesting that the frequency of the global syntactic form is not what determines whether a structure is canonical. Thus, the hypotheses of the study were supported. The results imply that the thematic roles assigned by language-specific mechanisms are quite fragile. The language comprehension system likely relies on nonlinguistic sources to reinforce these linguistically based interpretations—sources such as immediate context and long-term knowledge.

Syntactic Vulnerability and Thematic Misinterpretation

Much of the research that has been conducted over the last twenty years or so on sentence comprehension has addressed a rather specific question: How is syntactic ambiguity resolved (Ferreira & Clifton, 1986; Ferreira & Henderson, 1990, 1991; Frazier & Rayner, 1982; MacDonald, 1994; Tanenhaus, Spivey-Knowlton, Eberhard & Sedivy, 1995; Traxler, Pickering, & Clifton, 1998)? The question arises because often a string of words can be given more than one syntactic analysis. For example, in *Mary put the book on the table onto the shelf*, the string *on the table* could serve either as modifier of book (the ultimately correct interpretation), or as the destination for the book (the incorrect analysis) (Boland & Boehm-Jernigan, 1998; Britt, 1994; Ferreira & Clifton, 1986; Speer & Clifton, 1998; Tanenhaus et al., 1995). The assumption is that the syntactic ambiguity must be resolved so that a correct interpretation for the sentence can be computed. According to what are known as "syntax-first" or "two-stage" models of sentence comprehension (or parsing, a term that focuses particular attention on the mechanism that assigns syntactic structure to sentences), the ambiguity is resolved first on a purely syntactic basis, without the help of information from nonsyntactic sources such as immediate discourse and visual context, real-world knowledge, or even lexical and prosodic constraints (Ferreira & Clifton, 1986; Ferreira & Henderson, 1990; Frazier & Rayner, 1982; Steinhauer, Alter & Friederici, 1999). A sentence is hard to comprehend when its syntactic form is incompatible with the parser's initial biases for creating syntactic structure. According to what are known as "constraint-based" or "interactive" models, the different syntactic alternatives are activated in proportion to the evidence for them. Sentences are difficult to understand when a syntactic analysis for which there initially appears to be a great deal of evidence turns out to be incorrect—as in the example given above (MacDonald, Pearlmutter, & Seidenberg, 1994; Tanenhaus et al., 1995; Trueswell, Tanenhaus, & Kello, 1993).

The back-and-forth between the syntax-first and the constraint-based camps has gradually pruned down the set of questions being investigated in the field to a very small subset of all the

critical issues one might explore concerning language processing. Presumably, all researchers are interested in how a person arrives at an interpretation of a sentence or some other significant chunk of linguistic material. The focus on syntactic analysis has arisen because it is assumed that meaning-based representations are built on syntactic frames (e.g., Frazier & Clifton, 1996; MacDonald et al., 1994). Thus, in the example above, the initial, incorrect syntactic analysis on which *on the table* is sister to the verb *put* supports the interpretation stating that *on the table* is the destination for the book. The focus on parsing has also led to a heavy reliance on what are termed "online" measures as the gold standard for psycholinguistic research. The disputes between the syntax-first and constraint-based approaches concern the time-course of activation of different sources of information, and those are most obviously resolved by examining moment-by-moment changes in processing load as a sentence unfolds over time.

Unfortunately, the combination of these two influences — the emphasis on parsing and the use of online measures — has led to a situation where few studies of "sentence comprehension" actually include serious measures of people's interpretations of sentences. Although researchers assume that a complex sentence is assigned the semantic interpretation supported by the syntactic frame (Frazier & Clifton, 1986; MacDonald et al., 1994), little direct evidence for that assumption has actually been collected. True, most experiments require participants to read sentences so that they can later answer "comprehension questions" about them. However, typically the questions tap into superficial features of the sentences and often data on question-answering accuracy are not collected. As a result, we lack evidence about the sorts of interpretations people actually derive for the sentences they are shown in psycholinguistic experiments, and we know little about how those interpretations were created.

Furthermore, evidence exists that under some circumstances comprehenders do **not** obtain interpretations consistent with a sentence's true content. For example, Fillenbaum (1971, 1974; as cited in Clark & Clark, 1977) conducted a number of studies demonstrating that people tend to recall sentences in a "normalized" form—they changed the sentences' meaning to make them sensible and

conventional rather than strange or anomalous. For example, most participants paraphrased *Don't print that or I won't sue you* to mean that if some item were printed, the result would be a lawsuit. The now-classic Moses illusion (Erickson & Mattson, 1981; Kamas, Reder, & Ayers, 1996) reveals the same phenomenon: If someone is asked *How many animals of each kind did Moses take on the ark?*, the person tends to overlook the problem with the question and answers "two" (see also Barton and Sanford, 1993; Sanford, 1999). Duffy, Henderson, and Morris (1989) made a similar point with a very different methodology. They presented sentence contexts using Rapid Serial Visual Presentation (RSVP), and the task of the participants was to name the sentence-final word. Duffy et al. observed facilitation relative to an appropriate baseline when participants were presented with "moustache" following a context such as *The barber who watched the woman trimmed the* --. The relevant finding for the present purposes was that the same amount of facilitation was observed for *The woman who watched the barber trimmed the*-- , in which the semantic relations among the content words as specified by the form of the sentence do not lead to the meaning that presumably underlies the facilitation. One way to account for this result, and for the others as well, is to suggest that when the content words of a sentence strongly activate a schema in long-term memory (Rumelhart, 1980), the interpretation the schema makes available "tricks" the comprehender. As a result, people overlook that it was Noah, not Moses, who saved animals from the great flood, and that it is not the barber but rather some unspecified woman removing someone's facial hair (Sanford, 1999).

In a study of people's interpretations of elliptical verb phrases, Garnham and Oakhill (1987) asked participants to read sequences such as *The elderly patient had been examined by the doctor. The child / nurse had too*, and the participants' task was to answer whether the doctor examined the child or the nurse. Garnham and Oakhill also varied whether an adjunct phrase occurred following the by-phrase of the first sentence (e.g., *The elderly patient had been examined by the doctor during the ward round*) in order to test whether question-answering accuracy was affected by the delay between receipt of the critical arguments of the full passive and the question that probed their representation. Garnham and Oakhill found that when the content of the elliptical verb phrase (VP) was plausible

(that is, when the doctor examined a child instead of examining a nurse), the error rate was 8% for the regular condition and 11% for the delayed condition. In contrast, when the content of the elliptical VP was implausible, the error rate for the same two conditions was 25% and 39%. A similar story emerged from the reaction time data: People were faster in the plausible conditions, faster with no intervening adjunct phrase, and the cost of delay was much greater for the implausible texts. Thus, this study again indicates that people's interpretations of sentences are sometimes incompatible with their actual content. Our schematic knowledge states that it is more plausible that a doctor would examine a child than that she would examine a nurse, and somehow that stored information influences the interpretation that is obtained for the sentence.

One important influence on whether misinterpretations occur appears to be sentence complexity. The example sentences that have been mentioned as leading to illusions of comprehension are typically not simple, active, declarative clauses. For example, the item *Don't print that or I won't sue you* (Fillenbaum, 1971, 1974) consists of two clauses, both of which include negation. Work by Wason (1959; Wason & Johnson-Laird, 1972) demonstrated that sentences containing negation (e.g., *57 is not an even number*) are harder to comprehend than affirmative sentences (see also Just & Carpenter, 1976; Just & Clark, 1973).The sentences that induce the Moses illusion involve a fairly complex type of wh-question that places the critical item (e.g., Moses) in a position usually used for presupposed information. Hornby's (1974) study of picture-sentence verification showed that comprehenders are more likely to overlook presupposed information than focused information in a sentence (see also Cutler and Fodor, 1979, for a study making a similar point). Some of the Duffy et al. materials involved embedding of a relative clause inside the main clause, and subject relatives are known to be more difficult than object relatives (King & Just, 1991; Sheldon, 1974). Finally, the Garnham and Oakhill sentences are stated in the passive voice, so not only does the comprehender have to assign thematic roles in an atypical order, he must do so in a full clause and then use those assignments to fill out elided material. This observation regarding complexity is critical, because while there is evidence that sometimes misinterpretations occur with

challenging structures, there is also work showing that people are willing to accept wildly implausible meanings of simple sentences. For example, MacWhinney, Bates, and Kliegl (1984) asked participants to identify the agent in sentences such as *the eraser bites the turtle*. MacWhinney et al. found that English speakers relentlessly chose the first noun phrase as the agent (the sentences' main verbs were all of the agent-patient variety) no matter how strange the result (and a similar finding will be reported here).

Clearly, then, much remains to be learned about people's understanding of sentences. To begin to fill this much-needed gap, this study focuses specifically on thematic roles, which are one important aspect of meaning (Fillmore, 1968). The experiments test how people assign semantic roles to the various concepts in a sentence and how they maintain those assignments. Consider the sentence *the dog was bitten by the man*. The syntax of the sentence together with the argument structure (MacDonald et al., 1994) of the verb *bite* specify that the man is the agent of the action and the dog is the theme or patient. On the other hand, schematic knowledge is consistent with the opposite thematic role assignments. Which source of information "wins", and under what conditions?

The experiments to be presented here examine the assumption that thematic roles come from two sources. One source is the syntax, through a process we will term *theta-transmission*. This mechanism uses the syntactic form of the sentence together with the lexical properties of critical words to assign roles to the component phrases. For the active sentence *The man bit the dog*, the verb *bite* is associated with the thematic roles of agent and patient. The sentence has the syntactic form of an active clause, and so the role of agent is to be assigned to the surface subject and the role of patient to the surface object. Both the lexical content and the overall syntactic shape of the sentence are critical. If the verb were changed to one such as *amazed*, yielding the sentence *The man amazed the dog*, then the subject would be a theme and the object would be an experiencer. And if the syntactic structure were a passive, as in *The dog was bitten by the man*, then the subject would be the patient and the object of *by* would be the agent. The important point about theta-transmission, then, is that

roles are assigned within the language system, and both global syntactic form and lexically based argument structures are relevant.

The other source of information for thematic role assignments is outside the language system, in long-term memory. The process that relies on this source will be termed *schema-transmission*. Rumelhart (1980) argued that long-term memory is organized into packets of information he termed schemas. Schemas encode our stereotypical knowledge of events and states and are activated when the appropriate concepts are retrieved from memory. For example, the concepts MAN, DOG, and BITE might activate a schema in long-term memory stating that dogs bite people. Kintsch (1974) proposed that the representation looks something like the following: BITE (dog: agent, man: patient). The critical feature of this representation is that it explicitly encodes thematic relations. An encounter with a sentence such as *the dog was bitten by the man* leads to the activation of a dog-biting schema, and that schema activates a set of thematic role assignments. One might expect that when the syntactically- and schematically-based role assignments are consistent, sentence comprehension would be easy, and that when they are inconsistent, comprehension would be more difficult. In addition, it is plausible that syntactic complexity will be relevant, so that schema-transmission is more likely to "win" over theta-transmission the more difficult the latter process becomes.

The general model of the language comprehension system that motivates this study, then, assumes that thematic roles are available from both inside and outside the language system (theta-transmission and schema-transmission respectively). Three hypotheses about thematic role assignments were tested in three experiments. The first is that theta-transmission in noncanonical syntactic structures results in weaker and more vulnerable thematic role assignments, compared with a canonical structure such as the active. A noncanonical structure can be thought of as one that is relatively infrequent, both globally in the language as a whole and specifically given a particular verb. For example, the passive structure is less frequent than the active, and so on this definition would be categorized as less canonical (Birner & Ward, 1988; Ferreira, 1994; MacWhinney & Bates, 1989; St. John & Gernsbacher, 1998). The second hypothesis is that schema-transmission yields its own set of

thematic role assignments which either reinforce or undermine theta-based assignments. Finally, if the theta-based assignments are secure because they were established easily (i.e., the structure is canonical), then any inconsistency between theta-based and schema-based thematic role assignments will not influence comprehension. But if the structure in which theta-transmission took place was noncanonical, then the assignments are vulnerable to influence from the schema. In the General Discussion we will speculate that immediate context has a similar effect as schematic knowledge—it influences whether theta-assigned roles stay bound or not. The fundamental idea is that the output of the language system is a fragile representation. It needs support from long-term memory, from context, or from some other source of information.

These hypotheses were tested in three experiments. All deviated from recent psycholinguistic practice in that the paradigms did not yield online measures of processing, but instead produced offline measures of people's interpretations of the sentences (Bates, Devescovi, & D'Amico, 1999). For the first experiment, participants were visually presented active and passive sentences that described either plausible or implausible events, and participants were asked to make plausibility judgments. The results showed that people were "fooled" by one particular type of sentence: reversible but implausible passives such as *the dog was bitten by the man*. For the second experiment, active and passive sentences of various types were presented aurally to participants, and the participants' task was to identify explicitly the concept corresponding to some thematic role. The results were straightforward: Participants were less accurate with passives, especially when the content of the sentence was inconsistent with schematic knowledge. In addition, there appears to be an asymmetry between the two roles involved in transitive actions: participants were less accurate at identifying the agent of the passive than the patient. The third experiment compared two infrequent structures — active clefts and passives — in order to assess whether it is the frequency of the form itself that is important, or instead some other correlated factor. The results from this experiment were essentially identical to those for Experiment 2, suggesting that the latter possibility is correct. Together, the three experiments provide compelling evidence for the model underlying this study:

Theta-transmission is more difficult in the passive, a certain kind of noncanonical structure; as a result, thematic roles are weakly bound to constituents. Schematic information influences the binding of thematic roles to concepts, either reinforcing or weakening them.

Experiment 1

Why would theta-transmission be more difficult in passive sentences than in actives? Let us consider the active structure first, which is shown in Figure 1. Assume that interpretations are built more-or-less incrementally, from left to right (Altmann & Steedman, 1988; Sedivy, Tanenhaus, Chambers, & Carlson, 1999; Traxler, Bybee, & Pickering, 1997). The sequence *the man* is analyzed as the subject of the sentence, and perhaps provisionally as some sort of a proto-agent (Dowty, 1991)—that is, the comprehender likely immediately accesses knowledge indicating that people are often the instigators of actions, particularly so when the concept is placed in subject position. Next, the verb *bit* is accessed and structured into the tree, and its activation makes available its argument structure (MacDonald et al., 1994): *bite* assigns the role of agent to subject and patient to object in active forms. The thematic role "agent" can be assigned to *the man*, so now the interpretation established through theta-transmission is that a man bit something. Next, the sequence *the dog* is encountered, and it is made into a direct object. The verb *bite* still has a theta-role to discharge, and so *the dog* is assigned the role of patient. Theta-transmission is now complete, and the interpretation that results is that a man did a rather strange thing: He bit a dog.

<< Insert Figure 1 about here >>

Now consider the passive, also shown in Figure 1. The parser makes the first noun phrase (the NP *the dog*) the subject of the sentence, and possibly it is provisionally made an agent as well. Now the verb sequence *was bitten* is encountered, and its argument structure becomes available. The information contained with *bitten* indicates that it is a passive participle (or can be), and that it assigns the roles of patient to subject and agent to object of *by* in the by-phrase. On some theories of syntax

(e.g., Baker, Johnson, & Roberts, 1989; Barss, 1985; Chomsky, 1995; Jaeggli, 1986), the representation of a passive sentence includes a trace in post-verbal position, which is a syntactic marker indicating the position from which the surface subject (in this example, *the dog*) was moved. The trace is symbolized in the figure with a letter "t", with the subscript "i" matching the subscript on the subject NP. This match in subscripts represents that the two elements co-refer. Thus, the first matter that might complicate processing of the passive is that the thematic role assigned to the surface subject *the dog* must be assigned first to the trace and then along the resulting "chain" to the noun phrase co-indexed with it. If the comprehender tentatively first assigned the phrase the role of agent, then that role will have to be revised.

Second, the thematic role that is to be assigned to the NP in the by-phrase must be transmitted along a chain as well: In the same theories of syntax referred to above, the passive morphology on the verb (*bitten* in this case) contains the role for what is termed the "external argument", and that role is sent to the by-phrase along a chain from an empty element coindexed with the passive morpheme and ultimately with the appropriate NP. Thus, theta-transmission in the passive requires that both the role for the surface subject and for the object of *by* be sent not directly, but first to an empty element and then to the appropriate lexical items. Assignment of roles to the by-phrase in the passive might also be complicated by the ability of the word *by* itself to assign a semantic role to the phrase which it governs. For example, in the sentence *Mary saw John by the lake*, the phrase *by the lake* is interpreted as a location, both because of the intrinsic meaning of *by* and because the verb *see* has assigned all the thematic roles it needs to discharge. Now consider *The murder was committed by the lake*. The phrase *the lake* should be interpreted as a location here as well, not as an agentive by-phrase (see Liversedge, Pickering, Branigan, & van Gompel, 1998 for evidence that by-phrases in passives are preferentially interpreted as agentive). Therefore, yet another matter that may complicate processing in the passive is that the preposition in the by-phrase is an additional element that can assign a semantic role, requiring the parser to distinguish an agentive by-phrase from some other type. The order of thematic role assignment might be critical as well: For actives, the first role assigned is the agent; but for

passives, the first role assigned is the patient. Finally, passives are far less frequent than actives, and it is well known that frequency of encounter with a structure influences the ease with which the structure is processed (MacDonald et al., 1994; Trueswell et al., 1993). Experiment 3 will present evidence that active clefts (*It was the man who bit the dog*) are just as easy to comprehend as regular actives, even though the structure itself is quite rare (Nelson, 1997). This result suggests that the surface frequency of the form is not critical; what matters is whether thematic roles are assigned in the most typical or frequent order—agent and then patient (for agent-patient verbs, obviously).

The assumption that theta-transmission is more difficult in the passive does not require a theory of grammar that assumes transformational movements and traces; theories that do not countenance transformations also postulate mechanisms that lead to more complex representations for passive sentences. For example, Bresnan (1978) proposed that the syntactic properties of passives may be captured without postulating noun phrase movement and traces. Yet, the theory leads to two distinct sources of difficulty for the passive: One is that the role in the by-phrase is "indirectly" related to the verb which assigns argument structures, while the surface subject role of the passive and both roles of the active are assigned directly by the verb. Second, "the identification of the grammatical function of the by-phrase is inherently complicated by the fact that the by-phrase is a prepositional phrase" (p. 50). As described above, the sentence comprehension system has to determine whether the prepositional phrase is the agentive by-phrase or some other semantic type. Or consider another example of a nontransformational syntactic theory: Perlmutter and Postal (1983)'s Relational Grammar. This approach also assumes that the passive requires a more complex representation than the active. In their theory, an active sentence is represented on just one layer or stratum, but the passive requires two—one to indicate the canonical position of the arguments given the main verb, and another to represent the promotion of the patient to a higher syntactic position. In addition, their theory postulates that the passive is actually an intransitive structure, with the by-phrase serving as what they term a "chomeur"—a constituent that requires a special morphological marker (in English, it is the preposition *by*) and that has a more inert semantic status than the other

phrase (the word “chomeur” is a French word meaning “unemployed” or “idle”). Thus, both the Bresnan and the Perlmutter and Postal theories assume a more complex representation for the passive, and a somewhat more complicated process for getting a thematic role to the by-phrase.

The greater challenge of theta-transmission in the passive compared with the active might cause thematic roles to be less securely attached to the appropriate phrases in the former structure. This insecurity might in turn cause the phrases to be vulnerable to influence from schematic information. If the thematic role assignments made available from an activated schema are compatible with those established via theta-transmission, then the theta-transmitted thematic role assignments will stay bound to their appropriate concepts. But if schematic knowledge is inconsistent, those same syntactically based thematic role assignments will tend to loosen, and misinterpretation of the sentence will result—the comprehender might assign a role compatible with the schema rather than the syntax.

To begin to test these hypotheses, participants were visually presented sentences that were either active or passive, and that described either a plausible or implausible event. The participants’ task was to decide at the end of each sentence whether the event described by the sentence was plausible. If thematic roles have more of a tendency to slip in noncanonical structures such as the passive compared to canonical forms such as the active, then comprehenders should tend to err by responding that a sentence like *the dog was bitten by the man* is plausible. Performance should be fine for the plausible passive (*the man was bitten by the dog*), because even though theta-transmission might be more difficult, schematic knowledge reinforces the syntactically assigned thematic roles and so supports the correct interpretation. The dependent measure was proportion correct: the proportion of sentences in a given condition correctly categorized as either plausible or implausible.

Method

Participants. A total of 34 undergraduates from Michigan State University were tested for this experiment. All were native speakers of American English. The data from two people were not

included because those participants did not properly follow instructions, and so 32 participants were included in the analyses.

Materials. All 72 experimental items described simple transitive events. Each could appear in one of four versions (the complete set of items is given in the Appendix). The item was either active or passive, and the two arguments were arranged in one order or the other. Twenty-four of the items were reversible but highly biased: The two arguments could be swapped but one arrangement was much more plausible than the other (e.g., *the dog bit the man* / *the man bit the dog*). Another twenty-four items were nonreversible: One arrangement of the objects produced not just implausible but semantically anomalous meanings (e.g., *the mouse ate the cheese* / *the cheese ate the mouse*). Items were nonreversible because one argument was animate and the other inanimate. A final set of 24 items was symmetrical: The arguments could be swapped, and the two arrangements were equally plausible (e.g., *the woman visited the man* / *the man visited the woman*).

The semantic properties of these (and many other) sentences were assessed in a separate normative study involving 100 participants. All were native speakers of English, and none participated in the three experiments described below. The purpose of this study was to assess the properties of a large number of stimuli that were candidates for various experiments in the laboratory, including the ones for the present experiments. To reduce the time-burden on participants, the stimuli were distributed over ten lists, and any one participant responded to just one of those lists. The first five lists included all 72 of the experimental items and all the fillers. Half of the 24 biased, reversible items and half of the 24 nonreversible items were presented in the plausible versions and the other half were presented in the implausible versions. The 24 symmetrical items were included as well, half in one arrangement and half in the other. The other five lists were simply the complement of the first five (i.e., if an item in lists 1-5 occurred in its plausible version, it was given in its implausible version for the lists 9-10). All experimental items were presented in their active forms. Any one list required a participant to respond to 120 sentences. Participants were told to read each item slowly and carefully, and they were warned that some of the sentences were implausible. They were told to rate each

sentence on a scale from one to seven, where "1" meant that the sentence was so implausible as to be anomalous and "7" meant that the sentence described an extremely likely event (examples were provided). The means and standard deviations for the six critical conditions are given in Table 1.

<< Insert Table 1 about here >>

As can be seen, the stimuli had the appropriate semantic properties for the experiments. The implausible sentences were rated as far less plausible than the plausible sentences, and the two symmetrical versions were rated almost exactly the same.

The 72 experimental items were presented with 12 filler items. The latter were randomly selected from the set of 144 used for the norming study (an example was *The truck was in front of the car*, and had been rated as reasonably plausible—about 2 on the rating scale). Thus, because half of the biased reversible and half of the nonreversible items were implausible, and all the symmetrical and filler items were reasonably plausible, the ratio of implausible to plausible trials in the experiment was 2 to 5.

Procedure. The experimental session began with the experimenter reading the instructions to the participant. The participant was told to read each sentence presented on the monitor carefully, and then to push one button if it was plausible and another if it was implausible. The experimenter gave examples of each kind of sentence.

Each trial was initiated by the participant. The structure of a trial was as follows: First, a fixation cross appeared on the screen. Participants pushed a pacing button to reveal a sentence, presented centered on the screen, all on one line. Once participants were confident they had understood the sentence, they made their decision about the sentence's plausibility and proceeded to the next trial. The entire experiment lasted approximately 20 minutes. Participants were tested individually in a quiet room.

Design. The experiment employed a 2x2 within-participants design: the syntactic form of the sentence was either active or passive, and the sentence's meaning varied (plausible v. implausible for the biased reversible items, plausible v. anomalous for the nonreversible items, and order one v. order two for the symmetrical items). Each of the three types of sentences — reversible but biased, nonreversible, and symmetrical — was analyzed separately. The dependent measure was accuracy. Decision times were not statistically analyzed, because the reaction times include both the time to read the sentence and the time to make the plausibility decision.

Results

Means were computed for all four conditions for both participants and items. The three sentence types were analyzed separately. Analyses of variance were performed with both participants (F1) and items (F2) as random effects. All effects are significant at $p < .05$ unless otherwise indicated.

Reversible, biased sentences (e.g., *the dog bit the man*). The data are shown in Table 2. The basic result is clear: Participants were highly accurate in all but the implausible, passive condition. For the plausible sentences, 96% of responses to the actives and 92% of responses to the passives were "yes". For the implausible sentences 95% of the responses to the actives were "no", but for the passives, only 74% of responses were "no". Thus, participants know that it is unlikely that a man would bite a dog; however, when the sentence is in the noncanonical passive form, they often get fooled and think the semantic relations are the opposite of what the syntax specifies.

<<Insert Table 2 about here >>

The interaction between form and meaning was highly reliable, $F1(1, 31) = 15.49$, SEM = 2.1%, $F2(1,23) = 13.29$, SEM = 2.9%. Both main effects were significant by participants and items as well: Participants were more accurate with actives than passives (96% v. 83%), $F1(1,31) = 26.92$, SEM = 2.5%, $F2(1,23) = 24.08$, SEM = 2.6%, and more accurate at judging the plausible sentences

than the implausible ones (94% v. 87%), F1(1,31) = 13.14, SEM = 2.6%, F2(1,23) = 8.05, SEM = 2.6%.

Nonreversible sentences (*the mouse ate the cheese*). The pattern for these sentences is different from that observed with the reversible sentences: Accuracy overall was quite high, and there do not appear to be large differences across conditions. Accuracy was somewhat higher for actives (97%) than for passives (94%), but this difference was not significant, F1(1,31) = 3.93, SEM = 1.6%, F2 < 1. Similarly, accuracy was higher for sentences describing plausible events (97%) than implausible events (93%), but this difference too was not significant, F1(1,31) = 3.96, SEM = 1.9%, F2 < 1. There was no interaction, F < 1.

Symmetrical Sentences (*the woman visited the man*). There was a small tendency for accuracy to be higher for the active sentences compared with the passives (89% v. 83%), but this difference was not significant, F1(1,31) = 2.48, SEM = 2.3%, F2< 1. Order had no effect, both F's < 1.

Decision Times. The decision time data cannot be compared across conditions, because actives have fewer words than passives, and because the correct response for the plausible and implausible sentences is different. The sentence types cannot be compared either, because no attempt was made to equate them on variables known to affect reading speed. Nevertheless, it is perhaps useful to know how long participants took to make their plausibility judgments. The mean collapsing over sentence type and all conditions was 2272 ms. The fastest reaction time was for the active, plausible, nonreversible condition (*the mouse ate the cheese*), and the slowest reaction time was for the passive, implausible, reversible condition (*the dog was bitten by the man*). Thus, it does not appear that participants were deliberating particularly extensively about the plausibility of these sentences, taking into account that the reaction times include the time to read the sentence.

Discussion

The key finding from this experiment was that in one particular condition and for one sentence type, participants were inaccurate at judging whether a sentence was plausible: They had trouble with passive sentences when the event described by the sentence is implausible, and when the two nouns in the sentence were both animate (*the dog was bitten by the man*). About one-quarter of the time, comprehenders misinterpreted the sentence: They labeled it as plausible, indicating that they interpreted it in the schema-based way rather than the syntactically mandated way. There are two reasons for thinking that the result is due to the interaction between meaning and syntactic difficulty, and not due to the participant actually thinking it might not be so unusual for a man to bite a dog. First, the normative data show that participants rate this event as implausible. Second, the active counterpart is labeled implausible virtually all of the time. Thus, the problem seems to be that the thematic role assignments established through theta-transmission were undermined by the information from the participants' schemas in long-term memory. This undermining of the syntactically based thematic role assignments only took place when the syntactic structure was noncanonical, as it is for the passive.

Moreover, this pattern held only for the reversible sentences. The migration of thematic role labels from syntactically appropriate to inappropriate concepts did not take place when the concepts differed in animacy. Participants were rarely tricked by *the mouse was eaten by the cheese*. This result might be due to the link between animacy and agency: In general, agents tend to be animate things (exceptions include objects such as cars and computers). Therefore, the participant does not have to rely exclusively on theta-transmission (i.e., the syntactic structure of the sentence) to obtain the correct interpretation; animacy constraints can be used as well.

The important result for now is that this experiment has yielded a misinterpretation effect that might be viewed as the syntactic analogue of the Moses illusion. In the same way that comprehenders overlook the fact that a sentence such as *How many animals of each type did Moses take on the ark* does not actually say what they think it says, they overlook the problem with a sentence such as *The*

dog was bitten by the man. This finding is striking, because not only is the passive sentence much easier than, for example, most garden-path sentences (e.g., *the horse was raced past the barn fell* or even *the man knew the judge was lying*), but it is important also to keep in mind that the participants were college-aged undergraduates. One would expect that even though the passive is encountered less frequently than the active, certainly over the course of 18 years or more of life participants must have encountered thousands of examples of this sentence type. Nevertheless, they have trouble understanding it when they must rely only on the structure alone to obtain a proper interpretation.

Experiment 2

The first experiment provided important evidence for the approach described in the Introduction. To explore the misinterpretation effect further, a second experiment was conducted using the same experimental materials. The task was changed, however: Instead of judging the plausibility of the sentences, the participant was asked to name out loud either the agent or the patient of the sentence. Decision accuracy and reaction times were recorded. This task was used in order to obtain more detailed information about the nature of the misinterpretation effect, and more generally about how syntactic and schematic information are combined to yield an interpretation. Because the participant judges only one thematic role on any given trial, this paradigm makes it possible to discern whether what underlies the overall misinterpretation effect observed in Experiment 1 is a differential difficulty with one of the thematic roles. In addition, it could be that when participants make a global plausibility judgment, they initially misinterpret one thematic role, but then reject the interpretation once they assign the second thematic role. Thus, the present paradigm might be more sensitive to the misinterpretation effect. This possibility is particularly relevant for the nonreversible sentences. Recall that performance was as good for sentences like *the mouse was eaten by the cheese* as for the active counterpart. This result might have occurred because *mouse* can be an agent or patient, but *cheese* can only be a patient. Therefore, in the present experiment using the thematic-role decision

task, participants might make more errors when judging the surface subject of these implausible passives rather than the thematic role contained in the by-phrase. Another advantage of the thematic role decision task used for Experiment 2 is that it allows reaction times to be interpreted (although the decisions themselves will still be the primary dependent measure).

This sort of task has been used in other studies of language comprehension, particularly those that have been conducted within the framework of the Competition Model (Bates et al., 1999; Bates, McNew, MacWhinney, Devescovi, & Smith, 1982; MacWhinney & Bates, 1989; MacWhinney et al., 1984). The Competition Model assumes that the language processor juggles all relevant sources of information to assign semantic roles. And because different languages weight different knowledge sources differently, the model has a strong cross-linguistic emphasis. The relevant point for now is that because the model focuses so heavily on the assignment of semantic roles, and because the design of most experiments conducted within this framework involves the orthogonal manipulation of various syntactic and nonsyntactic factors, the primary dependent measure that has been used in those experiments is the proportion of trials on which participants declare the first noun in a sentence to be the agent. Clearly, this measure has yielded a large body of important work concerning how different languages are comprehended, which lends some validity to the use of the thematic role decision task in the present experiment. (See Bates et al., 1999, for a discussion of why the various criticisms that have been made of the task are inappropriate.) One difference between the agent-decision task used by proponents of the Competition Model and the task used here is that here both thematic roles are tested. Nevertheless, because only one role is probed on any given trial, the logic of both paradigms is similar.

To test the hypotheses motivating this study – that during language comprehension, interpretations come from both the syntax (theta-transmission) and from world knowledge (schema-transmission), and that the two compete in syntactically demanding constructions – participants were presented sentences and asked to name the agent or patient of the action. Sentences were presented aurally, and for two reasons: First, comprehenders have much more experience with spoken than with

written language, but most of psycholinguistics has focused on visually presented materials. The task used in this experiment can be implemented just as easily with spoken as with written materials, and so there was no reason not to present the stimuli in the more ecologically valid modality. Second, it is possible that prosodic information present in naturally spoken sentences aids in the comprehension of these active and passive sentences (see MacWhinney, Bates, & Kliegl, 1984, for evidence that this is true at least for actives). The use of auditory presentation allows participants to take advantage of an additional source of potentially useful information during comprehension. One possible concern about using auditory presentation for this experiment is that it makes comparison with the results from Experiment 1 more difficult. Therefore, the first experiment was re-run after the second experiment was conducted, using the spoken auditory versions of the sentences presented visually in Experiment 1. The plausibility judgment results were similar[1]. Therefore, the basic misinterpretation effect found in Experiment 1 is a phenomenon of language comprehension, and does not depend on the stimuli being presented in a particular modality.

Method

Participants. A total of sixty-three undergraduates attending Michigan State University participated in the experiment in exchange for partial credit in their Introductory Psychology courses. Seven of the participants were not included in the data analyses because they were non- native speakers of English[2], five because they could not understand the task (as indicated by their performance on the practice trials), and three because they did not speak loudly enough to reliably set off the voice-activated relay switch. Thus, the data from 48 participants were included in the data analyses.

The same 72 experimental items used for Experiment 1 (each of which occurred in one of four versions, defined by the orthogonal combination of voice and plausibility) were used for this experiment. A total of 144 filler items was included as well—the fillers that were normed as part of the larger normative study. These were sentences of a variety of different syntactic types. One half of

the fillers were constructed so that they could be probed regarding either the location in which some event took place or the color of some critical object (e.g., *Dave fed Alpo to the brown dog at the park*). The other 72 were written so either a temporal period or the action could be probed (e.g., *Bicycles were banned by the authorities in May*).

The 72 experimental items in their four different versions (active/passive by plausible/implausible), the 144 filler sentences, and the practice sentences were recorded by a female native speaker of American Midwestern English and the sentences were digitized at a rate of 10 kHz. Each sentence was stored as a speech file for presentation over headphones. An individual participant heard a given item only once and thus heard just one version of any experimental sentence. Across experimental items, a participant heard an equal number of actives and passives, and an equal number of plausible and implausible sentences. In total, a participant responded to 216 sentences: 24 that were biased but reversible, 24 nonreversibles, 24 symmetricals, and 144 fillers. For half the 72 experimental items, the participant was required to identify the agent; for the remaining 36 experimental items, the participant identified the patient. For the 144 fillers, the participant made 36 decisions regarding a color, 36 regarding a temporal interval, 36 concerning a location, and 36 about the action. The 216 items were presented in a random order, generated separately for each participant in the experiment.

Procedure. The experimental session began with instructions. Participants were told that they would listen to sentences, and after each, make a semantic decision. They were informed that the decisions were of six different types, and the types were described and illustrated with a sample sentence. These six types were: (1) DO-ER (corresponding to agent): Participants were told that in *the man fixed the dress*, the man would be the do-er, because he is the one who did the action. (2) ACTED-ON (corresponding to patient or theme): In the same sentence the dress is the thing acted-on, because it is the dress that is acted on by the do-er. (3) ACTION: For the same sentence the correct response would be "fix" or "fixing" (both variants were scored as correct), because fixing is the action described in the sentence. (4) LOCATION: Given *the bank was across the street,* the correct response

would be “across the street”, because that is where one of the things mentioned in the sentence is located. (5) COLOR: For *I saw a bright yellow Volkswagon yesterday* the correct response would be "yellow", because that is the color of an object provided in the sentence. Finally, (6) WHEN: For the same sentence, the correct response would be “yesterday”, because the sentence states that that is when the event took place.

The participants were then read 12 example sentences from the instructions sheet, and after each they had to make two decisions for each of the six types. The experimenter corrected any errors and then asked the participants whether they understood the rationale for each response. If participants provided a satisfactory response, the experimenter then set up the practice session. The practice session was identical to the experimental portion, and included twelve unique sentences presented aurally (two for each of the six decisions). If a participant made more than two errors, that person was excused from the rest of the experiment (five people were not asked to continue based on this criterion). If the participant made fewer than two errors, the experimental session was initiated.

A trial began with a message to the participant to begin the trial when ready. After a button on a response panel was pushed, a sentence was played out over headphones. At the end of the sentence, one of the six prompts appeared in Arial 24-point font, and the participant’s task was to provide the appropriate response out loud. The onset of vocalization triggered a voice-activated relay, and thus decision times were automatically stored in a computer file. The participant’s response was written down by the experimenter so that the trial could be scored off-line as either correct or incorrect. Participants were tested individually, and each experimental session lasted between 45 minutes and 1 hr (depending on how much time participants chose to take between trials).

Design. The experiment employed a 2x2x2 within-participants design: the syntactic form of the sentence was either active or passive, the sentence’s meaning varied (plausible v. implausible for the biased reversible items, plausible v. anomalous for the nonreversible items, and order one v. order two for the symmetrical items), and the participant either made a decision about the agent or patient/theme. Each of the three types of sentences — reversible but biased, nonreversible, and

symmetrical — was analyzed separately. The primary dependent measure was accuracy, but decision times were analyzed as well.

Results and Discussion

Reaction times shorter than 300 ms and longer than 7500 ms were eliminated. These criteria resulted in the removal of less than 3% of the data. Means were computed for all eight conditions for both participants and items, and analyses of variance were performed with both participants (F1) and items (F2) as random effects. All effects are significant at $p < .05$ unless otherwise indicated.

Reversible, biased sentences. The percentage of decisions that were correct in each of the eight conditions is shown in Table 3. For agent decisions, accuracy was the same for plausible and implausible active sentences (99% for both). Thus, people had no trouble stating that the man was the agent in a sentence such as *the man bit the dog*. With passives, participants were less accurate overall (81%), and less accurate for sentences that were implausible (74% v. 88%). For patient decisions, participants were less accurate in response to passives, but for the two sentence types accuracy was equivalently higher in the two plausibility conditions.

<< Insert Table 3 about here >>

The overall 2x2x2 ANOVA revealed a significant three-way interaction, $F1(1,47) = 5.23$, SEM = = 2.1%, $F2(1,23) = 5.43$, SEM = 2.7%. Collapsing over the agent v. patient decision, there was also an interaction between form and meaning, $F1(1,47) = 5.63$, SEM = 2.4%, $F2(1,23) = 17.89$, SEM = 2.1%. For actives, participants were about as accurate with plausible sentences (98%) as with implausible sentences (95%). For passives, participants were more accurate with plausible sentences (90% v. 80%). There was also a significant two-way interaction between form and decision type, $F1(1,47) = 14.19$, SEM = 2.4%, $F2(1,23) = 18.65$, SEM = 2.0%. For actives, participants were better at identifying the agent than the patient (99% and 94% respectively); for passives, the opposite was true (81% and 89%). There was no interaction between meaning and decision type, both F's < 1. There was a significant main effect of form, $F1(1,47) = 28.91$, SEM = 3.0%, $F2(1,23) = 78.85$, SEM

= 2.4% and of meaning, F1(1,47) = 24.60, SEM = 1.8%, F2(1,23) = 11.26, 2.9%, but no main effect of decision type, F1 = <1, F2(1,23) = 2.5, SEM = 2.4%, p > .10.

The decision time data (correct trials only), while of secondary importance, are also of interest. For agent decisions, participants took longer with implausible sentences, but only for the actives. Participants required more time with the passives overall, but plausibility had little effect on the decision times. For patient decisions, participants took longer with passives than with actives, and they were faster when the meaning of the sentence was plausible. The three way interaction among form, meaning, and decision type was marginal by participants and significant by items, F1(1,47) = 2.64, SEM = 66 ms, p = .10, F2(1,23) = 4.17, SEM = 63 ms. None of the two-way interactions was significant, all p's > .15. Each of the main effects was highly significant: Participants took longer to make decisions about passives than actives (2071 v. 1807 ms), F1(1,47) = 27.52, SEM = 71 ms, F2(1,23) = 94.49, SEM = 42 ms; longer with implausible sentences than plausible ones (2057 v. 1822 ms), F1(1,47) = 24.37, SEM = 67 ms, F2(1,23) = 49.48, SEM = 44 ms; and they took longer to make patient decisions than agent decisions (1999 v. 1879 ms), F1(1,47) = 5.63, SEM = 71 ms, F2(1,23) = 14.97, SEM = 66.

Participants had more difficulty identifying thematic roles both when a sentence was syntactically challenging, as in a passive, and when it was implausible. Interestingly, decisions were affected by plausibility even for active sentences, but in general, the effect of plausibility was larger for passives than actives. Certainly, overall, there was a major cost for the passive; apparently, even college students have some difficulty keeping track of thematic role assignments in this particular noncanonical structure. Thus, the results of this experiment for biased, reversible sentences are quite similar to those obtained in Experiment 1, and the basic pattern held for both agent and patient decisions. At the same time, the task used in this experiment yielded an important, new result: Participants were less accurate by 11% when they had to identify the agent rather than the patient of the implausible passive (74% v. 85%).

Interestingly, this experiment showed a cost for the passive structure overall, even when it was highly plausible. Since the critical studies conducted by Slobin (1966), it has been generally believed that if a passive is highly biased and plausible, it is as easy to process as an active, because people can go immediately to the semantic roles without having to compute a syntactic structure. These sentences were highly biased (as the rating data make clear), yet participants had more difficulty with plausible passives than with implausible actives. Perhaps this is because the meaning was highly biased but the arguments did not differ in animacy. Thus, it is of interest to examine the results for the nonreversible items.

Nonreversible sentences. The data are shown in Table 3. Consider first just the accuracy data. For agent decisions, and for both active and passive forms, accuracy was lower when the sentence was implausible, and performance overall was worse with passives than with actives. For the patient decisions, plausibility had some effect on performance with the two structures, and again, accuracy was lower with passive forms. As the pattern of means suggests, there was no three-way interaction, $F < 1$, $F2(1,23) = 1.52$, SEM = 1.6%, $p > .20$. None of the two-way interactions was significant either, all p's > .05. There was no main effect of decision type (91% accuracy for agent decisions and 90% for patient decisions), both p's > .15. Thus, the only significant main effects were of structure (96% accuracy with actives and 85% with passives), $F1(1,47) = 23.90$, SEM = 3.3%, $F2(1,23) = 46.94$, SEM = 2.2% and of meaning (93% accuracy with plausible sentences and 88% with implausible sentences), $F1(1,47) = 9.66$, SEM = 2.1%, $F2(1,23) = 14.32$, SEM = 1.9%.

The reaction time results are similar. Overall, participants took longer to make correct thematic decisions for passives than for actives (2009 v. 1858 ms), $F1(1,47) = 9.12$, SEM = 71 ms, $F2(1,23) = 13.46$, SEM = 81 ms, and for implausible sentences than for plausible ones (2077 v. 1789 ms), $F1(1,47) = 22.11$, SEM = 87 ms, $F2(1,23) = 26.96$, SEM = 72 ms. One difference, though, is that in the latency data there is a main effect of decision type: Participants took longer to make patient decisions than agent decisions (2032 v. 1835 ms), $F1(1,47) = 12.85$, SEM = 78 ms, $F2(1,23) =$

11.83, SEM = 90 ms. None of the two-way interactions was significant, nor was the three-way, all p's > .10.

The results for nonreversible sentences are striking and counterintuitive. It might be expected that if a passive sentence is nonreversible, participants would be accurate and fast at retrieving thematic roles because there is only one semantically reasonable arrangement of the arguments. It is possible, then, that the effect obtained here was observed because the task specifically required comprehenders to identify whatever the agent or patient was for a sentence as stated—even if the result made no sense (an approach that has been used with quite fruitful results within the context of the Competition Model, for example). An unfortunate side effect of this requirement might have been that it was not possible for participants to use the semantic information maximally and in a typical fashion, because atypically, the sentences sometimes expressed anomalous events.

To examine this possibility, a separate experiment was conducted in which participants received only plausible, nonreversible sentences in active or passive form and had to identify the agent or patient. All the fillers from the main experiment were included with these 24 experimental items. A total of 40 participants was tested. The results were clear: For the active sentences, participants were 100% accurate at identifying the agent and 99% accurate at identifying the patient. For the passives, accuracy levels in the same two conditions were 90% and 95% respectively. The interaction between syntactic form and decision type was marginal by participants, $F1(1,39) = 3.46$, $p < .07$, SEM = 1.6% and not significant by items, $F2(1,23) = 2.41$, $p > .10$, SEM = 1.8%. There was a significant main effect of syntactic form, $F1(1,39) = 14.24$, SEM = 1.9%, $F2(1,23) =(1,23) = 11.89$, SEM = 2.0%, but no effect of decision type, both p's > .20. Reaction times associated with correct trials were 1699 ms for identifying the agent of the active, 1422 ms for identifying the patient of the active, 1916 ms for identifying the agent of the passive, and 1695 ms for identifying the patient of the passive. Both the main effects of structure and decision type were significant, but the interaction was not, $F < 1$.

It appears, then, that even when participants deal only with nonreversible and plausible sentences (and a number of fillers, of course), there is still a cost for the passive sentences. Accuracy overall was high (over 90%), and in particular, higher than in the main experiment, but decisions were still influenced by syntactic complexity.

Symmetrical Sentences. These items were constructed so that both arrangements of the arguments were equally plausible. For example, it is as reasonable that a customer would thank a clerk as that a clerk would thank a customer. In addition, our intuitions about plausibility were supported by the normative data described in the Methods section. Thus, these conditions can be viewed as providing a baseline for the amount of difficulty that a passive causes when semantic information neither reinforces nor contradicts syntactically based thematic role assignments. Note that although a 2x2x2 ANOVA was performed on these data, the second variable is now arrangement of arguments rather than plausibility. (The first variable is syntactic form and the second is decision type, as in the previous analyses.)

The data are shown in Table 3. The pattern of results is now familiar: Participants were equally accurate at identifying the agent and patient of the active, and performance overall was high (94% and 92% respectively). Accuracy was lower for the passive, and lower for the agent than the patient (85% v. 79%) of those passives. The interaction between syntactic form and decision type was significant by participants, $F1(1,47) = 5.63$, SEM = 2.5% but not by items, $F2(1,23) = 1.20$, $p > .25$, SEM = 3.8%. There was also a main effect of syntactic form, $F1(1,47) = 25.80$, SEM = 3.2%, $F2(1,23) = 17.92$, SEM = 4.2%: Decisions were more accurate for actives (93%) than for passives (82%). There was no main effect of decision type, both $F's < 1$.

Oddly, there appears to be an effect of the order variable: Accuracy was 85% for the order arbitrarily designated as “one”, and 90% for the order arbitrarily labeled as “two”, $F1(1,47) = 6.75$, SEM = 2.5%, $F2(1,23) = 3.09$, $p < .09$, SEM = 3.6%. In other words, although it appears that it is as likely that a customer would thank a clerk as the contrary, these participants apparently thought otherwise. This result is especially strange given that the norms did not reveal any significant

differences between the two orders. This order variable did not participate in either of the possible two-way interactions, all p's > .20. However, the three-way interaction was reliable by participants, $F1(1,47) = 5.78$, SEM = 2.2%, $F2(1,23) = 3.32$, $p < .08$, SEM = 2.5%. Since this result does not appear to make much sense, it may perhaps be considered spurious.

The results for decision times are shown in Table 3. Latencies were longer for passives than for actives, $F1(1,47) = 20.81$, SEM = 80 ms, $F2(1,23) = 32.28$, SEM = 71 ms. Participants required about 2156 ms to respond to the passives, and 1899 to respond to the actives. Decision times for passives were not affected by decision type (agent or patient), but active decisions were, $F1(1,47) = 7.29$, SEM = 77 ms, $F2(1,23) = 9.68$, SEM = 62 ms for the interaction between syntactic form and decision type. All other possible effects were not significant, all F's < 1.

The data for the symmetrical sentences, then, are consistent with the hypothesis that thematic roles are not as tightly bound in passives as they are in actives. In addition, performance was worse for the agent role in the passive compared with the patient, consistent with what was observed for the reversible, biased sentences.

In summary, the main findings from this experiment are the following. First, for all sentence types, passives are more difficult than actives. Clearly, thematic role assignments are more difficult to maintain in passives than in actives, even when the sentence is nonreversible (contrary to results reported by Slobin, 1966). Thus, there is every reason to think that comprehenders made an honest attempt to build a syntactic structure even for the highly biased passive sentences. In addition, it is more difficult to maintain theta-based role assignments in the passive when a schema is not available to reinforce them. This effect is revealed both by the large difference in accuracy for plausible and implausible passive sentences, and in the overall difference between passive symmetrical sentences and the plausible biased, reversible and nonreversible items. The symmetrical sentences can be viewed as ones that are neither confirmed nor contradicted by schematic knowledge, and so theta-assignments do not get help from schematic information. Thus, the worst case is the one in which the meaning of a sentence based on theta-transmission is actually contradicted by schematic knowledge;

not quite as bad but still non-optimal is the case in which a schema is not available to reinforce the meaning of the sentence. Of course, in normal discourse an implausible sentence such as *the dog was bitten by the man* or a symmetrical one like *the man was visited by the woman* would likely be easy to process, because the theta-based assignments would be reinforced by discourse information. Indeed, one of the main points of these experiments is that when a comprehender must reply on nothing but linguistic knowledge to make thematic role assignments, the result is a fragile representation that can easily be distorted (e.g., by real-world knowledge). Linguistic representations such as theta-role assignments need support either from discourse or from world-knowledge.

Another intriguing result that has not been reported before is that the difficulty of the passive is particularly evident when the participant must make decisions about the agent of the action rather than the patient. This finding runs counter to the speculation made in the Discussion section of the first experiment. There, it was predicted that participants might have more trouble with **patients** in passives (the surface subject) than with agents, because there are more constraints on what an agent can be (agents must be animate, so the participant can reject concepts such as *cheese* as agents without even understanding the sentence). Another reason for suspecting that participants might have had more trouble with patients in passives has to do with the order in which thematic roles are assigned. Many researchers in linguistics and psycholinguistics have assumed that comprehenders have a default strategy of making the first NP in a sentence an agent, especially if it is animate (Lakoff, 1987). Therefore, in passives, the surface subject would usually be assigned the wrong thematic role initially—the NP *the dog* is not the agent in *the dog was bitten by the man*, but is rather the patient. This revision can be made as soon as the passive morphology on the verb is encountered, before the by-phrase. And once the first thematic role is fixed, there are no degrees of freedom for the NP in the by-phrase: It must be the agent, the only role left to be assigned. Yet, despite all of these advantages that the agent of the passive would seem to enjoy, comprehenders are less accurate assigning that thematic role, not more. This striking result will be discussed in more detail later.

Experiment 3

The first and second experiments together make the point that a noncanonical syntactic structure like the passive is difficult to comprehend. This difficulty is revealed particularly when the sentence describes an event that is highly implausible. In implausible sentences, the thematic role assignments that are computed via theta-transmission and that are activated from world knowledge conflict. If the syntactic structure of the sentence is canonical and theta-transmission is therefore easy, then in general the sentence is interpreted correctly. But if the syntactic structure of the sentence is noncanonical, the binding of thematic roles to concepts is not as strong as it is for canonical structures. Sentences that are plausible and noncanonical have more tightly bound thematic roles because the roles established through theta-transmission are reinforced by role assignments that come from schemas. But sentences that are implausible and noncanonical are sometimes misinterpreted, because the theta-transmitted roles are already weaker and the information from the participant's schema undermines those assignments. The second experiment yielded an important additional result: It appears that the agent is more problematic than the patient in passive sentences.

The third and final experiment was conducted in part to see whether the results of Experiment 2 would replicate, especially the finding that performance was worse for the agent of the passive than for the patient. More importantly, the third experiment expands on the previous ones by setting up a comparison between two noncanonical structures: the active-cleft and the passive. For example, consider *It was the man who bit the dog* and *The dog was bitten by the man*. The first sentence, the active-cleft, occurs quite rarely (Nelson, 1997; Quirk, Greenbaum, Leech, & Svartvik, 1985). It is also more syntactically complex than the ordinary active, because (according to transformational theories of grammar), the phrase *the man* has been moved from its initial position as subject of *bit*. The moved phrase leaves behind a trace, and the trace must be coindexed with the moved constituent. In addition, the cleft structure is a device for focusing information in discourse (Ball, 1994; Delahunty, 1984; Nelson, 1997): The moved phrase is the informational focus, and the sentence

carries a strong presupposition that the event described in the rest of the sentence (e.g., biting of a dog) is already established in the discourse. Thus, the active-cleft might also be complex because it requires a particular discourse context to make it felicitous.

The interesting question, then, is whether the active-cleft behaves more like an active or a passive sentence. It is like a passive in that it is infrequent, noncanonical, and is tightly discourse constrained, but it is like an active in that thematic roles ultimately are assigned to constituents in a frequent and typical order (agent and then patient). To evaluate the difficulty of the active-cleft, one of two strategies could be adopted: One is to compare the active-cleft to the active in the same experiment, and the other is to compare the active-cleft to the passive. It is not practical to include all comparisons in a single experiment, because the design would be exceedingly complex. Therefore, the decision was made to run Experiment 3 as a comparison between active-clefts and passives. This choice was made because our intuitions suggested that active-clefts would be quite easy, and so an experiment comparing actives and active-clefts might simply have yielded a null effect (indeed, a cross-experiment comparison will demonstrate just that). This third experiment, then, had the same design as Experiment 2, except that the active condition was replaced with an active-cleft condition. The materials were identical, as was the task.

Method

A total of forty-four undergraduates attending Michigan State University participated in the experiment in exchange for partial credit in their Introductory Psychology courses. Four of the participants were not included in the data analyses because they were non-native speakers of English, two because they could not understand the task (as indicated by their performance on the practice trials), and two because they did not speak loudly enough to reliably set off the voice-activated relay switch. Thus, the data from 32 participants were included in the data analyses.

The materials for this experiment were identical to the ones used for Experiment 2, except that the active versions were modified to be active-clefts. Thus, for each of the 72 experimental

sentences, a sentence such as *The man bit the dog* was changed to *It was the man that bit the dog*. The procedure was the same as that used for the second experiment.

The experiment employed a 2x2x2 within-participants design: The syntactic form of the sentence was either active-cleft or passive, the sentence's meaning varied (plausible v. implausible for the biased reversible items, plausible v. anomalous for the nonreversible items, and order one v. order two for the symmetrical items), and the participant made a decision either about the agent or patient/theme. Each of the three types of sentences — reversible but biased, nonreversible, and symmetrical — was analyzed separately.

Results

Reaction times shorter than 300 ms and longer than 7500 ms were eliminated. These criteria resulted in the removal of less than 4% of the data. Means were computed for all eight conditions for both participants and items, and analyses of variance were performed with both participants (F1) and items (F2) as random effects. All effects are significant at $p < .05$ unless otherwise indicated.

Reversible, biased sentences. The percentage of decisions that were correct in each of the eight conditions is shown in Table 4. For agent decisions, accuracy was the same for plausible and implausible active-cleft sentences (97% for both). Thus, people had no trouble stating that the man was the agent in a sentence such as *It was the man who bit the dog.* With passives, participants were less accurate overall (72%), and less accurate for sentences that were implausible (68% v. 77%). For patient decisions, a similar pattern held: high accuracy in the active-cleft condition, and no effect of plausibility (95% and 93% for the plausible and implausible conditions, respectively); lower accuracy overall for the passives, and a large effect of plausibility (87% accuracy in the plausible condition, 74% in the implausible condition). Comparing performance on passives in the agent and patient conditions, it can be seen that the finding of greater vulnerability for the agent thematic role in the passive replicated in this experiment: Performance is better for the patient than for the agent in both plausibility conditions.

<< Insert Table 4 about here >>

The ANOVA revealed a significant two-way interaction between syntactic structure and plausibility, F1(1,31) = 7.48, SEM = 3.1%, F2(1,23) = 12.37, SEM = 2.4% : The effect of plausibility was absent for active-clefts but large for passives. There was also a significant interaction between form and thematic role decision, F1(1,31) = 5.67, SEM = 3.2%, F2(1,23) = 3.75, p > .06, SEM = 4.0%: Performance on active-clefts was equally good for both thematic roles, but for passives, performance was much worse with agents than patients. The three-way interaction in this experiment was not significant, both F's < 1. The pattern taking into account all three variables together differs slightly from what was obtained in Experiment 2 (which employed actives and passives) in the following away: In Experiment 2, the effect of plausibility was present only for passives and when participants made agent decisions on those passives. In the present experiment, the effect of plausibility was apparent only for passives, but for both agent and patient decisions. Finally, the main effect of structure was significant, F1(1,31) = 30.26, SEM = 4.9%; F2(1,23) = 50.58, SEM = 3.8%, the effect of plausibility was marginal, both p's > .08, and there was no main effect of thematic role decision, both F's < 1.

Decision times were longer overall for passives than for active-clefts (2004 v. 1640 ms), F1(1,31) = 31.36, SEM = 92 ms, F2(1,23) = 17.09, SEM = 127 ms, longer for implausible sentences than for plausible sentences (1904 v. 1740 ms), F1(1,31) = 6.13, SEM = 94 ms, F2(1,23) = 6.69, SEM = 94 ms, and longer for patient decisions than for agent decisions (1939 v. 1705 ms), F1(1,31) = 12.75, SEM = 92 ms, F2(1,23) = 8.76, SEM = 102 ms. There was a significant interaction between structure and plausibility by participants only, F1(1,31) = 4.18, SEM = 77 ms, F2(1,23) = 1.03, SEM = 136 ms.

Nonreversible sentences. Accuracy overall was lower for passives than for active-clefts (84% v. 94%), F1(1,31) = 14.43, SEM = 3.7%, F2(1,23) = 31.56, SEM = 2.5%). Accuracy was lower for implausible compared with plausible sentences (83% v. 95%), F1(1,31) = 25.94, SEM = 3.5%,

F2(1,23) = 27.60, SEM = 3.4%. Decisions about the agent were made more accurately than those about the patient (92% v. 86%), F1(1,31) = 6.05, SEM = 3.6%, F2(1,23) = 8.62, SEM = 3.0%. The only other significant effect was the interaction between syntactic form and meaning, F1(1,31) = 7.01, SEM = 3.1%, F2(1,23) = 7.26, SEM = 3.0%. For active-clefts, accuracy was higher for plausible sentences than for implausible sentences (97% v. 91%); the same was true for passives, but the difference was much larger (93% v. 75%).

Decision times for the nonreversible sentences were longer overall for passives than for active-clefts (2065 v. 1639 ms), F1(1,31) = 43.08, SEM = 92 ms, F2(1,23) = 13.83, SEM = 156 ms, longer for implausible sentences than for plausible ones (2019 v. 1685 ms), F1(1,31) = 25.73, SEM = 93 ms, F2(1,23) = 23.29, SEM = 102 ms, and longer for patient decisions than agent decisions (1967 v. 1737 ms), F1(1,31) = 14.12, SEM = 87 ms, F2(1,23) = 8.05, SEM = 100 ms. No other effects were significant.

Symmetrical Sentences. Recall that these sentences were labeled "symmetrical" because they were supposed to be equivalently plausible in both versions (e.g., *the woman visited the man* is no more or less plausible than *the man visited the woman*). The normative data supported this assumption: the versions arbitrarily designated as "order 1" were rated 2.95 on a 7 point scale (1 being highly plausible, 7 being highly implausible), and their reversed counterparts were rated 2.98 on the same scale. Nevertheless, in the present experiment, accuracy overall was 85% for the version 1 sentences and 89% for the version 2 sentences, F1(1,31) = 4.13, SEM = 2.9%, F2(1,23) = 5.41, 2.5%. This significant difference is surprising, obviously, but the difference is not large. Clearly some slight semantic differences do distinguish the versions, and it appears that the decision task (used in Experiments 2 and in this one) is more sensitive to them than the plausibility judgment tasks (i.e., both the normative study and Experiment 1). Accuracy was higher for active-clefts than for passives (95% v. 79%), F1(1,31) = 22.41, SEM = 4.7%, F2(1,23) = 90.78, SEM = 2.3%. Accuracy was the same overall for agent and patient decisions, both F's < 1.

Most critically, the interaction between syntactic structure and decision type was significant, $F1(1,31) = 8.85$, SEM = 4.0%, $F2(1,23) = 14.15$, SEM = 3.1%. For active-clefts, participants were more accurate making decisions about the agent than about the patient (98% v. 91%). For passives, the opposite was true (74% and 84%).

Decision times were longer for passives than for active-clefts (2154 v. 1703 ms), $F1(1,31) = 41.89$, SEM = 99 ms and longer for patient decisions than agent decisions (2080 v. 1778 ms), $F1(1,31) = 10.86$, SEM = 129 ms, $F2(1,23) = 111$ ms. Decision times did not differ for the two versions, both $F's < 1$. The only other significant effect was an interaction between syntactic form and decision type, $F1(1,31) = 5.69$, SEM = 88 ms, $F2(1,23) = 3.47$, SEM = 151 ms, $p < .08$. For both active-clefts and passives, participants took longer to make patient than agent decisions. However, the difference was larger for active-clefts (1928 v. 1479 ms) than for passives (2231 v. 2078 ms).

The main results of Experiment 3 replicate those of the second experiment. Performance is worse for passive sentences, particularly when they express implausible events. The asymmetry between the agent and patient roles in the passive was found here as well: Comprehenders are less accurate at identifying the agent of a passive compared with the patient. Interestingly, this effect shows up only for the biased, reversible sentences and for the symmetrical sentences; in neither Experiment 2 nor 3 was the asymmetry found for the nonreversible passives. Therefore, it appears that whatever the challenge is that is presented by the agent role in the passive, it is overcome when the two thematic roles differ in animacy. Finally, this third experiment makes clear that a structure may be quite infrequent but still easily processed. The active-cleft is a rarely used form, yet comprehenders had little difficulty with it. To reinforce this point, an analysis between the two experiments was conducted.

Between-Experiment Comparison Between Actives and Active-Clefts

The results of Experiment 3 make clear that the active-cleft is a much easier structure for comprehenders to process than is the passive. In addition, an informal examination of the numbers

seems to suggest that the active-clefts are no more difficult than regular actives. To formalize this comparison, the active conditions from Experiment 2 were compared with the active-cleft conditions from Experiment 3. Only the data from the first 32 participants from Experiment 2 were included, so that both experiments would have an equal number of participants. The result is a design much like the ones for Experiments 2 and 3, except that the structure variable is now between-participants rather than within. Because this analysis is exploratory and to maximize the chances of finding any differences, the three difference sentence types – biased reversible, nonreversible, and symmetrical – were combined.

The overall accuracy for actives and active-clefts was 96% and 98% respectively. Thus, any numerical difference actually disfavors the canonical structure, but this difference was not significant (both p's > .25). Indeed, the only significant effect was that agent decisions were made more accurately than patient decisions (98% v. 94% correct), $F(1,62) = 9.95$, SEM = 1.4%. In addition, as a comparison of Tables 3 and 4 reveals, decision times were no slower for active-clefts than for actives. Therefore, all the available evidence suggests that the active-cleft is no harder to process than the ordinary active structure.

General Discussion

The three experiments reported here provide striking support for the approach described in the Introduction. Recall that these experiments were designed to test the following hypotheses: First, theta-transmission in certain noncanonical structures is difficult. As a result, thematic roles are not as tightly linked to words in these structures as they are in structures such as the active. Second, schemas in long-term memory provide their own thematic roles for the concepts in a sentence. Third, the thematic role assignments in the noncanonical structure (the passive) are more loosely bound than they are in actives; as a result, the schema-based assignments may interfere, causing comprehenders to misinterpret these sentences.

The most important results from the three experiments are summarized in Table 5. Perhaps the first point to make about the entire set of results is that active sentences are clearly easy to interpret, and in particular, comprehenders are willing to accept just about whatever interpretation for them that is mandated by the syntax. Thus, just as MacWhinney et al. and Bates et al. (1999) found, if a sentence states that some cheese ate a mouse, then people simply live with the anomalous meaning. Bates and MacWhinney's Competition Model explains the result as a consequence of English speakers' heavy reliance on word order for making thematic role assignments. This result is also compatible with the hypotheses motivating this study: Theta-transmission happens easily in actives, and so thematic roles are tightly bound to words. As a result, information from schemas cannot easily interfere and cause misinterpretations.

<< Insert Table 5 about here >>

Second, passive structures are hard to comprehend. Indeed, it is striking that virtually every contrast from all three experiments demonstrates a cost for the passive, whether the sentence was nonreversible or merely plausible, and whether the measure was accuracy of decisions or reaction time. Following the demise of the Derivational Theory of Complexity (Fodor, Bever, & Garrett, 1974) and the demonstrations by researchers such as Slobin (1966) that under some circumstances passives are easy to process, the consensus in psycholinguistics became that passives are not more demanding than actives as long as they are semantically constrained. The current results seriously challenge this assumption. Perhaps the picture-sentence verification task used by Slobin and others during the 1960s was not sensitive enough to detect differences in complexity (as argued, for instance, by Gough, 1965, 1966). Consistent with this possibility, note that the plausibility judgment task used in Experiment 1 in this study did not reveal a cost for the nonreversible passive, whereas virtually every measure from the other two experiments using the thematic role identification task did. Clearly, then, passives are difficult to understand, even when animacy constraints permit only one

sensible assignment of thematic roles to constituents (and even when participants did not have to deal with the anomalous passives; see Experiment 2).

The finding that passives are more difficult even when the sentences are tightly constrained semantically suggests that the thematic role assignments the schema provides are not powerful enough to compensate entirely for the weak binding caused by less successful theta-transmission. Schema-based roles help with the binding, but they do not absolutely lock the roles down to the appropriate words. In addition, the results show that the degree to which schema-based information is helpful varies with the amount of semantic constraint. Performance is worst on implausible passives that contradict a schema, better with the symmetrical passives that are neither incompatible with nor reinforced by any existing schema, and best of all with passives that are highly biased and so have a reinforcing schema. But again, even in this latter, most semantically constrained case, performance with passives does not equal the level of performance with actives.

One of the most intriguing results from the second and third experiments is the discovery that comprehenders have more difficulty dealing with the agent role of the passive (the by-phrase) than with the patient role (the surface subject). Both experiments demonstrated that if the concepts described in the sentence were reversible (as they are in the biased, reversible and the symmetrical conditions), then consistently people had more trouble identifying the agent of the passive than the patient. This result suggests that the role assigned to the constituent in the by-phrase is more fragile than the role assigned to the surface subject. Why might this be? Three possibilities suggest themselves. First, perhaps comprehenders end up with a better understanding of the concept to which they theta-assigned a role first. And indeed, there are suggestions in the data that accuracy is higher for the agent of the active compared with the patient (recall that this contrast was significant in the between-experiments comparison between actives and active-clefts), the opposite from what is found with passives but consistent with what would be expected if order of thematic role assignments is important. Second, comprehenders have less experience assigning the role in the by-phrase, because the majority of passives are truncated (Quirk et al., 1985). Therefore, people have twice as much

experience assigning the role to the subject of the passive than they do assigning a role to the NP in the by-phrase.

Third, theories of the syntax of passives lead to the expectation that there could be an asymmetry disfavoring the role in the by-phrase. For example, as described in the introduction to Experiment 1, transformational theories assume that theta-transmission to the by-phrase is more complex than is theta-transmission to the surface subject. Even nontransformational theories make the same prediction: Recall that Relational Grammar treats the by-phrase as a "chomeur", and Lexical-Functional Grammar predicts a unique difficulty for the by-phrase based on the lexical ambiguity of the preposition *by* (which may serve to mark an agent or some other semantic roles such as location). Birner and Ward's (1998) corpus analyses of passives reveal that the by-phrase is often presupposed information, so yet another possibility is that the by-phrase requires more contextual support than does the subject. Moreover, an aspect of this asymmetry that must be accounted for is that it seems to be manifest only in the reversible passives (biased reversibles and symmetricals), and not in the nonreversible passives. Thus, something about the animacy contrast eliminates the asymmetry; how animacy does this is an important topic for further investigation.

The extent to which the present experiments reveal the passive to be a challenging structure to comprehend might lead one to speculate that the entire semantic representation for this structure is fragile and potentially up for misinterpretation. This idea is not consistent with the spirit of the approach proposed here, because the hypotheses assume that it is the process of assigning thematic roles that is difficult. It should not be the case, then, that (for example) comprehenders are muddled about the tense of a passive sentence, or about some concept in the sentence that does not correspond to a thematic role. To examine this issue, a further analysis of the data from Experiments 2 and 3 was performed. The 144 fillers included 36 active sentences and 36 passive sentences for which participants responded to either a color or a location probe. For example, *the blue book was on the shelf* is an active sentence for which a color or a location probe would be appropriate. The same is true for the passive filler *the pedestrian was hit by a yellow car on Fifth Avenue*. These fillers then

allow us to examine whether it is more difficult to identify the location or color concept in a passive sentence compared to an active. The results were unambiguous: For active sentences, accuracy at identifying the correct color was 99%, and accuracy was the same for locations. For passives, the values for color and location were 97% and 99% respectively. These values did not differ, all F's < 1. Decision times did not differ either. Therefore, it is clear that what comprehenders have trouble keeping straight in the passive is the thematic roles; the representation for other semantic concepts seems to be as accurate as it is in active sentences.

The final result from the experiments that deserves comment is the striking finding that active-clefts are no harder to understand than regular active sentences. It appears, then, that more work needs to be done to discover what sorts of properties of a sentence make theta-transmission shaky and cause the sentence to be more vulnerable to influence from a schema. The base frequency of the global syntactic form does not seem to be the critical variable, given that active-clefts are much more rare than actives but are as easy to comprehend. Further evidence for this conclusion comes from a post-hoc analysis that was performed on the passive data. For each of the 72 experimental passive sentences, the frequency with which the participle tends to be used in a passive structure was assessed based on the Francis and Kucera (1982) values. For example, the morphological form *killed* occurs 153 times according to Francis and Kucera, and 41 of those uses are as a passive participle. The bias value for this verb, then, is .27. The form *ruined* occurs 22 times, 16 as a passive participle, so its bias value is .73. An irregular form such as *bitten* has a bias value close to 1.00, because it almost always occurs in passive sentences. These bias values were correlated with the size of the misinterpretation effect in both Experiments 2 and 3 (combined). The misinterpretation effect was measured as the difference between performance in the implausible active and the implausible active-cleft conditions, on the one hand, and the implausible passive conditions, on the other, collapsing over decision type (agent or patient). The correlation was -.02, obviously indicating that the frequency with which the verb in the sentence occurred in the passive form did not predict the extent to which the sentence was misinterpreted. Another analysis was performed, comparing the size of the

misinterpretation effect for all the ambiguous verbs (ones such as *killed* which are ambiguous between past tense and participle) versus the unambiguous ones (e.g., *bitten*). No difference was observed, F's < 1. Clearly, other analyses could be done to see whether an effect for the frequency of the global syntactic form might emerge, but these analyses might take us far a field from our main purpose at this point. The important conclusion for now is that, based on these experiments and analyses, there is little evidence that the frequency of the global syntactic form influences how easily the thematic roles can be assigned.

What does account for the difference, then, between actives and active-clefts, on the one hand, and passives, on the other? At this point, it is possible only to speculate, but one reasonable suggestion is that what matters is the order in which people assign the thematic roles, an idea that is central to the Competition Model of language processing (Bates & MacWhinney). The property that all passives have in common compared to the actives and active-clefts is that (assuming incremental interpretation) thematic roles are assigned in what could be viewed as an atypical order: patient and then agent. Perhaps comprehenders have trouble keeping track of theta-assigned roles when they must be assigned and maintained in this less frequent way. This hypothesis is being investigated in a couple of different studies: First, preliminary results from a study comparing active-clefts and passive-clefts (e.g., comparing *it was the man who bit the dog* v. *it was the dog the man bit*) are revealing a pattern quite similar to what has reported thus far, with the active-clefts behaving like actives and the passive-clefts behaving like passives. A second and much more innovative line of research involves examination of an Ojibwa language called Odawa, which grammatically permits all six logical combinations of subject, verb, and object (i.e., it is a so-called "nonconfigurational" language; Hale, 1983). A major research project underway in our laboratory is to see whether native speakers of this language (of which there are about 30,00 to 50,000 in northern Ontario, Canada) have more trouble understanding sentences when the patient is assigned before the agent, and in general when the order in which thematic roles occur is contrary to the overall frequencies in the language.

To summarize, then, the reason passives are hard to understand seems to be because of the way thematic roles are assigned and maintained within them. The process of theta-transmission is simply less reliable in passives, and as a result thematic misinterpretations often occur. This idea explains why semantic features of passives that do not concern thematic roles (e.g., locations and colors) are reliably represented. In addition, this observation might explain why it is that when people misunderstand passives, they do not come up with some wild misinterpretation (e.g., in *the dog was bitten by the man* they do not err by thinking the agent was a cat); their error is always to end up with the concepts in the wrong places. The errors take this particular form because the problem is the binding of thematic roles to concepts within the sentence; looser bindings lead to migration of the roles from one concept to another within the sentence. This idea might also explain why truncated passives are easy to understand, at least intuitively (i.e., it seems fairly obvious that in a sentence such as *the mouse was chased* people completely understand what was chased, but empirical data to support that claim are surprisingly lacking). Truncated passives present little problem because there is only one place where the thematic role can go, so even if the binding of role to concept is somewhat weak, the role can only migrate back to the same spot.

What are the broader implications of these results? In recent work (Ferreira & Henderson, 1999; Christianson, Hollingworth, Halliwell, & Ferreira, submitted), we have argued for what we term "good enough representations" in language processing (and other cognitive domains). The fundamental idea is to challenge the assumption that the language comprehension system builds rich and complete representations for the utterances it encounters. The phenomena described in the Introduction are difficult to reconcile with the completeness assumption: the Moses illusion (Erickson & Mattson, 1981; Kamas et al., 1996), the earlier Fillenbaum (1971, 1974) work on normalization, and the Duffy et al. (1988) study on sentence-level facilitation of naming processes all reveal that people create incomplete and distorted representations. Recent work in visual cognition demonstrating so-called "change blindness" also undermines the completeness assumption (in another cognitive domain): Researchers have demonstrated that viewers of real-world visual scenes are

surprisingly insensitive to changes made to those scenes while they are being viewed (Henderson & Hollingworth, 1999; Simons & Levin, 1997). Thus, we argue that input systems do not generally deliver full and complete representations of the stimuli they encounter.

Christianson et al. (submitted) demonstrated this point with garden-path sentences. They had participants read sentences such as *While Anna bathed the baby played in the crib*, and the participants' task was to answer comprehension questions after each one. Christianson et al. found that accuracy was high for a question such as *Did the baby play in the crib*, indicating that the noun phrase *the baby* had been successfully restructured as the subject of the second clause (from its initial position as object of the first). If Christianson et al. had stopped there, they might have concluded that people are able to understand these difficult sentences fully and completely. But by also asking questions such as *Did Anna bathe the baby*, to which participants replied "yes" the majority of the time, they were able to demonstrate that the ultimate semantic representation for the sentence was not complete and accurate. In addition, participants had a great deal of confidence in both their correct and incorrect answers. Furthermore, participants did not answer "yes" as often to the question about the subordinate clause when the clauses were inverted or when a comma separated the two clauses, because both of those modifications eliminated the garden-path (i.e., the ultimately incorrect syntactic structure that supported the misinterpretation). Christianson et al. concluded that the representations for sentences are "good enough" rather than duplicates of the actual information in the sentence.

Another study demonstrating the "good enough" nature of language comprehension was conducted recently by Brysbaert and Mitchell (submitted). They used Dutch sentences to examine whether Dutch-speaking participants would use disambiguating gender cues to attach relative clauses in sentences. For example, even in English, the sentence *Mary liked the son of the actresses who are on the balconies* is unambiguous, because the form of *to be* makes clear that the relative clause attaches to *actresses*, not *son*. In a questionnaire study in which participants read sentences such as these at their own pace and then indicated where the relative clause attached (e.g., who was on the balcony), Brysbaert and Mitchell found that people were surprisingly insensitive to the morphological

cues. Chance performance would have been 50%, and perfect performance (using all the cues consistently) would have been 100%. Their participants were accurate 79% of the time, suggesting that they sometimes used the information but they sometimes instead went with whatever interpretation seemed more semantically sensible to them. This result is important for a number of reasons, and one of them is methodological: Morphologically disambiguated sentences are often used as control conditions in psycholinguistic experiments, and these results suggest that practice needs to be reevaluated. More importantly for current purposes, the results again suggest that the language comprehension system delivers representations that are "good enough" rather than rich and complete.

Finally, Gibson and Thomas (1999) studied readers' comprehension of center-embedded structures such as *The ancient manuscript that the graduate student who the new card catalog had confused a great deal was studying in the library was missing a page*. Their goal was to determine under what circumstances comprehenders overlook that a center-embedded sentence is missing a syntactically obligatory verb phrase. An example of such an ungrammatical sentence was *The ancient manuscript that the graduate student who the new card catalog had confused a great deal was studying in the library*. Gibson and Thomas found that these two items were rated as equivalently easy to understand, even though the one missing a verb phrase should be rejected as uninterpretable because one of the noun phrase constituents is missing its required companion—its verb phrase. This study again illustrates that, particularly when a sentence becomes extremely difficult to parse and interpret, comprehenders adopt a good-enough strategy to trying to understand it. As a result, they even tolerate outright ungrammaticality. (Note that this analysis of the results is not the same as the one offered by Gibson and Thomas, although it is not incompatible with it.)

But what does "good enough" mean in the context of language understanding? It is important to note that all the results that have been mentioned or described thus far demonstrating less than perfect comprehension have been obtained under conditions that would seem to maximize the chances that people would obtain the right interpretations. In psycholinguistics experiments, sentences are presented without background noise, the input is perceptually clear, often the participant

controls the pace at which the sentence is presented, and most critically, the goal of the participant is specifically to understand the sentence so as to be able to perform well on a comprehension task. Contrast this situation with a more ecologically valid one such as a person having a conversation in a noisy restaurant, with music and other conversations competing with and occluding the input. The person's goal is probably not to construct faithful representations of her interlocutor's utterances, but rather to get enough out of them so that she can take her turn at appropriate times and keep the social exchange functioning properly. In the laboratory situation, the criterion for what will be considered "good enough" will likely be set quite high; in a restaurant, it might be set much lower. Thus, it appears that even when a situation and task put a premium on accurate comprehension, people often do not achieve it.

What about the present study? In the Introduction, we argued that both the linguistic system and preexisting schemas in long-term memory deliver thematic role assignments. The question then becomes, what will cause a comprehender to rely more on one set of assignments than the other? The results of the three experiments suggest that if theta-transmission is easy so that thematic roles are tightly linked to concepts, then the schema-based roles do not have a chance to interfere. But if theta-transmission is hard, then the schema will interfere. One might expect, then, that if a person received not a passive sentence but something that is virtually unparseable, such as a center-embedded structure (Bates et al., 1999; Gibson, 1998), that person will shift to relying entirely on schema-based assignments if they are available. For example, consider the sentence *the dog the cat chased meowed*. The prediction based on this approach would be that people would feel they had comprehended this sentence adequately and would not detect the problem with it, because the lexical items activate a schema in long-term memory (i.e., that cats meow and participate in chasing events) , and the schema delivers a sensible interpretation.

The structures created by the linguistic system are the framework for interpretation, but they are fragile. They deteriorate rapidly (Sachs, 1967) and so they need support from outside the linguistic system. Schematic knowledge is one sort of support (or a source of interference when the

sentence is challenging and implausible); discourse is another. It is likely that the implausible passive sentences used in these experiments would have been understood almost flawlessly if they had occurred in a supportive context, because then the context would have reinforced the theta-based assignments. A unique and counterintuitive prediction based on the results of these experiments is that the agent role needs more support than does the patient role, because the former is more syntactically vulnerable.

The important conclusion from this study, then, is that it is not just garden-path sentences that challenge the language system. Even a structure like the passive is difficult for college students to understand when the interpretation must be built from nothing more than the sentence itself. This phenomenon occurs because the ultimate product of the language comprehension system is a representation that is "good enough"; it is not a faithful replica of the input that the comprehension system received.

References

Altmann, G., & Steedman, M. (1988). Interaction with context during human sentence processing. *Cognition*, *30*, 191-238.

Baker, M., Johnson, K., & Roberts, I. (1989). Passive arguments raised. *Linguistic Inquiry*, *20*, 219-252.

Ball, C.N. (1994). The origins of the informative-presupposition It-Cleft. *Journal of Pragmatics*, *22*, 603-628.

Barss, A. (1985). The acquisition of trace in passive. *MIT Working Papers in Linguistics*, *6*, 14-44.

Barton, S.B., & Sanford, A.J. (1993). A case study of anomaly detection: Shallow semantic processing and cohesion establishment. *Memory & Cognition*, *21*, 477-487.

Bates, E., Devescovi, A., & D'Amico, S. (1999). Processing complex sentences: A cross-linguistic study. *Language and Cognitive Processes*, *14*, 69-123.

Bates, E., McNew, S., MacWhinney, B., Devescovi, A., & Smith, S. (1982). Functional constraints on sentence processing: A cross-linguistic study. *Cognition*, *11*, 245-299.

Birner, B.J., & Ward, G. (1988). Information status and noncanonical word order in English. Philadelphia, PA: John Benjamins.

Boland, J.E., & Boehm-Jernigan, H. (1998). Lexical constraints and prepositional phrase attachment. *Journal of Memory and Language*, *39*, 684-719.

Bresnan, J. (1978). A realistic transformational grammar. In M. Halle, J. Bresnan, & G.A. Miller (Eds.), *Linguistic theory and psychological reality* (pp. 1-59). Cambridge, MA: MIT Press.

Britt, M.A. (1994). The interaction of referential **ambiguity** and argument structure in the parsing of prepositional phrases. *Journal of Memory and Language, 33,* 251-283.

Brysbaert, M., & Mitchell, D.C. (submitted). The failiure to use gender information in parsing: A comment on van Berkum, Brown, and Haggort (1999).

Chomsky, N. (1995). *The minimalist program.* Cambridge, MA: MIT Press.

Christianson, K., Hollingworth, A., Halliwell, J., & Ferreira, F. (submitted). Thematic roles assigned along the garden path linger.

Clark, H.H., & Clark, E. (1977). *Psychology and language: An introduction to psycholinguistics*. New York: Harcourt Brace.

Cutler, A., & Fodor, J.A. (1979). Semantic focus and sentence comprehension. *Cognition*, *7,* 49-59.

Delahunty, G.P. (1984). The analysis of English cleft sentences. *Linguistic Analysis*, *13*, 63-113.

Dowty, D. (1991). Thematic Proto-Rules and Argument Selection. *Language*, *67,* 547-619.

Duffy, S.A., Henderson, J.M., & Morris, R. K. (1989). Semantic facilitation of lexical access during sentence processing. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *15*, 791-801.

Erickson, T.D., & Mattson, M.E. (1981). From words to meaning: A semantic illusion. *Journal of Verbal Learning and Verbal Behavior*, *20*, 540-551.

Ferreira, F. (1994). Choice of passive voice is affected by verb type and animacy. *Journal of Memory and Language, 33,* 715-736.

Ferreira, F., & Clifton, C. (1986). The independence of syntactic processing. Journal of Memory and Language, 25, 348-368.

Ferreira, F., & Henderson, J.M. (1990). Use of verb information in syntactic parsing: Evidence from eye movements and word-by-word self-paced reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16*, 555-568.

Ferreira, F., & Henderson, J.M. (1991). Recovery from misanalyses of garden-path sentences. *Journal of Memory and Language, 30*, 725-745.

Fillenbaum, S. (1971). Processing and recall of compatible and incompatible question and answer pairs. *Language and Speech, 14*, 256-265.

Fillenbaum, S. (1974). Pragmatic normalization: Further results for some conjunctive and disjunctive sentences. *Journal of Experimental Psychology, 102*, 574-578.

Fillmore, C.J. (1968). The case for case. In E. Bach & R.T. Harms (Eds.), *Universals of linguistic theory.* New York: Holt, Rinehart, and Winston.

Fodor, J.A., Bever, T.G., & Garrett, M.F. (1974). *The psychology of language: An introduction to psycholinguistics and generative grammar*. New York: McGraw-Hill.

Francis, W.N., & Kucera, H. (1982). Frequency analysis of English usage. Boston, MA: Houghton Mifflin Company.

Frazier, L. & Clifton, C. 1996. *Construal*. Cambridge, MA: MIT Press.

Frazier, L., & Rayner, K. (1982). Making and correcting errors during sentence comprehension: Eye movements in the analysis of structurally ambiguous sentences. *Cognitive Psychology*, 14, 178-210.

Garnham, A., & Oakhill, J. (1987). Interpreting elliptical verb phrases. *The Quarterly Journal of Experimental Psychology, 39A*, 611-625.

Gibson, E. (1998). Linguistic complexity: locality of syntactic dependencies. *Cognition, 68,* 1-76.

Gibson, E., & Thomas, J. (1999). Memory limitations and structural forgetting: The perception of complex ungrammatical sentences as grammatical. *Language and Cognitive Processes, 14,* 225-248.

Gough, P.B. (1965). Grammatical transformations and speed of understanding. *Journal of Verbal Learning and Verbal Behavior, 4,* 107-111.

Gough, P.B. (1966). The verification of sentences: The effects of delay of evidence and sentence length. *Journal of Verbal Learning and Verbal Behavior, 5,* 492-496.

Hale, K. (1983). Walpiri and the grammar of non-configurational languages. *Natural Language and Linguistic Theory,* 1, 5-47.

Henderson, J. M., & Hollingworth, A. (1999). The role of fixation position in detecting scene changes across saccades. *Psychological Science, 10,* 438-443.

Hornby, P.A. (1974). Surface structure and presupposition. *Journal of Verbal Learning and Verbal Behavior, 13,* 530-538.

Jaeggli, O.A. (1986). Passive. *Linguistic Inquiry, 17,* 587-622.

Just, M.A., & Clark, H.H. (1973). Drawing inferences from the presuppositions and implications of affirmative and negative sentences. *Journal of Verbal Learning and Verbal Behavior, 12,* 21-31.

Kamas, E.N., Reder, L.M., & Ayers, M.S. (1996). Partial matching in the Moses illusion: response bias not sensitivity. *Memory & Cognition, 24,* 687-699.

King, J., & Just, M.A. (1991). Individual differences in syntactic processing: The role of working memory. *Journal of Memory & Language, 30,* 580-602.

Kintsch, W. (1974). *The representation of meaning in memory*. Hillsdale, NJ: Erlbaum.

Liversedge, S.P., Pickering, M.J., Branigan, H.P., & van Gompel, R.P.G. (1998). Processing arguments and adjuncts in isolation and context: The case of by-phrase ambiguities in passives. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24*, 461-475.

MacDonald, M.C. (1994). Probabilistic constraints and syntactic ambiguity resolution. *Language and Cognitive Processes, 9,* 157-201.

MacWhinney, B., & Bates, E. (Eds.) (1989). *The crosslinguistic study of sentence processing*. New York: Cambridge University Press.

MacWhinney, B., Bates, E., & Kliegl, R. (1984). Cue validity and sentence interpretation in English, German, and Italian. *Journal of Memory and Language, 23*, 127-150.

Nelson, G. (1997). Cleft constructions in spoken and written English. *Journal of English Linguistics, 25*, 340-348.

Perlmutter, D., & Postal, P. (1983). Towards a universal characterization of passivization. In D. Perlmutter (Ed.), *Studies in relational grammar 1* (pp. 3-29). Chicago, IL: University of Chicago Press.

Quirk, R., Greenbaum, S., Leech, G. & Svartvik, J. (1985). *A comprehensive grammar of the English language*. London: Longman.

Rumelhart, D.E. (1980). Schemata: The building blocks of cognition. In R.J. Spiro, B.C. Bruce, & W.F. Brewer (Eds.), *Theoretical issues in reading comprehension*. Hillsdale, NJ: Erlbaum, 33-58.

Sachs, J.S. (1967). Recognition memory for syntactic and semantic aspects of connected discourse. *Perception & Psychophysics, 2*, 437-442.

Sanford, A.J. (1999). Word meaning and discourse processing: A tutorial review. In S. Garrod & M. Pickering (Eds.), *Language processing* (pp. 301-334). East Sussex, U.K.: Psychology Press Ltd.

Sedivy, J.C., Tanenhaus, M.K., Chambers, C. G., & Carlson, G.N. (1999). Achieving incremental semantic interpretation through contextual representation. *Cognition, 71*, 109-147.

Sheldon, A. (1974). On the role of parallel function in the acquisition of relative clauses in English. *Journal of Verbal Learning and Verbal Behavior, 13*, 272-281.

Simons, D. J., & Levin, D. T. (1997). Change blindness. *Trends in cognitive science, 1*, 261-267.

Slobin, D.I. (1966). Grammatical transformations and sentence comprehension in childhood and adulthood. *Journal of Verbal Learning and Verbal Behavior, 5*, 219-227.

Speer, S.R., & Clifton, C. (1998). Plausibility and argument structure in sentence comprehension. *Memory and Cognition, 26*, 965-978.

St. John, M.F., & Gernsbacher, M.A. (1998). Learning and syntax: practice makes perfect and frequency builds fortitude. In A. Healy (Ed.), *Foreign language learning: psycholinguistic studies on training and retention* (pp. 231-255). Mahwah, NJ: Lawrence Erlbaum Associates.

Steinhauer, K., Alter, K., & Friederici, A.D. (1999). Brain potentials indicate immediate use of prosodic cues in natural speech processing. *Nature, 2*, 191-196.

Tanenhaus, M.K., Spivey-Knowlton, M. J. Eberhard, K. M., Sedivy, J. C. (1995). Integration of visual and linguistic information in spoken language comprehension. *Science, 268*, 1632-1634.

Traxler, M.J., Bybee, M.D., & Pickering, M.J. (1997). Influence of connectives on language comprehension: Eye-tracking evidence for incremental interpretation. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 50A*, 481-497.

Traxler, M.J., Pickering, M.J., & Clifton, C., Jr. (1998). Adjunct attachment is not a form of ambiguity resolution. *Journal of Memory and Language, 35*, 454-475.

Trueswell, J.C., Tanenhaus, M.K., & Kello, C. (1993). Verb-specific constraints in sentence processing: Separating effects of lexical preference from garden-paths. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19*, 528-553.

Wason, P.C. (1959). The processing of positive and negative information. *Quarterly Journal of Experimental Psychology, 11*, 92-107.

Wason, P.C., & Johnson-Laird, P.N. (1972). *Psychology of reasoning: Structure and content*. London: B.T. Batsford.

Appendix: Sentences Used in the Experiments

The sentences are presented below only in the active, plausible version. The implausible version can be created by reversing the nouns (for the symmetrical sentences, the two versions are arbitrary). The passive forms are created as follows: e.g., *the dog bit the man → the man was bitten by the dog*. The active-clefts are created as follows: e.g., *the dog bit the man → it was the dog that bit the man*.

Set 1: Biased, Reversible Sentences

1. The dog bit the man.
2. The cook ruined the food.
3. The bird ate the worm.
4. The cat chased the mouse.
5. The soldier protected the villager.
6. The lawyer sued the doctor.
7. The teacher quizzed the student.
8. The cop pursued the thief.
9. The waitress served the man.
10. The owner fed the cat.
11. The detective investigated the suspect.
12. The doctor treated the patient.
13. The politician deceived the voter.
14. The hiker killed the mosquito.
15. The horse threw the rider.
16. The golfer hit the ball.
17. The hunter shot the deer.
18. The frog ate the fly.
19. The ghost scared the boy.
20. The horse kicked the jockey.
21. The angler caught the fish.
22. The matador dodged the bull.
23. The officer arrested the citizen.
24. The prince slayed the dragon.

Set 2: Nonreversible Sentences

1. The chef wore the apron.
2. The farmer planted the corn.
3. The mouse ate the cheese.
4. The dog buried the bone.
5. The editor reviewed the paper.
6. The comic told the joke.
7. The plumber fixed the drain.
8. The runner won the race.

9. The cow chewed the cud.
10. The DJ played the music.
11. The secretary typed the letter.
12. The artist painted the picture.
13. The termite chewed the wood.
14. The chicken laid the egg.
15. The ant built the hill.
16. The doctor took the x-ray.
17. The pirate buried the treasure.
18. The nurse gave the shot.
19. The dentist pulled the tooth.
20. The beaver gnawed the tree.
21. The child pulled the wagon.
22. The bulldozer pushed the dirt.
23. The tailor hemmed the skirt.
24. The pilot flew the plane.

Set 3: Symmetrical Sentences

1. The boy kicked the girl.
2. The girlfriend kissed the boyfriend.
3. The sister hugged the brother.
4. The committee introduced the chairman.
5. The runner saw the driver.
6. The woman called the girl.
7. The man visited the woman.
8. The boy touched the man.
9. The bird heard the lady.
10. The producer recognized the director.
11. The priest approached the rabbi.
12. The child loved the puppy.
13. The butcher despised the baker.
14. The team chose the player.
15. The clerk thanked the customer.
16. The teacher greeted the parent.
17. The mother adored the son.
18. The realtor faxed the buyer.
19. The catcher signaled the pitcher.
20. The broker phoned the client.
21. The guest insulted the host.
22. The model met the photographer.
23. The prime minister embraced the pope.
24. The witch praised the wizard.

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Footnotes

1. The means were as follows for the active plausible, active implausible, passive plausible, and passive implausible conditions respectively: For biased reversible sentences, 94%, 96%, 93%, and 74%; for nonreversible sentences, 97%, 95%, 97%, and 93%. Performance in the active and passive symmetrical conditions was 89% and 92% respectively.

2. The practice in our laboratory is to allow those who are non-native speakers and are taking courses that require them to obtain experimental credits to sign up for the experiments we conduct. We then eliminate their data rather than restricting their participation.

Table 1. Mean plausibility ratings and standard deviations for experimental sentences used in Experiments 1 and 2

Sentence Type	**Mean Rating from 1 (plausible) to 7 (implausible) / standard deviations**
Biased Reversible, Plausible (*The dog bit the man*)	5.82 / .93
Biased Reversible, Implausible (*The man bit the dog*)	2.08 / 1.00
Nonreversible, Plausible (*The mouse ate the cheese*)	6.85 / .40
Nonreversible, Implausible (*The cheese ate the mouse*)	1.86 / 1.01
Symmetrical, one order (*The woman visited the man*)	2.95 / 1.03
Symmetrical, other order (*The man visited the woman*)	2.98 / 1.09

Table 2. Percentage of sentences correctly judged to be plausible (according to normative data), and reaction times (which include time to read sentence and make decision), in ms, correct trials only, Experiment 1.

Reversible Sentences (e.g., *the dog bit the man*)				
	Judgments		Reaction Times	
	Plausible	Implausible	Plausible	Implausible
Active	96	92	1923	2278
Passive	95	74	2527	2661

Nonreversible Sentences (e.g., *the mouse ate the cheese*)				
	Judgments		Reaction Times	
	Plausible	Implausible	Plausible	Implausible
Active	99	95	1786	2084
Passive	95	92	2006	2391

Symmetrical Sentences (e.g., *the woman visited the man*)		
	Judgments	Reaction Times
Active	89	2305
Passive	83	2531

Table 3. Accuracy data and correct decision times (in ms),Experiment 2

		Accuracy (in percent)		Decision Times (ms)	
Decision		Agent	Patient	Agent	Patient
Reversible sentences (e.g., *the dog bit the man*)					
Actives					
	Plausible	99	97	1596	1773
	Implausible	99	91	1855	2005
Passives	Plausible	88	92	1990	1927
	Implausible	74	85	2075	2292
Nonreversible sentences (e.g., *the mouse ate the cheese*)					
Actives	Plausible	100	98	1520	1851
	Implausible	96	91	1946	2114
Passives	Plausible	87	87	1826	1960
	Implausible	82	84	2047	2202
Symmetrical sentences (e.g., *the woman visited the man*)					
Actives	Version1	94	97	1737	2032
	Version2	95	87	1771	2057
Passives	Version1	82	86	2211	2139
	Version2	87	83	2104	2172

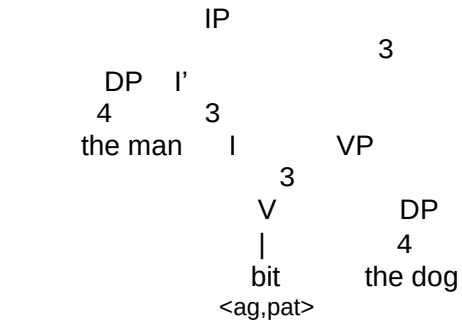
Table 4. Accuracy data and correction decision times (in ms), Experiment 3

		Accuracy (in percent)		Decision Times (ms)	
Decision		Agent	Patient	Agent	Patient
Reversible sentences (e.g., *the dog bit the man*)					
Active-clefts					
	Plausible	97	95	1411	1593
	Implausible	97	93	1570	1984
Passives	Plausible	77	87	1879	2076
	Implausible	68	74	1960	2102
Nonreversible sentences (e.g., *the mouse ate the cheese*)					
Actives-clefts	Plausible	100	95	1309	1638
	Implausible	95	87	1634	1974
Passives	Plausible	98	89	1823	1969
	Implausible	76	74	2181	2288
Symmetrical sentences (e.g., *the woman visited the man*)					
Actives	Version1	98	93	1523	2003
	Version2	98	90	1434	1853
Passives	Version1	77	88	2057	2209
Passives	Version2	87	83	2104	2172

Table 5. Main results from the three experiments.

Comparisons	Task and Conditions	Results
Experiment One	• Participant judged whether visually presented sentence plausible or implausible • Sentences either active or passive, plausible or implausible	• One sentence type causes difficulty: implausible passives judged to be plausible if sentence is reversible but highly biased
Experiment Two	• Participant identified agent or patient of aurally presented sentence • Sentence either active or passive, plausible or implausible	• Reversible, biased sentences: accuracy lower with passives, especially if sentence implausible. Effect exaggerated for agent decisions • Nonreversible sentences: accuracy lower for passives and lower for implausible sentences. Equal difficulty with agent and patient decisions. • Symmetrical sentences: worse performance with passives, especially for agent decisions
Experiment Three	• Participant identified agent or patient of aurally presented sentence • Sentence either active-cleft or passive, plausible or implausible	• Reversible, biased sentences: accuracy lower with passives, especially if sentence implausible. Effect exaggerated for agent decisions • Nonreversible sentences: accuracy lower for passives, especially if sentence implausible. Equal difficulty with agent and patient decisions. • Symmetrical sentences: worse performance with passives, especially for agent decisions
Experiment 2 versus Experiment 3	• Compared actives and active-clefts	• Equally easy

Active Sentence: *the man bit the dog*



Passive Sentence: *the dog was bitten by the man*

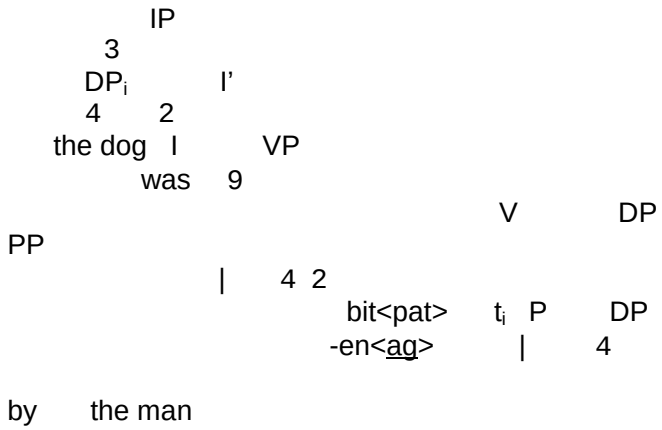


Figure 1. Syntactic structures for active and passive sentences.