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# Asyntactic Thematic Role Assignment: The Use of a Temporal–Spatial Strategy

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We report syntactic comprehension performance of a left-handed man with a right-hemisphere infarct. He was unable to accurately map grammatical categories (subject, object) onto thematic roles (agent, patient), despite demonstrating intact conceptual knowledge of these thematic roles. He performed poorly on both active and passive reversible sentences. His asyntactic thematic role assignment cannot be accounted for by a short-term memory impairment or any hypothesis that predicts selective vulnerability to passive sentence constructions. Rather than performing randomly, our patient used a temporal or spatial strategy in assigning thematic roles. Because he also had a production-mapping deficit and used the same temporal–spatial strategy in production tasks, we hypothesize that the mapping of thematic roles onto grammatical categories and vice versa may be a specific aspect of sentence processing that is common to sentential production and comprehension. We also raise the possibility that thematic roles have underlying spatial representations prior to being elaborated by grammar. 

At the beginning of this century it was generally recognized that agrammatic patients frequently had parallel deficits in comprehension. Bonhoeffer, Golstein, Salomon, and Kleist were among investigators that

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discussed these comprehension deficits in terms of short-term memory impairments, the loss of "grammatical concepts," and the loss of stored sentence frames (Kolk, Grunsven, & Keyser, 1985). For uncertain reasons, these ideas were abandoned in the subsequent aphasia literature, and Broca's aphasia came to be conceived of as primarily an expressive disorder. In 1976, two reports resurrected the notion that patients with agrammatic production also had deficits in comprehension. These deficits were manifest specifically when the meaning of sentences hinged on accurate syntactic processing. Heilman and Scholes (1976) reported that Broca's aphasic patients had difficulty distinguishing between the following kinds of dative constructions: "The man showed her the baby pictures" and "The man showed her baby the pictures." Caramazza and Zurif (1976) reported that such patients had difficulty comprehending sentences with center-embedded relative clauses, such as "The cat that the dog is chasing is brown." These observations led to the hypothesis that agrammatic Broca's aphasics had a disruption of a single central syntactic processor, resulting in production and comprehension syntactic deficits (Berndt & Caramazza, 1980).

The strong version of the central syntactic disruption hypothesis in agrammatic patients was subsequently not entirely supported. Patients with agrammatic production and normal syntactic comprehension (Miceli, Mazzucchi, Menn, & Goodglass, 1983; Kolk & Van Grunsven, 1985; Nespoulous, Dordain, Perron, Ska, Bub, Caplan, Mehler, & Lecours, 1988; Caramazza & Hillis, 1989), as well as patients with normal production and asyntactic comprehension (Vallar & Baddeley, 1984; Saffran, 1990a) have been reported. In addition, the variety of deficits of sentence processing that result in agrammatic production (reviewed in Berndt, 1991) lead some investigators to question the theoretical basis for considering agrammatism as a unified syndrome (Badecker & Caramazza, 1985). The fragmentation of agrammatism may have obscured the question of whether there are aspects of sentence processing common to comprehension and production. In a recent review, Berndt has suggested that it may be "premature to abandon attempts to find processing or representational commonalities in sentence comprehension and production" (Berndt, 1991). She calls for detailed studies of single patients using tasks designed to isolate specific aspects of sentence processing that might be common to production and comprehension.

In this paper, we report investigations of asyntactic comprehension in a well-educated left-handed gentleman, WH, with a right-hemisphere stroke. This paper accompanies a detailed report of his production deficit (Maher, Chatterjee, Gonzalez Rothi, & Heilman, 1995). A critical feature of this patient's production defect was his inability to accurately map thematic roles (the logical agent or patient) onto their linguistic grammatical categories (subject or object). Saffran, Schwartz, and Marin (1980)

originally described this "word-order problem" in agrammatic production. They demonstrated that some patients had difficulty describing relations signified by the ordering of noun phrases around verbs and prepositions. They also demonstrated that these patients had a word-order comprehension deficit (Schwartz, Saffran, & Marin, 1980). The patient that we describe here demonstrated a similar word order deficit. However, in production tasks, he reliably used a nonlinguistic strategy to assign thematic roles. He used either a temporal or a spatial strategy, such that thematic agents were mapped onto nouns that were produced first in speech or to the left of the verb in written language. In this report, we focus on his comprehension abilities and address the following questions: (1) What is the nature of WH's syntactic comprehension deficit? (2) How well do current accounts of asyntactic comprehension explain WH's behavior? (3) Does he use a nonlinguistic heuristic in attempts to comprehend thematic roles? (4) Do these data have implications for parallelism of syntactic production and comprehension defects? (5) Does WH's behavior have implications for the nature of thematic role representation.

## CASE HISTORY

WH was a 66-year-old, left-handed college professor, with a large stroke in the distribution of the right middle cerebral artery, involving frontal, parietal, and temporal regions. Details of his presentation are provided in the accompanying report (Maher et al., 1995). Briefly, he had a left hemiparesis, without evidence of a visual field defect. He did not demonstrate evidence of spatial neglect on line bisection, cancellation, and drawing tasks. His prosodic production and comprehension was normal. His digit span was six digits forward and five digits backward. Performance on the Western Aphasia Battery (Kertesz & Poole, 1974) was most consistent with a transcortical sensory aphasia, although, he had flawless comprehension of single words. His preserved lexical–semantic system was evidenced by superior performance on the Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1983) and the Peabody Picture Vocabulary Test (Dunn, 1965).

WH could repeat, read, and write to dictation accurately. Although his production was notable for syntactic errors, he had near normal rate of speech and near normal use of determiners, pronouns, and main verbs. On picture description tasks, his production was remarkable for a word order deficit in which he seemed to use a temporal–spatial strategy in assigning thematic roles. When animacy or semantic plausibility were eliminated as factors, he always chose to produce the logical subject (agent) first or to place it to the left of the verb.

## METHODS

### *General Measures of Syntactic Comprehension*

*The Token Test (De Renzi & Vignolo, 1962).* He did well on the first four subtests of the Token Test, suggesting adequate short-term memory for sentences. He performed poorly on Part V of the Token Test (20%). The last part of the Token Test assesses a wide variety of syntactic structures, including the assignment of thematic roles and the temporal ordering of actions. WH also did poorly on a task designed by Heilman and Scholes (1976) which tests syntactic comprehension of dative constructions (8/20 correct responses, 10/20 being a chance performance). From these two tasks it was clear that WH had difficulty comprehending sentential semantics despite having normal lexical semantic comprehension.

Asyntactic comprehension does not necessarily imply complete insensitivity to grammatical morphemes. Some patients may be able to judge whether sentences are grammatically constructed despite being unable to extract sentential semantics (Linebarger, Schwartz, & Saffran, 1983). In WH's production assessment, under constrained conditions he could accurately construct anagrams and correctly choose between inflectional or derivational bound morphemes. These production results suggested that WH retained some knowledge of surface syntactic features. To determine if similar knowledge of the form of grammatical morphemes was preserved in the comprehension aspects of sentence processing, he was given a grammaticality judgment task.

### *Grammaticality Judgment*

A grammaticality judgment task was constructed using 40 six-word sentences from the *Assessment of Intelligibility of Dysarthric Speech* (Yorkston & Beckelman, 1981). Twenty of these sentences were grammatically correct, and 20 were altered such that they had inflectional or functor choice or word transposition errors. The following were the types of errors: 9/20 bound morpheme errors (5 omission errors, 4 substitution errors), 4/20 auxiliary verb form errors (3 omissions, 1 inappropriate inclusion), 5/20 free-standing functor errors (2 omissions, 3 substitutions), and 2/20 word order errors. The sentences were presented auditorily and in written form on different days.

*Auditory presentation.* WH judged 18/20 grammatical sentences as being grammatic and 18/20 incorrect sentences as being incorrect. He failed to detect one past-tense inflectional error and one functor choice error.

*Written presentation.* WH judged 18/20 grammatical sentences as being accurate. There was one grammatical sentence, "The little girls cut lacy valentines," that he judged to be agrammatic in both auditory and written presentation. He judged 18/20 inaccurate sentences as being inaccurate. His two "false negatives" were a sentence with an adverbial inflectional error and a sentence with an auxiliary verb form error.

Thus WH demonstrated that he was sensitive to surface grammatic distortions within most sentences. His asyntactic comprehension could not be ascribed to a total inability to process grammatical morphemes.

One of the most remarkable features of WH's production was his inability to accurately map thematic roles onto grammatical categories. Rather than applying syntactic rules or algorithms, he systematically used either a temporal or spatial heuristic. To determine if he had a parallel deficit in comprehending thematic relations, and to learn if the same nonlinguistic heuristics dominated his performance, the following experiments were conducted.

### *Experiment 1: Comprehension of Thematic Roles in Speech*

A word-order task similar to that described by Schwartz and coworkers (Schwartz et al., 1980) was devised, in which with circle and square stick figures were depicted performing

actions. The use of these circle and square stick figures eliminates animacy or semantic plausibility cues, forcing syntactic comprehension of thematic relations. WH was read 24 active and 24 passive sentences. He was asked to match each sentence to one of two pictures, the correct depiction of the sentence and a drawing of the opposite thematic role relationship (see Fig. 1). Both choices for a given sentence depicted actions going in the same direction, right to left or left to right. The direction of the action across all the sentences was counterbalanced.

*Results.* WH chose the correct corresponding picture in 12/24 active sentences and 13/24 passive sentences. Thus he did not comprehend active sentences any better than passive sentences ($\chi^2 = 0.08$, 3 *df*, NS). Although these results might suggest that he was guessing, a further analysis of his responses reveal that WH was not performing randomly. For active sentences, when the correct choice was depicted with the action going from left to right, he was accurate 12/12 times. However, when the action was depicted going from right to left, for active sentences, he was accurate 0/12 times. The spatial direction of depicted actions clearly determined his accuracy ($\chi^2 = 24.0$, 3 *df*, $p < .001$). In the passive form he scored 2/12 when the action was depicted left to right and 11/12 when the action was depicted right to left. Again, the spatial direction of depicted actions determined his accuracy ($\chi^2 = 12.76$, 3 *df*, $p < .01$). Thus, he was using a temporal–spatial strategy similar to what was observed in his production. He would match the first noun that he heard to the drawing on the left regardless of its grammatical role in the sentence.

To confirm that WH's temporal spatial strategy was modality independent, the same task was repeated except that WH read the target sentences, rather than heard them. This procedure would also minimize short-term memory demands.

## *Experiment 2: Comprehension of Thematic Roles in Reading*

If WH continued to use a temporal spatial heuristic, then he would perform better in active sentences when the correct choice was depicted going left to right than when the action was depicted going right to left. Analogously, for passive sentences he would perform better when the action was going right to left than when the action was depicted from left to right.

*Results.* WH performed as predicted. Again there was no difference in his accuracy rate for active versus passive constructions ($\chi^2 = 2.09$, 3 *df*, NS). For active sentences he chose correctly 12/12 times when the action was depicted going left to right and 2/12 times when the action was depicted going right to left. Direction of action again determined his response ($\chi^2 = 17.14$, 3 *df*, $p < .001$). For passive sentences he was accurate 8/12 times when the action was depicted going right to left and 1/12 when the action was depicted going left to right and direction of action influenced his performance ($\chi^2 = 8.71$, 3 *df*, $p < .05$).

The hypothesis that some patients have a mapping deficit assumes intact prelinguistic conceptual knowledge of thematic relations which is incorrectly being mapped onto grammatical categories. From these two experiments we could not be sure that WH had such knowledge. Perhaps he was arbitrarily using a spatial strategy to assign grammatical categories. Because he lived independently and was able to interact with real world knowledge of thematic relations, such as knowing who pays what to whom when he went grocery shopping, it seemed likely that he did possess conceptual knowledge of thematic roles. To experimentally determine if he had such thematic conceptual knowledge, a nonverbal consequences task was devised.

## *Experiment 3: Conceptual Knowledge of Thematic Roles: Nonverbal Stimuli*

WH was presented with 40 pictures in which an action was being depicted (e.g., a circle shooting a square). He was told to look at the picture of the action and then to choose

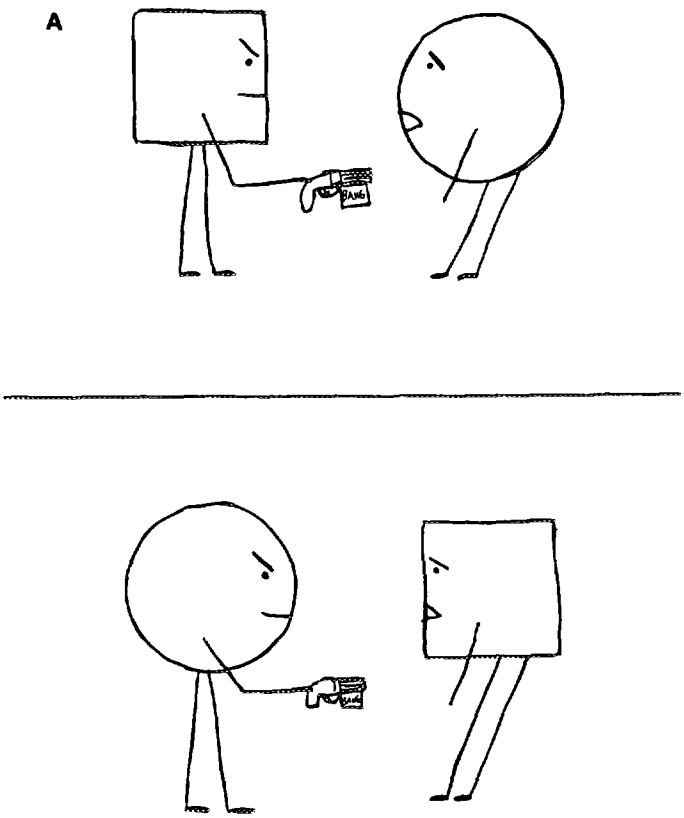


FIG. 1. Examples of pictures that WH matched to sentences. Actions were depicted in either (A) a left to right direction or (B) a right to left direction.

which of two pictures depicting potential consequences of the action was the correct one (a circle lying in a pool of blood or a square lying in a pool of blood; see Fig. 2). The direction of action depicted in the action pictures was counterbalanced (left to right or right to left). If WH comprehended who was doing what to whom he would perform well on this task.

*Results.* As predicted, WH performed accurately (39/40) on this task. In these conditions, the direction of the depicted action did not influence his performance. (His one error appeared to be due to carelessness, as he answered impatiently because he found this task trivial and boring). To confirm that WH specifically did not comprehend the linguistic expression of thematic relations, a parallel consequence task was constructed using words rather than pictures.

## *Experiment 4: Linguistic Knowledge of Thematic Roles— Verbal Stimuli*

WH was given a verbal counterpart to the task in experiment 3. He read 20 active (e.g., The circle shoots the square) and 20 passive sentences administered randomly. Each was


followed by a verbal description of the possible consequences (e.g., The square is dead, or The circle is dead). This task explicitly requires that WH made a thematic assignment to the nouns in the sentence in order to perform the task in a way that is only inferred in experiments 1 and 2. In those experiments he might have been only matching the temporal or spatial characteristics of the nouns to the pictures, without any specific thematic role assignment. We predicted that if he was likely to assign the first noun that was also on the left as agent, he should perform well on active sentences and poorly on passive sentences.

*Results.* WH performed more accurately with active sentences (16/20) than passive sentences (4/20) ($\chi^2 = 14.4$, 3 *df*, $p < .01$).

## GENERAL DISCUSSION

WH is a well-educated left-handed gentleman who became aphasic after a right-hemisphere stroke. He demonstrated a pattern of deficits not often reported in right-handed aphasics. His production deficit is dis-

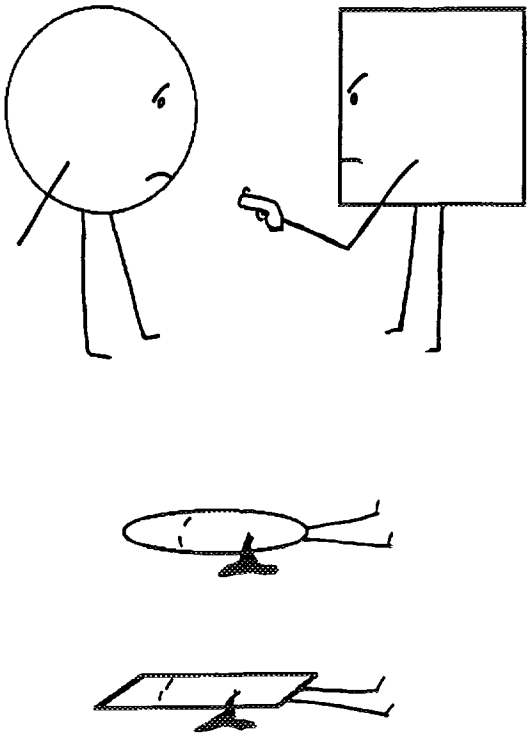

FIG. 2. Examples of nonverbal stimuli used to test conceptual knowledge of thematic roles. WH chose which of the two drawings would be the appropriate consequence of the action depicted at the top.

cussed in detail in the accompanying report (Maher et al., 1995). He clearly demonstrated a syntactic deficit in the face of normal lexical–semantics and phonological processing. On production tasks he demonstrated a word-order problem suggestive of an inability to map thematic relations onto appropriate grammatical categories. Despite this deficit, his mapping procedure was not random. Instead of using linguistic rules and algorithms, he seemed to use temporal–spatial strategies in making thematic assignments. In this report, we investigated the nature of his asyntactic comprehension and examined the extent to which his comprehension deficit paralleled his production deficit.

WH did well on an anagram tasks and tasks of grammaticality judgment. His inability to comprehend sentences cannot be ascribed to a total insensitivity to the role of grammatical morphemes in syntactic comprehension. He is capable of retrieving enough syntactic structural information to determine whether or not these sentences are grammatical. As in the cases described by Linebarger and co-workers (1983), WH demon-

strates that recognition of syntactic form may be dissociated from the ability to extract meaning that depends on knowledge of that form. Knowledge of surface syntactic form may be necessary, but is not sufficient for accurate syntactic comprehension.

WH made systematic errors in procedures that map thematic relations onto grammatic categories and vice versa. He used nonlinguistic rules to assign thematic roles. These heuristics were employed automatically and without hesitation. When he chose incorrectly, WH did not struggle with alternatives or appear to be guessing. In general, he appeared confident that his answers were accurate and was unaware of substituting a spatial rule for a linguistic one. Of particular significance is the fact that he performed equally poorly on both active and passive sentences (experiments 1 and 2). One could mistakenly assume that he had privileged comprehension of the active form of sentences if the results of experiment 4 were taken in isolation. His superior performance for active sentence constructions in this experiment was because of the temporal–spatial characteristics of the active form, not its syntactic properties.

WH clearly demonstrates that conceptual knowledge of thematic relations may exist independent of the accuracy of its linguistic expression. He easily comprehends pictures of who is doing what to whom and accurately predicts the appropriate consequences of actions. However, when the same actions are verbally described, his performance is abysmal.

It has been suggested that some cases of asyntactic comprehension are a result of an impaired short-term memory or a phonological working memory deficit (Caramazza, Basili, Koller, & Berndt, 1981; Friedrich, Martin, & Kemper, 1985). The argument is that in sentence comprehension, words encountered early must be retained in a short term store and held for subsequent deciphering. Words with little intrinsic semantic content such as functors must be retained in a phonological form. The loss of a phonological storage results in relatively selective lack of retention of grammatical morphemes resulting in asyntactic comprehension. This hypothesis cannot account for WH's performance. His digit span was normal, as was his repetition of sentences, suggesting normal short-term memory. Additionally, it is difficult to see how short-term memory abilities would play a role in the highly constrained tasks of matching a written simple active sentence to a picture.

Grodzinsky (1986), motivated by Chomsky's theory of Government and Binding (Chomsky, 1981), proposed a "Trace Deletion" hypothesis for asyntactic comprehension. This hypothesis assumes that sentences have different levels of representations. An active and a passive sentence may have an identical underlying representation, but transformations are performed on this deeper representation (D-structure) to create the surface passive form (S-structure). Constituent noun phrases are moved from their original positions in the D-structure, but leave an abstract trace

of their original position in the S-structure. The moved noun phrase is grammatically bound to the trace of its original position. Thus a passive sentence such as "The circle was hit by the square," is conceived of representing the underlying structure, $[_S[_{NP}e]$ was $[_{VP}$ hit $[_{NP}$ the circle] $[_{PP}$ by the square]]], which is transformed into the S-structure; $[_S[_{NP}$ The circle$]_i$ was $[_{VP}$ hit $t_i[_{PP}$ by the square]]]. "The square" derives its thematic role from the preposition "by" that directly governs it. However, the thematic role for "the circle" is assigned to its trace ($t_i$) position which is grammatically bound to its moved location. Grodzinsky hypothesizes that patients with asyntactic comprehension are unable to appreciate the grammatical link between the moved constituent and its underlying trace. They delete the trace in the S-structure of sentences, are unable to recover an underlying deeper representation of the sentence, and thus are unable to comprehend these transformed sentences. As Grodzinsky (1989) states, this hypothesis stems directly from the observation that some patients with asyntactic comprehension perform above chance on active sentences and at chance on passive sentences. Experiments 1 and 2 demonstrate that WH has difficulty comprehending thematic relations in both active and passive sentences. The "Trace Deletion" hypothesis cannot apply to WH's performance or that of other cases of asyntactic comprehension in which significant difficulties are observed in the comprehension of simple active reversible sentences (Schwartz et al., 1980; Badecker, Nathan, & Caramazza, 1991), since there are no traces to be deleted.

WH's performance can in part be explained by the proposal that he had lost the ability to map thematic roles onto grammatical categories. Schwartz, Linebarger, and Saffran (1987) distinguish between two variants of the mapping hypothesis. In one variant, patients are postulated to have lost verb specific mapping information. The lexical entry of verbs determines the predicate argument structure and establishes thematic roles in sentences. This lexical mapping hypothesis explains errors of even simple reversible active sentences. The alternative is a "procedural" variant of the mapping hypothesis. This procedural hypothesis emphasizes deficits in the operations that assign thematic roles to NPs based on their syntactic function and is invoked to explain why some patients perform worse on sentence constructions that deviate from canonical ordering. As Grodzinsky (1989) points out, the procedural variant of the mapping hypothesis resembles a "transformational" account and makes the same empirical predictions as his Trace Deletion theory. Setting aside controversies regarding the adequacy or testability of the procedural variant of the mapping hypothesis, the lexical mapping hypothesis captures some of WH's performance. This hypothesis predicts that for reversible sentences, performance would be equally inadequate for both active and passive sentences. Experiments 1 and 2 confirms this

prediction. However, this hypothesis does not explain all of WH's behavior. Saffran and Schwartz (1988) observe that their patients, unlike WH, do not use nonlinguistic strategies in systematic or principled ways. While their hypothesis explains the errors that WH made, it remains uninformative with regard to his particular systematic use of a temporal–spatial strategy.

Caplan and his co-workers (1983, 1986) have suggested that some agrammatic patients use linear strategies in assignments of thematic roles. He argues that they have lost knowledge of sytactic hierarchical representations that organize major lexical items and instead adopt prelinguistic or nonlinguistic rules to interpret sentences. In sentences of the form N–V–N, which include simple active and simple passive sentences a linear rule is adopted and the first noun is assigned the role of agent. This linear strategy cannot account for WH's performance. Specifically, he is unable to match a simple active sentence, such as "the circle hits the square," when the correct drawing depicts the action proceeding from right to left. From experiment 3, we know that he has knowledge of thematic relations as depicted by drawings, regardless of the direction of actions. Thus, if he were using a linear strategy and assigned the first noun to the role of agent, he would be able to match this noun to the agent in the drawing irrespective of its spatial location in the drawing. Caplan's linear hypothesis would predict normal performance on simple active sentences and cannot explain WH's performance. Rather than using a linear strategy, WH uses a temporal spatial strategy. He maps the first noun that he hears or the left-sided noun to the left picture and the second noun or the right-sided noun to the right picture regardless of their respective thematic roles. While WH does resort to a nonlinguistic heuristic as suggested by Caplan, he does not adopt the specific heuristic postulated by Caplan. (Note that in a footnote, Caplan and Futter (1986) refer to a patient who also uses a spatial strategy, but do not provide data or discussion of this phenomenon.)

In summary, WH's asyntactic comprehension can be characterized by his inability to map grammatical categories onto thematic relations (of which he has preserved knowledge). He seems impervious to sentential semantic differences created by active and passive sentence constructions. However, his performance is not random. He uses a temporal or spatial strategy to map nouns onto thematic relations. When his responses require matching sentences to alternatives without intrinsic spatial characteristics (consequences tasks), he uses either a temporal (first noun as subject) or a spatial (left noun as subject) strategy. When the alternatives also have spatial characteristics, he simply matches corresponding spatial locations. Importantly, he does not have privileged understanding of active sentences, and his performance cannot be explained by any hypothesis that invokes deficts that would be particularly sensitive

to passive constructions or those that rely on deficits of short-term memory.

WH demonstrates parallel deficits in the mapping of thematic roles in both production and comprehension. The inability to map thematic relations onto grammatical categories may be a specific deficit that is manifest in both production and comprehension. Cases reported with agrammatic production and normal comprehension have deficits in the production of grammatical morphemes, which in Garrett's model of sentence production (Garrett, 1980) is primarily at the "positional" level. In the same way that different deficits may result in agrammatism, it seems self-evident that different deficits may superficially resemble each other in asyntactic comprehension. Cases with asyntactic comprehension and grammatic production have had short-term memory deficits (reviewed in Saffran, 1990b). To our knowledge, every case described with thematic role mapping deficits, presumably a "functional" level deficit (Caramazza & Miceli, 1991), have had similar comprehension and production deficits. It may be that at this "deep" interface between nonlinguistic conceptual knowledge of thematic relations and corresponding linguistic codes, common procedures are performed in both syntactic comprehension and production. If production and comprehension aspects of thematic role-mapping procedures were conducted by separate functional modules, it would be a remarkable coincidence that WH not only had both modules damaged, but developed identical alternate temporal–spatial strategies in response to or as a consequence of these two functionally independent deficits. Additional evidence for parallel production and comprehension mapping deficits comes from Byng's report of therapeutic interventions (Byng, 1988). She was able to demonstrate that in a patient with such a mapping deficit, treatment of mapping procedures in the comprehension of thematic roles in locative reversible sentences generalized to both the comprehension of simple active and passive sentences, as well as improved production which was reflected in an increase in the use of appropriate argument structures in spontaneous speech. Taken together, these observations suggest that mapping (or matching) of grammatical categories on to thematic roles may be an element of sentence processing common to both sentential comprehension and production, a hypothesis that is, of course, testable. His difficulty with thematic roles are in contrast to his ability to process grammatical morphemes. He makes errors of omission and substitution of grammatical morphemes in spontaneous production, despite being able to detect morphological errors in judgments of grammaticality.

Finally, does WH's use of a spatial heuristic have implications for the nature of thematic representations? WH's spatial strategy may have been an idiosyncratic response to his linguistic disabilities without any generalizable implications; or his strategy may have been an opportunistic com-

pensatory mechanism arising in the absence of normal linguistic algorithms. As such, it would be one of a number of adaptive strategies potentially available to patients, created specifically to compensate for their deficits (Kolk & Van Grunsven, 1985). Another possibility is that the loss of syntactic algorithms bared underlying primitive methods of representing thematic relations. Rather than being adaptive, spatial characteristics of thematic representations may be normal, but obscured by language. Language per se does not appear to be a necessary precondition for conceptual knowledge of thematic relations. Household pets appear to have some real world knowledge of thematic relations, such as who will feed them and when and where. Apes are capable of matching geometric symbols to videotaped actions in ways that indicate knowledge of thematic agent, instrument, and patient (Premack, 1988). We are not suggesting that thematic relations can be comprehended with equal facility and sophistication nonverbally as they are verbally. However, WH's performance raises the possibility that spatial mechanisms are used to represent simple thematic relations. With the evolution of language capacities, grammatical encoding of thematic relations may have developed superimposed on primitive spatial representations of thematic relations. Consistent with these speculations, preliminary data from normal subjects suggest that spatial characteristics may underlie representation of thematic relations, characteristics normally obscured by dominant linguistic rules (Chatterjee, Maher, & Heilman, 1995).

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