

Selective Impairment of Thematic Role Assignment in Sentence Processing

ALFONSO CARAMAZZA

The Johns Hopkins University

AND

GABRIELE MICELI

Università Cattolica, Rome

We report the performance of a brain-damaged subject showing a particularly pure dissociation between impairment in processing thematic roles and spared ability to process the morphological structure of sentences. The thematic role processing impairment was observed in both comprehension and production of active and passive reversible sentences, although it was more severe for the latter sentence type. This pattern of performance poses interesting challenges for current conceptions of the nature of language breakdown in aphasia and for models of normal sentence processing. © 1991 Academic Press, Inc.

Since the mid seventies a large literature has accumulated on the issue of sentence comprehension impairment in relation to the clinical category of agrammatic Broca's aphasia. The original proposal by Caramazza and Zurif (1976; see also Heilman & Scholes, 1976), that a particular form of sentence comprehension characterized by disproportionate difficulty in comprehending semantically reversible compared to nonreversible sentences—asyntactic comprehension—and the production impairment char-

The research reported here was supported in part by NIH Grant CD00036 and by a grant from the Ministero della Sanità and the Consiglio Nazionale delle Ricerche, Italy. We thank E.B. for his patience and good cheer throughout the many testing sessions. We also thank Bill Badecker, Rita Berndt, Sampo Law, Brenda Rapp, and two anonymous referees for suggestions in the interpretation of the reported results or for helpful comments on an earlier version of this paper. Address requests for reprints to: Alfonso Caramazza, Cognitive Neuropsychology Laboratory, Department of Cognitive Science, The Johns Hopkins University, Baltimore, MD 21218, or Gabriele Miceli, Department of Neurology, Università Cattolica, Rome, Italy.

acterized by difficulty in producing grammatical morphemes are the result of a single underlying deficit to syntactic processing mechanisms, has been subjected to much scrutiny, spawning various attempts at explanation of the putative facts as well as controversy on the very nature of the facts to be explained (see Badecker & Caramazza, 1985; Caramazza & Badecker, 1989; Berndt, 1987, 1991; Caplan & Hildebrandt, 1988; Howard, 1985; Linebarger, 1990; Schwartz, 1987; Zurif, Gardner, & Brownell, 1989; see also papers in Kean, 1985, for discussion of these issues). The resulting picture is extremely complex. In this paper we will not attempt to address the many unresolved issues in this area. Instead, we will report the performance of a patient whose performance in comprehending and producing sentences suggests, as originally proposed by Saffran, Schwartz, and Marin (1980a, b; see also Berndt, 1987; Caplan, Baker, & Dehaut, 1985; Caramazza & Berndt, 1985; Jones, 1984; Schwartz, Saffran, & Marin, 1980), that at least one form of sentence processing impairment may result from damage to procedures for mapping thematic roles (agent, theme, and so forth) onto grammatical categories (subject, direct object) and vice versa. More specifically, we present evidence which suggests that morphosyntactic and thematic role assignment procedures in sentence processing may be damaged independently of each other.

Caramazza and Zurif (1976) reported that, in a sentence/picture matching task, patients classified as Broca's aphasics were impaired in understanding center-embedded relative clause sentences such as "the girl that the boy is chasing is tall." The sentence comprehension impairment did not affect all types of sentences, but was restricted to semantically reversible ones; thus, the patients had no difficulty in selecting the correct picture choice for sentences such as "the apple that the boy is eating is red," presumably because the meaning of the words allows only one plausible interpretation of the sentence—that a red apple is being eaten by a boy, in the example used here. The selective nature of the comprehension difficulty, restricted as it was to semantically reversible sentences, led these authors to suggest that the patients failed to understand sentences only when the correct choice of a picture required the successful analysis of syntactic information in sentences: the patients failed because they could not adequately process syntactic information. And, on the assumption that agrammatic production was similarly the result of failure to adequately use syntactic processes in sentence production, the obtained results could be interpreted as indicating that agrammatic production and asyntactic comprehension are caused by a common deficit to the syntactic knowledge that supports sentence processing.

Although this hypothesis received considerable initial support (Amsell & Flowers, 1982; Caramazza, Berndt, Basili, & Koller, 1981b; Gallagher & Canter, 1982; Heilman & Scholes, 1976; Schwartz et al., 1980), it has since been shown to be inadequate in several respects. First, it is now

known that agrammatic production is not always associated with asyntactic comprehension; various reports of single-patient studies have shown that some agrammatic speakers fail to show *any* comprehension difficulties whatsoever (Caramazza & Hillis, 1989; Kolk, van Grunsven, & Keyser, 1985; Miceli, Mazzucchi, Menn, & Goodglass, 1983; Nespoulous, Dordain, Perron, Ska, Bub, Caplan, Mehler, & Lecours, 1988). Second, it is now also known that asyntactic comprehension can occur independently of agrammatic production; various studies have shown that some patients with short-term memory impairment (Berndt & Mitchum, 1990; Caramazza, Basili, Koller, & Berndt, 1981a; Saffran & Martin, 1990; Vallar & Baddeley, 1984; Vallar, Basso, Bottini, 1990; see Caplan & Waters, 1990; Saffran, 1990; for review) and some patients clinically classified as Wernicke's aphasics (Berndt, 1987; Caramazza & Berndt, 1985; Goodglass, Blumstein, Gleason, Hyde, Green, & Statlender, 1979; Heesch, 1980, 1985; Martin & Blossom-Stach, 1986) present with asyntactic comprehension. Third, and most importantly, the very characterizations of the putative production and comprehension impairments in these patients have been challenged on several levels. Thus, Linebarger, Schwartz, and Saffran (1983; see also Berndt, Salasoo, Mitchum, & Blumstein, 1988; Shankweiler, Crain, Gorrell, & Tuller, 1989) reported that agrammatic patients with asyntactic comprehension can nonetheless perform very well in judging the grammatical well-formedness of sentences, demonstrating considerable sensitivity to surface structure syntactic information. This result suggests that the characterization of these patients as having a syntactic processing deficit is too broad or incorrect. Another result that undermines the strong version of the Caramazza/Zurif hypothesis concerns the characterization of the production deficit in agrammatic speakers. These authors simply assumed that the theoretically relevant feature of agrammatic production was the omission of grammatical morphemes. However, Saffran et al. (1980a, b) reported that agrammatic speakers when tested in a picture description task also present with difficulties in producing main verbs and the correct order of arguments; for example, instead of producing "boy/hit/girl" they might produce "girl/hit/boy" (see also Caramazza & Berndt, 1985). These results show that patients clinically classified as agrammatic Broca's aphasics may have a more complex disorder than just an impairment in producing grammatical morphemes.

In light of these recent developments, which aspects, if any, of the original Caramazza/Zurif proposal remain valid? Certainly, the observation that *some* agrammatic patients are selectively impaired in processing semantically reversible sentences is now taken to be a basic neuropsychological fact. Less clear is the status of the theoretical significance of this fact when interpreted in the context of the subsequent research cited above. Several positions have been taken on the matter. The position of

some authors is to deny the relevance or validity of the cited complicating factors and to seek to restrict the domain of relevant facts to a loosely defined notion of productive agrammatism, as simply the omission/substitution of grammatical morphemes, and a comprehension impairment characterized as poor performance on sentences with moved constituents, for example, passives (e.g., Grodzinsky, 1986, 1990). The dangers of this solution to the complexities presented by recent experimental results are obvious—one runs the risk of tailoring facts to fit one's theoretical preconceptions.

Other authors have not been dismissive of the results reviewed above and have attempted, instead, to articulate explanatory proposals that consider as the relevant facts for explanation a complex disorder characterized, in the case of production, by the omission/substitution of grammatical morphemes, the omission/nominalization of main verbs, and the misordering of arguments, and, in the case of comprehension, by asyntactic comprehension cooccurring with surprisingly spared ability to judge the grammatical well-formedness of sentences (Berndt, 1987; Caplan & Hilderbrandt, 1988; Linebarger, 1990; Saffran & Schwartz, 1988; Schwartz, Linebarger, & Saffran, 1985; Schwartz, Linebarger, Saffran, & Pate, 1987). This solution, in a fashion similar to the position argued for by Caramazza and Zurif, is based on the assumption that the cited constellation of performance features forms part of a unitary disorder arising from a common underlying deficit (see Berndt & Caramazza, 1980, for a detailed description of this position). Various hypotheses have been offered in this regard, including the possibility that the disorder arises from damage to short-term memory (e.g., Linebarger, 1990) or that it arises from damage to processes that map thematic role information onto grammatical categories and vice versa (e.g., Saffran & Schwartz, 1988; Schwartz et al., 1987).

A position adopted by some authors has been to reject the assumption that the cited constellation of performance features arises from a single underlying deficit and to propose, instead, that damage to different components of the language processing system underlies different features of the clinical syndrome of agrammatic aphasia; that is, agrammatic Broca's aphasia is considered to be a heterogeneous disorder consisting of functionally independent deficits (Berndt, 1991; Caramazza & Berndt, 1985; Caramazza & Hillis, 1989; Martin & Blossom-Stach, 1986; Martin, Wetzel, Blossom-Stach, & Feher, 1989; Miceli & Caramazza, 1988; Miceli & Mazzucchi, 1990). On this view, the clinical category of agrammatic Broca's aphasia does not constitute the basic explanandum to which we should direct our efforts at explanation. The alternative proposal is made that the basic units of analysis to which our explanatory efforts should be directed are individual patients—experiments of nature in whom the language processing system has been damaged in some way or other (Bad-

ecker & Caramazza, 1985; Caramazza, 1984, 1986; Caramazza & Badecker, 1989; McCloskey & Caramazza, 1988). A corollary of this view is that the observed heterogeneity of performance among patients clinically classified as agrammatic aphasics is not to be simply interpreted as reflecting random "noise" which may be safely ignored but, instead, and until shown otherwise, it is assumed that the observed variation in the patterns of performance among such patients *may* be theoretically significant (Miceli, Silveri, Romani, & Caramazza, 1989; Saffran, Berndt, & Schwartz, 1989). The program of research entailed by this view is particularly sensitive, therefore, to the patterns of associations and dissociations of symptoms found in individual brain-damaged patients, *independently of their clinical classification*—a single theory of language processing must account for all patterns of language impairment independently of the clinical classification of the patients manifesting the observed symptom complexes.

An interesting pattern of impaired and spared language processing performance has recently been reported by Martin and Blossom-Stach (1986; see Berndt, 1987; Caramazza & Berndt, 1985, for other cases). These authors described a fluent aphasic patient who made reversal errors in production and comprehension despite relatively preserved ability to produce grammatically well-formed sentences. They interpreted the results as showing that syntactic processing difficulties at the functional level (Garrett, 1980) of sentence representation may be damaged independently of other levels of sentence processing. This pattern of performance contrasts instructively with one reported by Caramazza and Hillis (1989; see also Nespoulous et al., 1988) which was interpreted as showing a selective deficit at the positional level (Garrett, 1980) of sentence production. In this paper, we report the performance of an Italian brain-damaged subject that is similar in many respects to that reported for patients described by Caramazza and Berndt (1985) and Martin and Blossom-Stach (1986). Specifically, we report the case of a striking dissociation between impaired ability to assign thematic roles in both comprehension and production in the context of spared ability to process morphosyntactic properties of sentences in both comprehension and production. The results are discussed in relation to current models of sentence processing.

CASE HISTORY

E.B. is a 64-year-old, right-handed Italian man with a degree in accounting. He had a stroke in 1984 that resulted in a fluent aphasia without noticeable neurological deficits, except for a subjective weakness of the right upper arm and extinctions on the right hand on double simultaneous tactile stimulation. E.B. also complained of mild paresthesias on the right side of his body. A CT-scan performed at that time revealed a hypodense area in the left parietal lobe. In 1987, he underwent heart valve surgery.

During surgery, his blood pressure fell and he was in a confusional state for approximately 1 week. Over the next month, he improved very quickly and his attending physician felt that he had made a complete recovery to his previous condition. The clinical neurological evaluation showed no noticeable objective changes, although E.B. complained of a mild increase of the right-sided paresthesias. A CT-scan performed several months later is reported in Fig. 1. The figure demonstrates the presence of a left hypodense lesion, involving the upper portion of the parietal lobe, associated with a mild dilation of the left lateral ventricle. The following study was performed between May 1988 and February 1990.

The neuropsychological exam revealed intact buccofacial, ideomotor, and constructional praxis. Intellectual functions were unimpaired on Raven's Colored Progressive Matrices.

On memory tasks, E.B.'s performance was impaired. His ability to reproduce sets of 2, 3, 4 and 6 words, presented auditorily by the examiner, was mildly but clearly below normal: he reproduced correctly 10/10, 8/10, 3/5, and 0/5 of the 4 sets of words, respectively. His performance with sets of 2, 3, and 4 nonwords was much poorer: he produced correctly only 5/10 sets of 2 nonword stimuli, and 0/10 correct responses for the 3- and 4-nonword sets of stimuli. In a probe task for auditorily presented words, E.B.'s performance was in the lower normal range: he made no errors on sets of 4 items, and made 3 and 2 errors on sets of 6 and 8 items, respectively ($N = 24$ for each set). On the nonword probe task, E.B. scored slightly but clearly below normal: he made no errors on sets of 4 items, but made 5 errors of 24 sets of 6 nonwords. His digit span was reduced (4 digits forward, 3 digits backward).

E.B. was administered an aphasia screening battery (Miceli, Laudanna, & Burani, 1991). Spontaneous speech was normally articulated. E.B. was able to use a normal variety of grammatical structures and lexical items. However, during conversation he frequently pauses, seemingly as the result of word finding difficulties and more frequently in phonemic groping, especially at the beginning of words. On a corpus of 720 words produced in spontaneous speech, the mean length of his utterances was 6.42 words, a value that falls just below the values reported in Miceli et al. (1989) for normal controls (range: 6.7 to 13 words). This reduced value, however, does not result from an inability to produce complex syntactic structures, as E.B. produced 99 main clauses and 31 subordinate clauses, with a main-to-subordinate clause ratio of 3.19, well within the range for normal subjects. Furthermore, he presented only extremely mild difficulties in producing free-standing grammatical morphemes (prepositions, definite and indefinite articles, clitics, and auxiliary verbs): of 269 obligatory contexts he produced the correct morpheme in 260 (96.6%) cases. In 72 contexts for prepositions, he made 1 omission error (1.4%) and 3 substitution errors (4.2%). He made 3 errors of 112 contexts for

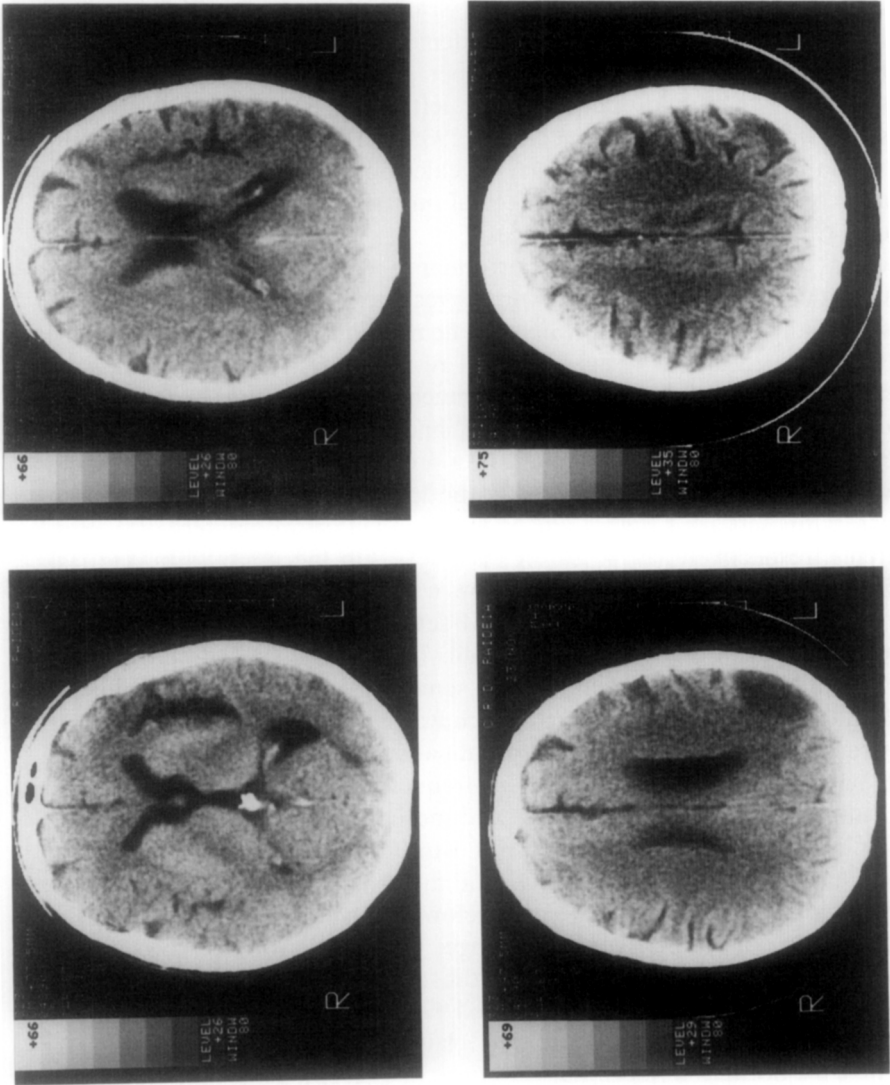


FIGURE 1

articles (0.9%), consisting of 1 omission and 2 substitutions. One clitic pronoun (of 33, 3.0%) was omitted, as well as 1 auxiliary verb (of 52, 1.9%). No errors on bound grammatical morphemes were observed.

In the tasks of oral and written naming of pictured objects and actions, E.B. demonstrated mild word finding problems and produced isolated semantic substitutions. In oral picture naming, E.B. produced 2/30 incorrect responses to pictured objects (6.7%), consisting of a semantic error and of a circumlocutory response, and 6/37 incorrect responses to pictured actions (16.2%), consisting of 4 semantic errors and 2 circumlocutions. In a similar task administered for written naming, he made no errors in naming 24 pictured objects and produced 6/29 incorrect responses to pictured actions (20.7%), resulting from 4 spelling errors and 1 semantic error and from 1 failure to respond to a stimulus. He read and repeated single words flawlessly; in delayed copy of single words he also performed flawlessly; but, he produced some spelling errors in writing words to dictation. He performed flawlessly in repeating ($N = 12$) and reading aloud ($N = 8$) short sentences of varying grammatical complexity, containing up to 7 words. Furthermore, he made no errors in auditory and visual lexical decision tasks. However, he was mildly impaired in reading, repetition, and writing to dictation of polysyllabic nonwords. His errors in these tasks consisted of responses that were orthographically/phonemically similar to the input string. Thus, for example, he read *geba* (correct pronunciation /'djeba/) as /'djema/; repeated /'katora/ as /'katola/; and wrote to dictation /ko'spivo/ as *cospido*.

E.B.'s comprehension of isolated nouns was normal. He was asked to select from two pictures the one that depicted an auditorily or visually presented word. One set of two pictures contained the correct response and a semantically related noun; the other set contained the correct response and a picture whose name was phonemically or visually related to the target response. Each task consisted of 40 stimuli. E.B.'s performance was error-free on both auditory and visual stimulus presentations. By contrast, his ability to comprehend verbs was mildly impaired. In two administrations of an action comprehension test (Miceli, Silveri, Nocentini, & Caramazza, 1988), he made 4 errors of 96 stimuli. In both cases, he confused "tirare" (to pull) with "spingere" (to push) and "camminare" (to walk) with "correre" (to run). In another verb comprehension test consisting of 11 pairs of "reversible" verbs (e.g., buy-sell; teach-learn; give-take, etc.) he produced 3/22 incorrect responses.

E.B.'s auditory comprehension of bound grammatical morphemes in single words was entirely normal. He performed flawlessly in a test in which, presented with a noun in the singular or in the plural form (e.g., "bambino," boy or "bambini," boys), he had to choose between two pictures: one representing the correct and the other the incorrect number of objects (e.g., one boy vs. two boys; number of stimuli = 20). He also

performed flawlessly in a test in which, presented with verbs either in the third singular (e.g., "corre," he runs) or in the third plural form (e.g., "corrono," they run) of the present indicative, he was required to indicate which of two pictures (e.g., a boy running vs. two boys running; number of stimuli = 20) corresponded to the presented verb form. In a third task, E.B. was asked to differentiate among verb tenses. A verb was auditorily presented in the present, future, or present perfect third singular form. At the same time he was shown three pictures that depicted the action corresponding to the three tenses. Thus, for example, he was aurally presented with the verb form "correra," he will run, and was shown three pictures: an athlete at the starting block (the correct response), an athlete running (corresponding to "corre," he runs), and an athlete past the arrival line (corresponding to "ha corso," he ran). E.B. performed correctly on all 30 trials of this test.

In striking contrast to his generally good performance in single word processing, E.B. was severely impaired in comprehension tasks with semantically reversible, active, and passive voice sentences. The tasks required the subject to match an auditorily ($N = 60$) or a visually presented ($N = 45$) sentence to one of two pictures. In each trial, in addition to the correct response (e.g., "Le ragazze sono spaventate dagli uomini" (The girls are frightened by the men)), one of three types of alternative pictures was used: a reversal of thematic roles (e.g., "Gli uomini sono spaventati dalle ragazze" (The men are frightened by the girls)), a morphologically related foil (e.g., "Le ragazze sono spaventate dall'uomo" (The girls are frightened by the man)), or a lexical-semantic foil (e.g., "Le ragazze sono spaventate dai bambini" (The girls are frightened by the children)). E.B. performed at chance level on trials with role reversal alternatives (9/20 incorrect responses: 2/10 on active and 7/10 on passive sentences), but made no errors with morphological or lexical foils. In the visual presentation task, he also performed at chance level on role reversal trials (7/15 incorrect responses: 3/8 on active and 4/7 on passive sentences), but made only 1 error on a lexical foil and no errors on morphological foils.

E.B.'s language performance, as assessed by the aphasia screening battery used in our laboratory, was essentially normal in processing nouns and inflectional-lexical morphology, mildly impaired in processing verbs, and severely impaired in comprehension of semantically reversible sentences. This study focuses on E.B.'s ability to comprehend and produce sentences.

EXPERIMENTAL STUDY

Comprehension

Before presenting the experimental materials and procedures, we briefly describe some properties of Italian sentence structure, focusing on the

role of number agreement in determining the grammatical roles of noun phrases. In Italian, nouns are marked for gender and number (not for case). In the case of active sentences, the subject is identified by number agreement between noun phrases and main verb. In general, when only one noun in a sentence agrees with the verb, that noun is assigned the grammatical role of subject. Consequently, word order in sentences of this type is substantially free (although subject-verb-object (SVO) is far more frequent than other word orders), independent of whether the sentence is semantically reversible or nonreversible. Thus, in sentences like “Il bambino mangia le mele” (The boy eats the apples) and “Il bambino insegue le bambine” (The boy chases the girls), “il bambino” is the subject, as it is the only noun that agrees in number with the verb. Changing word order in these sentences (“Le mele mangia il bambino”) (“Le bambine insegue il bambino”) does not influence interpretation.

When more than one noun agrees in number with the main verb, as in “Il bambino mangia la mela” (The boy eats the apple) or “Il bambino insegue la bambina” (The boy chases the girl), word order is still substantially free in semantically nonreversible sentences—“La mela mangia il bambino” (The apple eats the boy) is an unambiguous sentence in Italian—but not in semantically reversible sentences. In the latter case, word order and/or emphatic stress are the only reliable cues for the assignment of grammatical roles—the string is interpreted as an SVO sentence, unless the first noun is emphatically stressed. Thus, the meaning assigned to “Il bambino insegue la bambina” (without emphatic stress) is that of a boy chasing a girl, and the meaning assigned to “La bambina insegue il bambino” is that of a girl chasing a boy.

Leaving aside stress marked sentences, whereas number is the only clue for subject role assignment in active sentences, several morphological cues unambiguously contribute to assignment of subject role in passives. In these sentences, the subject noun agrees in number with the auxiliary verb and agrees in number *and* gender with the past participle form of the main verb (consider for example “La (f.sg.) bambina (f.sg.) è (3rd sg.) inseguita (f.sg.) dal bambino” (The girl is chased by the boy). Furthermore, since the *by*-phrase unambiguously assigns the agent role, word order can also vary freely, *independent of morphological cues and semantic reversibility* (note that with respect to this issue, passive sentences differ from active sentences where word order must be SVO when morphological cues are insufficient to constrain role assignment). Thus, for example, the sentence “Dalla donna è inseguita la bambina” (by the woman is chased the girl) is unambiguously “the girl is chased by the woman” even though there are no number and gender agreement cues.

Number agreement between subject and main verb in active sentences and number + gender agreement between subject and main verb in passive sentences allow subject deletion, in both sentence voices. Sen-

TABLE 1
 EXAMPLES OF SENTENCES ADMINISTERED TO E.B. IN THE AUDITORY AND VISUAL
 SENTENCE- TO-PICTURE MATCHING

a. Active sentence voice

Both arguments in the singular form

Il bambino accarezza la nonna (The boy caresses the grandmother).

First argument in the singular form, second argument in the plural form

Il bambino accarezza le nonne (The boy caresses the grandmothers).

First argument in the plural form, second argument in the plural form

I bambini accarezzano la nonna (The boys caress the grandmother).

Both arguments in the plural form

I bambini accarezzano le nonne (The boys caress the grandmothers).

b. Passive sentence voice

Both arguments in the singular form

La nonna è accarezzata dal bambino (The grandmother is caressed by the boy).

First argument in the singular form, second argument in the plural form

La nonna è accarezzata dai bambini (The grandmother is caressed by the boys).

First argument in the plural form, second argument in the singular form

Le nonne sono accarezzate dal bambino (The grandmothers are caressed by the boy).

Both arguments in the plural form

Le nonne sono accarezzate dai bambini (The grandmothers are caressed by the boys).

tences like "Mangia la mela" (Eats the apple), "Insegue la bambina" (Chases the girl), "E' mangiata dal bambino" (Is eaten by the boy), and "E' inseguita dal bambino" (Is chased by the boy) are perfectly grammatical in Italian. Deletion of the *by*-phrase in passive sentences is also grammatical ("La mela è mangiata" (The apple is eaten) and "La bambina è inseguita, (The girl is chased)). By contrast, object deletion in active sentences is not permitted ("Il bambino insegue" (The boy chases) is ungrammatical).

Active and passive reversible sentences. Semantically reversible sentences were used in this task. Ten basic stimuli were constructed. Each sentence consisted of a two-predicate verb with animate agents and themes. The two nouns in each sentence were always one in the masculine gender and one in the feminine gender. Each basic sentence was manipulated so as to construct 8 sentence stimuli to be used in the test. The factors manipulated were voice (active vs passive) and number of the agent or theme nouns (singular vs. plural). A basic stimulus sentence and the sentences obtained by systematically changing sentence voice and argument number are shown in Table 1. Several randomized blocks of 80 sentences each were prepared (10 basic sentences \times 8 factors).

The task was administered both auditorily and visually. Three types of

foils were used: a *role reversal foil* portraying a reversal of thematic roles; a *morphological foil* in which the number of either the agent or the theme was different from that used in the stimulus sentence; and a *lexical foil* in which either one of the nouns or the verb was semantically related to the stimulus sentence. An example of the three types of foils for the sentence “**Il bambino accarezza la nonna**” (The boy caresses the grandmother) follows:

Role reversal foil (thematic role reversal):

La nonna accarezza il bambino (The grandmother caresses the boy).

Morphological foil:

Il bambino accarezza le nonne (The boy caresses the grandmothers) or
I bambini accarezzano la nonna (The boys caress the grandmother).

Lexical foil:

Il bambino abbraccia la nonna (The boy hugs the grandmother), or
Il bambino accarezza la bambina (The boy caresses the girl), or
L'uomo accarezza la nonna (The man caresses the grandmother).

The occurrence of morphological foils was balanced across first and second noun. Also balanced was the occurrence of semantically related nouns in first and second position in the sentence. A total of 240 experimental trials each was used in the auditory and the visual version of the test: 80 sentences by three foil types. An experimental block consisted of 80 trials. In each block, a stimulus sentence appeared only once, paired with one of the three foils and the correct picture. Within an experimental block the different foil types were represented approximately equally.

In the *auditory sentence comprehension task*, the examiner read aloud the stimulus sentence and E.B. was asked to point to the picture that most closely matched the sentence. A stimulus could be repeated up to three times, if requested. However, this was very seldom necessary. In the *visual sentence comprehension task*, a written sentence was presented on a card. E.B. could read the sentence for as long as he wished, until he felt that he could provide an answer, then the card was removed and, upon presentation of the stimulus pictures, he indicated his choice. Usually, E.B. read the sentence very quickly and responded promptly. Although not required to do so, E.B. always repeated the aurally presented sentences and read aloud the written sentences before responding. He always read and repeated the stimulus sentences correctly.

A summary of the results is shown in Table 2. E.B.'s performance on the auditory and on the visual administrations of the task was very similar, both in terms of overall performance and in terms of the distribution of errors as a function of sentence and foil type: performance on actives was

TABLE 2
INCIDENCE OF THE ERRORS PRODUCED BY E.B. IN THE AUDITORY COMPREHENSION TASK AND
IN THE VISUAL SENTENCE COMPREHENSION TASK

Foil type	Active	Passive	Total
Auditory			
Reversal	10 (25)	23 (57.5)	33 (41.2)
Morphological	—	3 (7.5)	3 (3.7)
Lexical	—	2 (5.0)	2 (2.5)
Total	10 (8.3)	28 (23.3)	38 (15.8)
Visual			
Reversal	9 (22.5)	23 (57.5)	32 (40.0)
Morphological	9 (7.5)	4 (10.0)	7 (8.7)
Lexical	2 (5.0)	1 (2.5)	3 (3.7)
Total	14 (11.7)	28 (23.3)	42 (17.5)

($N = 40$ in each cell; Total = 120 in each cell). Percentages are reported in parentheses.

better than on passives, in both the auditory (10/120 vs. 28/120 errors, $\chi^2 = 9.036$; $p < .005$) and the visual administration of the task (14/120 vs. 28/120, $\chi^2 = 4.877$; $p < .05$); also, performance in the reversal foil condition was not different from chance level (auditory: 33/80, $\chi^2 = 3.2$; $p = n.s.$; visual: 32/80, $\chi^2 = 2.45$; $p = n.s.$) and much worse than the other two foil conditions, where error rates ranged from 2.5 to 8.7%.

When performance on active and passive sentences is considered separately for each foil condition, it is immediately apparent that E.B. is severely impaired in comprehension of **both** sentence types, in the condition where lexical-semantic and lexical-morphological information is not available to help choose the correct response. Thus, in the reversal foil condition, E.B. performed very poorly for both active and passive sentences, although worse on the latter (auditory: 25 vs. 57.5% errors, for actives and passives, respectively; visual: 22.5 vs. 57.5%, for actives and passives, respectively).

In short, E.B. is severely impaired in assigning thematic roles in the comprehension of active and passive reversible sentences, while retaining the ability to process the lexical-semantic and lexical-morphological information in these sentences.

Truncated reversible sentences. E.B.'s ability to understand truncated and cleft active and passive sentences was evaluated with the same picture materials as those just reported. Five types of sentences were used in this task: two types of truncated active sentences and three types of truncated passive sentences. The sentences were administered once auditorily and once visually.

One type of active sentence resulted from the omission of the subject of the sentence (e.g., "Insegue la bambina" (Chases the girl)—recall that

TABLE 3

EXAMPLES OF TRUNCATED AND CLEFT SENTENCES FOR THE ACTIVE STIMULUS "IL BAMBINO INSEGUE LA BAMBINA" (THE BOY CHASES THE GIRL) AND FOR THE CORRESPONDING PASSIVE STIMULUS "LA BAMBINA È INSEGUITA DAL BAMBINO" (THE GIRL IS CHASED BY THE BOY)

a. Active sentence voice

Truncated agent

Insegue la bambina (Chases the girl).

Cleft, truncated theme

E' il bambino che insegue (It is the boy who chases).

b. Passive sentence voice

Truncated agent

La bambina è inseguita (the girl is chased).

Truncated theme

E' inseguita dal bambino ((She) is chased by the boy).

Cleft, truncated agent

E' la bambina che è inseguita (It is the girl who is chased).

in all the sentences used for this task the subject is also the agent). Note that, since in Italian (unlike English) the subject pronoun can be dropped, these sentences are grammatical. It should also be noted, as discussed above, that the order of noun phrases around the verb can vary rather freely in Italian. As a consequence, even though in an active sentence like "Insegue la bambina," the noun phrase "la bambina" is usually interpreted as the theme ("X chases the girl"), the alternative interpretation that "la bambina" is the agent ("The girl chases X") is also permissible. The intonational profile of the sentence is different in the two cases, however. The stimuli were always read with the intonation appropriate for the first interpretation. The other type of active sentence consisted of truncated cleft sentences in which the object was omitted (as in "E' il bambino che insegue" (It is the boy who is chasing)). Object/theme truncated sentences were not used, since deletion of the theme would result in ungrammatical stimuli (like "La bambina accarezza" (The girl caresses)).

One type of passive stimuli consisted of truncated sentences in which the agent was omitted (as in "La bambina è inseguita" (The girl is chased)). A second type of passive sentences consisted of truncated forms in which the theme was omitted (as in "E' abbracciata dal bambino" (She is hugged by the boy)). A third type of passive stimuli consisted of truncated cleft sentences with an unexpressed agent (as in "E' la nonna che è abbracciata" (It is the grandmother who is hugged)). Examples of the five types of stimuli used for this task are reported in Table 3.

One hundred trials were administered for each sentence type for each

TABLE 4

INCIDENCE OF INCORRECT RESPONSES IN THE AUDITORY AND IN THE VISUAL COMPREHENSION OF TWO TYPES OF TRUNCATED, ACTIVE REVERSIBLE SENTENCES AND OF THREE TYPES OF TRUNCATED, PASSIVE REVERSIBLE SENTENCES

Foil type	Truncated agent	Cleft, truncated theme	
Active sentences			
a. Auditory presentation			
Role reversal	14 (35.0)	8 (20.0)	
Morphological	1 (5.0)	—	
Lexical	—	1 (2.5)	
Total	15 (15.0)	9 (9.0)	
b. Visual presentation			
Role reversal	14 (35.0)	8 (20.0)	
Morphological	1 (5.0)	1 (5.0)	
Lexical	—	—	
Total	15 (15.0)	9 (9.0)	
	Truncated agent	Truncated theme	Cleft, truncated agent
Passive sentences			
a. Auditory presentation			
Role reversal	22 (55.0)	23 (57.5)	28 (70.0)
Morphological	—	1 (5.0)	1 (5.0)
Lexical	1 (2.5)	—	—
Total	23 (23.0)	24 (24.0)	29 (29.0)
b. Visual presentation			
Role reversal	15 (37.5)	22 (55.0)	25 (62.5)
Morphological	1 (5.0)	2 (10.0)	—
Lexical	—	—	—
Total	16 (16.0)	24 (24.0)	25 (25.0)

Note. For each sentence type, and for each sentence voice, 100 stimuli were presented (40 reversal foils, 20 morphological foils, and 40 lexical foils). Percentages are reported in parentheses. (See text for interpretation of sentence types).

modality (auditory and visual) or presentation: 40 sentences each presented with a role reversal foil or with a semantic foil, and 20 sentences presented with a morphological foil, as in the case of full active and passive sentences.

E.B.'s performance on truncated and cleft sentences was similar to that reported for full sentences. The results are summarized in Table 4. He was worse on passives than actives, both in the auditory and visual administration of the tests. Error rates on active sentences ranged from 9 to 15%; error rates on passives ranged from 24 to 29%. He was also much more impaired in the reversal foil condition (error rates greater than 40%) than in either the semantic or morphological foil conditions

(error rates of 10% or lower). Furthermore, and as in the case of full sentences, when performance on active and passive sentences is considered separately for the different foil types, it is apparent that E.B. is impaired in comprehending both types of sentences, although he shows greater difficulties with passives. Thus, his error rates on active and passive sentences in the reversal foil condition ranged from 20 to 70%, indicating a severe comprehension deficit. χ^2 analyses of the performance obtained by E.B. on these conditions showed that his performance was significantly different from chance only in the auditory and visual administrations of active sentences in the cleft condition.

Noun phrases. Despite E.B.'s excellent performance in single-word, morphological processing tasks (above), he did make a number of morphological foil errors in sentence comprehension. To explore in greater detail his morphological processing abilities, an analysis was undertaken of his comprehension performance of auditorily presented noun phrases with the structure det-noun-adjective.

The *auditory noun phrase comprehension test* consisted of 64 stimuli. The examiner pronounced a noun phrase (e.g., "La bottiglia vuota" (The empty bottle)), and the subject was requested to point to the correct picture among eight alternatives. The following foils were chosen: (a) morphologically related noun phrase—a NP in the alternative number (e.g., "Le bottiglie vuote" (The empty bottles)); (b) semantically related adjective (e.g., "La bottiglia piena" (The full bottle)); (c) morphologically related noun phrase with a semantically related adjective (e.g., "Le bottiglie piene" (The full bottles)); (d) semantically related noun—a noun conceptually related to the target, but of a different lexical gender (e.g., "Il bicchiere vuoto" (The empty glass)); (e) morphologically related noun phrase with a semantically related noun (e.g., "I bicchieri vuoti" (The empty glasses)); (f) semantically related noun and adjective (e.g., "Il bicchiere pieno" (The full glass)); (g) morphologically related noun phrase with semantically related noun and adjective (e.g., "I bicchieri pieni" (The full glasses)). The occurrence of masculine and feminine, singular and plural stimuli was balanced (16 stimuli each in the m.sg., m.pl., f.sg., and f.pl. forms). On this task, E.B. made one error, consisting of the incorrect choice of a semantically related adjective. This performance is comparable to that obtained by 20 control subjects matched for age and education.

Grammaticality judgments. E.B. was asked to perform a grammaticality judgement task ($N = 270$). Half of the stimuli were grammatical, half were ungrammatical. The patient made no errors on this task: he flawlessly detected 20 within-constituent order violations (Bambino il mangia (Boy the eats)), 20 omissions of grammatical markers (determiners, prepositions, and auxiliary verbs), 55 violations of agreement between contiguous constituents (determiner-noun, noun-adjective, subject noun-copula,

and subject noun–main verb), 28 violations of long-distance agreement (subject noun–past participle and noun–pronoun) as in *La* (f.sg.) *bambina* (f.sg.) *è baciato* (m.sg.) *dalla mamma* (The girl is kissed by the mother), and in *La* (f.sg.) *mamma* (f.sg.) *ha deciso di partire anche lui* (m.sg.) (The mother has decided to leave, he too—respectively), and 12 incorrectly filled gaps as in *La mamma ha mangiato la frutta che il papà ha sbucciato la banana* (The mother ate the fruit that the father peeled the banana). Also, E.B. never judged a grammatical sentence as ungrammatical.

Interim Discussion of Comprehension Tasks

There are several features of E.B.'s performance that are of particular interest here:

1. he is selectively impaired in comprehending semantically reversible sentences;
2. he is more impaired in comprehending passive than active sentences, but he is impaired in both;
3. he is equally impaired in comprehending full and truncated active, passive, and cleft sentences;
4. he is not impaired (to any appreciable extent) in processing morphosyntactic information;
5. he is not impaired in judgments of grammaticality of simple and complex sentences with long-distance agreement and moved constituents.

This pattern of results allows several conclusions about the nature of E.B.'s comprehension impairment. First, although he has a reduced memory span, it is unlikely that the memory impairment is responsible for the poor comprehension performance. As noted above (see also below), he always repeated or read the stimulus sentences correctly before pointing to a picture choice. Second, the comprehension impairment cannot be the result of inability to process S-structure information of sentences. This conclusion is supported by the fact that he performed flawlessly in the grammaticality judgment task and in processing morphological information both in single words (including number and tense features of verbs) and in noun phrases. Third, the impairment cannot be attributed to an inability to process traces (Grodzinsky, 1986). Such a deficit would predict normal performance for active sentences. However, as reported, E.B. was impaired in the comprehension of both full and truncated active sentences. Furthermore, on the view that thematic role assignment, following damage to the trace binding apparatus, is accomplished by a heuristic that assigns thematic roles on the basis of the canonical position occupied by these roles, we would expect that the subject noun phrase in truncated passives would be systematically (and inappropriately) assigned the thematic role agent (see Badecker, Nathan, & Caramazza, 1991; Martin et al., 1989, for discussion). That is, on this view, the claim

is that for a sentence such as "the boy is chased" the noun phrase "the boy" would be systematically assigned the default thematic role agent in virtue of its position as grammatical subject. The thematic role theme would not be assigned to the noun phrase presumably because of damage to the impaired trace apparatus which, had it been unimpaired, would have allowed the moved noun phrase to be linked with the theme position indicated by the trace. However, E.B.'s performance on truncated passives was comparable to his performance with full passives. Thus, E.B.'s impairment cannot be attributed to a deficit in processing traces.

In light of the above considerations, the only option open to us is to assume that the impairment is the result of damage to the procedure that assigns thematic roles to the normally recovered S-structure, either because of damage to the procedure itself or because of damage to the predicates that specify the types of thematic roles with which they are associated (or both). We will return to this issue under General Discussion, after we have considered E.B.'s ability to produce reversible sentences.

Production: Metalinguistic and On-Line Tasks

Analysis of E.B.'s spontaneous production (above) revealed only very mild difficulties, consisting principally of word finding and phonological groping pauses. Also noted were extremely minor problems in the production of grammatical morphemes—3.4% omissions and substitutions of prepositions, articles, and clitic pronouns. No role reversal errors were noted. However, this might only indicate that there were no clear contexts in which such errors could occur. Thus, a systematic evaluation of E.B.'s ability to produce reversible sentences in controlled contexts was undertaken.

Sentence repetition. Although we have reported that E.B. presented with no difficulty in repeating the sentences used in the comprehension tasks, we undertook to assess formally his ability to repeat reversible and nonreversible, active and passive sentences. The sentences used in the comprehension test were administered as a repetition test. E.B. was asked to repeat the 80 stimulus sentences in each block three times, for a total of 240 sentences. He reproduced all the sentences accurately. Only twice did he ask for repetition of the stimulus sentence. In each of the two exceptions, he started to produce an incorrect response, but stopped promptly, commented that his response was wrong, and asked for repetition of the stimulus. Subsequently, he repeated the sentence correctly. Thus, in a task that requires immediate repetition of simple declarative reversible and nonreversible sentences either in the active or in the passive voice, E.B. has no difficulty retaining the phonological string and producing the correct morphology. In other words, it appears that although he has a reduced span, it is, nonetheless, sufficient to support retention of the simple sentences used in the comprehension task. This result would

seem to rule out a STM deficit as the principal cause of his severe comprehension difficulties.

Active-passive voice transformation. E.B. was asked to transform active sentences into passive sentences and passive sentences into active sentences. Both semantically reversible and semantically nonreversible sentences and morphologically "ambiguous" and morphologically "unambiguous" sentences were used in this task. In morphologically "ambiguous" sentences, both arguments were either singular or plural, thus failing to provide crucial cues for unambiguous assignment of grammatical roles to noun phrases; in morphologically "unambiguous" sentences, one argument was in the singular and the other was in the plural, allowing the unambiguous identification of the subject noun phrase. In all sentences, and unlike the case for the comprehension tasks, the two arguments were of the same gender. Thus, four types of sentences were included in this task. *Morphologically "ambiguous" reversible sentences* contained either two masculine or two feminine nouns, both in the singular or both in the plural form. Sentences of this type were "La nonna accarezza la bambina" (The grandmother caresses the girl) or "Il poliziotto è chiamato dal cuoco" (The policeman is called by the cook). *Morphologically "unambiguous" reversible sentences* always contained a singular and a plural noun. The occurrence of singular and plural nouns in first and second positions was balanced across stimuli. Examples of these sentences are "Le infermiere salutano la bambina" (The nurses greet the girl) or "Il bambino è rincorso dagli uomini" (The boy is chased by the men). *Morphologically "ambiguous" nonreversible sentences* contained two masculine or two feminine nouns, both singular or both plural. In these stimuli, semantic factors constrained the assignment of thematic roles. Sentences of this type were "Il bambino mangia il gelato" (The boy eats the ice cream) or "La mela è sbucciata dalla bambina" (The apple is peeled by the girl). *Morphologically "unambiguous" nonreversible sentences* always contained a singular and a plural noun. The occurrence of singular and plural nouns in first and second positions in the sentence was balanced. This subset of stimuli included sentences like "La donna mangia le caramelle" (The woman eats the candies) or "I bicchieri sono riempiti dai cuochi" (The glasses are filled by the cooks).

Seventy sentences of each type were prepared, for a total of 280 sentences. In each sentence type, half of the stimuli were presented in the active voice, half in the passive voice, in random order.

Before presenting the analysis of E.B.'s performance on this task (and, at the risk of being repetitious), we briefly describe some general features of Italian sentence structure, concerning passive morphology and word order in active sentences, that are important for interpretation of the results. These considerations are presented here, but apply to all the sentence production tasks in this report.

The structure of a passive declarative sentence in Italian is det – noun – aux – verb + past participle – prep + det – noun, as in “La mamma è baciata dal bambino” (The mother is kissed by the boy). In passive sentences the auxiliary verb agrees in number with the noun in subject position, and the past participle of the verb agrees in number and gender with the noun in subject position (compare “La mamma (f.sg.) è baciata (f.sg.) dal bambino,” “Il bambino (m.sg.) è baciato (m.sg.) dalla mamma,” and “Le mamme (f.pl.) sono (pl.) bacciate (f.pl.) dal bambino”).

For active reversible sentences, the canonical word order in Italian is SVO. The OVS order is permissible only when they are morphologically “unambiguous,” as in this case subject–verb agreement allows disambiguation (as previously discussed, OVS is also unambiguous with appropriate stress). For example, in the sentence “Il giudice guardano i ladri” (The judge watch the thieves), agreement between the plural subject noun and the verb in the third plural unambiguously indicates that “i ladri” is the agent and “il giudice” is the theme. The situation is different in morphologically “ambiguous,” reversible sentences like “Il ladro guarda il giudice” (The thief watches the judge). Since both arguments are in the singular number, word order is the only cue (in the absence of emphatic stress) to the correct assignment of thematic roles (that is, thief = agent and judge = theme). As a consequence, only the canonical SVO order is permitted with these sentences (unless marked by emphatic stress—“Il ladro guarda il giudice” (The *thief* watches the judge) which can have the meaning “The judge watches the thief”). The utterance resulting from the exchange of the arguments around the verb would not be interpreted as a sentence with noncanonical OVS order, but as a role reversal (in the sentence “Il giudice guarda il ladro,” without emphatic stress, it is unambiguously the judge who is doing the watching and the thief who is being watched).¹

With these considerations in mind, we now turn to the analysis of the incorrect responses produced by E.B. on the active–passive sentence transformation test. A summary of his performance on this task is shown in Table 5.

All but six of the sentences produced by E.B. in this task were grammatically well-formed. All active sentence responses consisted of det–noun–verb–det–noun sequences; all passive sentences consisted of det–noun–aux–verb + past participle–prep + det–noun sequences. Three responses of the type “I ladri sono guardati dal giudice” (The thieves are

¹ Note that, in the case of nonreversible sentences and passive sentences, changes of canonical word order do not result in ambiguous sequences. OVS utterances like “La mela mangia il bambino” (The apple eats the boy), and noncanonical order passives, like “Dalla mamma è baciato il bambino” (By the mother is kissed the boy), although infrequent, are grammatical and unambiguous.

TABLE 5
 ERRORS MADE BY E.B. IN ACTIVE-PASSIVE SENTENCE TRANSFORMATION

	Reversals	Morphological	Morphological deviant	Total
Reversible				
Active to passive				
Ambiguous	5	1	—	6
Unambiguous	2	9	3	14
Passive to active				
Ambiguous	7	1	—	8
Unambiguous	6	8	—	14
Total	20	19	3	42
Nonreversible				
Active to passive				
Ambiguous	—	—	—	—
Unambiguous	—	3	—	4
Passive to active				
Ambiguous	—	—	—	—
Unambiguous	1	6	3	10
Total	1	9	3	14

Note. For each sentence type and for each sentence voice, 35 morphologically “unambiguous” and 35 morphologically “ambiguous” stimuli were presented. For each sentence type (reversible and nonreversible), each column totals 140 stimuli.

watched by the judge) → “Il giudice guardano i ladri” (The judge watch the thieves) were excluded from analysis because they could not be scored unambiguously as role reversal or as morphological errors.

E.B. produced 54/280 (19.3%) classifiable incorrect responses on this task. Comparable error rates were obtained for active (24/140, 17.1%) and passive sentences (32/140, 22.9%). The vast majority of the incorrect responses produced by E.B. in this task fell into two categories, morphological errors and role reversal errors. In transforming the voice of a sentence, E.B. produced 28/280 (10%) morphological errors consisting of utterances in which one of the nouns was in the incorrect number; for example, “Il pallone è inseguito dai cani” (The ball is chased by the dogs) → “Il cane insegue il pallone” (The dog chases the ball). Errors of this type were produced on 26/140 (18.6%) morphologically “ambiguous” sentences and on 2/140 (1.4%) morphologically “unambiguous” sentences—a highly significant difference ($\chi^2 = 20.782$; $p < .001$). They occurred more frequently on reversible sentences (19/140, 13.6%) than on nonreversible sentences (9/140, 6.4%), but this difference was not statistically significant ($\chi^2 = 3.182$; $p = \text{n.s.}$).

Role reversal errors constituted the other major error type. All but one occurred on reversible sentences—20/140 (14.3%) on reversible sen-

tences versus 1/140 (0.7%) on nonreversible. The incidence of role reversals on the reversible sentences was slightly higher in transformations of passive sentences (13/70, 18.6%) than in transformations of active sentences (7/70, 10%). This difference is not significant ($\chi^2 = 2.042$; $p = \text{n.s.}$). In active-to-passive transformation, E.B.'s errors consisted of 3 incorrect passive responses ("La ballerina applaude la bambina" (The dancer applauds the girl) → "La ballerina è applaudita dalla bambina" (The dancer is applauded by the girl)) and of 4 incorrect active responses ("L'uomo applaude gli atleti" (The man applauds the athletes) → "Gli atleti applaudono l'uomo" (The athletes applaud the man)). In passive-to-active transformation, E.B. produced 4 incorrect active responses ("Le zebre sono spinte dalle scimmie" (The zebras are pushed by the monkeys) → "Le zebre spingono le scimmie" (The zebras push the monkeys)) and 10 incorrect passive responses ("Il cane è morso dai cavalli" (The dog is bitten by the horses) → "I cavalli sono morsi dal cane" (The horses are bitten by the dog)). The observation that the majority of the errors resulted in the production of grammatically correct passive sentences (13/21, 61.9%) rules out the possibility that E.B.'s impairment in this task derives from a difficulty in producing the morphology of passive sentences.

A few other errors not germane to the issues under consideration in this report were also produced by E.B. These included one semantic error (the substitution of a verb) and six morphologically deviant responses, the latter distributed equally for reversible and nonreversible sentences (e.g., "Le librerie sono dipinte dalla ragazza" (the bookshelves are painted by the girl), transformed to "La ragazza dipingono le librerie" (The girl paint (3rd pl.) the bookshelves)).

As in the comprehension task, E.B. produced many role reversal errors in the sentence voice transformation task. All but one of these errors occurred on reversible sentences. In the face of a severe difficulty assigning thematic roles, E.B. demonstrates only a minimal impairment in the ability to produce grammatically well-formed sentences. However, many incorrect responses, especially to morphologically "unambiguous" sentences, resulted in utterances that did not preserve the number of one of the arguments. Failure to preserve the number of one of the arguments might reflect a morphological processing deficit, but it might also be the consequence of E.B.'s memory impairment. In order to arrive at a better definition of his sentence production disorder, an "anagram/production" task was administered. This task was chosen because it is less demanding on memory—the lexical items are provided to the subject—thereby allowing a more direct measure of E.B.'s grammatical disorder in sentence production.

Sentence anagram/production. The same sentence types as in the previous task were used (morphologically "ambiguous" reversible sentences; morphologically "unambiguous" reversible sentences; morphologically

TABLE 6
 ERRORS MADE BY E.B. IN THE SENTENCE ANAGRAM TASK
 (PERCENTAGES ARE IN PARENTHESES)

Sentence type	Sentence voice		
	Active	Passive	Total
Reversible, morphologically ambiguous	10/70 (14.3)	46/70 (65.7)	56/140 (40.0)
Reversible, morphologically marked	See text	0/70 (0.0)	0/70 (0.0)
Nonreversible, morphologically ambiguous	0/70 (0.0)	9/70 (12.9)	9/140 (6.4)
Nonreversible, morphologically marked	0/70 (0.0)	0/70 (0.0)	0/140 (0.0)
Total	10/210 (4.8)	55/280 (19.6)	65/490 (23.2)

“ambiguous” nonreversible sentences; morphologically “unambiguous” nonreversible sentences). Thirty-five stimuli for each of the four sentence types were prepared. Each stimulus was administered both in the active and in the passive voice. The test was administered twice, for a total of 560 sentences—140 sentences for each of the four types.

The task was administered as follows. E.B. was shown at the same time a picture and the words of the stimulus sentence, each printed on a separate card, in random order. He was instructed to produce a sentence representing the meaning of the picture by rearranging all the cards. The task was administered without time limits.

The responses produced by E.B. to 70 morphologically “unambiguous” reversible sentences in the active voice were excluded from the error analysis because “incorrect” arrangements of words for these sentences are not unambiguously interpretable as role reversal errors (e.g., the production “Il ladro guardano i giudici” (The thief watch the judges) for a picture showing judges watching a thief). The results obtained by E.B. on the remaining 490 sentences were retained for further analysis and are presented in Table 6. (In this Table, the cell corresponding to active reversible, morphologically ambiguous sentences is empty.)

E.B. always produced correct within-phrase anagrams: No agreement errors were observed (that is, in rearranging morphologically “unambiguous” sentences he never placed a singular noun next to a plural determiner or viceversa). E.B.’s relatively normal ability to process morphological information was also demonstrated by his correct ordering of nouns in the morphologically “unambiguous” sentences. That is, he was able to use agreement information between the nouns and the verb to correctly order the words in a sentence, preventing role reversal errors for these sentences. The implication of this result is that the morphological errors

reported in the preceding task are most likely the result of a memory impairment and not a specific deficit in morphological processing. The remaining analyses will focus on his performance with morphologically "ambiguous" sentences. On the 280 sentences with both nouns in the singular or in the plural form, E.B. produced 65 (23.2%) role reversal errors: 56/140 (40%) for reversible sentences (40%) and 9/140 (6.4%) for nonreversible sentences. This difference is statistically reliable ($\chi^2 = 40.511$; $p < .001$). A significantly greater incidence of errors on passive than on active sentences was observed for reversible sentences. E.B. arranged incorrectly 10/70 (14.3%) active sentences and 46/70 (65.7%)² passive sentences ($\chi^2 = 36.458$; $p < .001$). Furthermore, he performed flawlessly on morphologically "unambiguous" active nonreversible sentences and made 9/140 (6.4%) errors on passive, nonreversible sentences.

The performance obtained by E.B. on the production/anagram task confirms that he has severe difficulties in assigning thematic roles to arguments in reversible sentences. In addition, E.B. displayed a normal ability to use morphological cues to arrange words in a sentence. This behavior suggests that the fairly high number of morphological errors observed in the sentence voice transformation task did not result from a morphological deficit, but perhaps from a memory disorder.

Constrained sentence production. The pictures used in the sentence comprehension tasks served as stimuli for this production task as well. In order to ensure production of both active and passive sentences, the following procedure was adopted. E.B. was presented with a stimulus picture and was asked to name the character corresponding to one of the arguments. Subsequently, he was asked to describe the scene portrayed in the picture, with the constraint that the argument that he had just named be the first noun in the sentence (Caramazza & Berndt, 1985). The choice of the first noun was such that the correct response consisted of an active sentence in half of the cases and a passive sentence in the other half. The 120 stimulus pictures (80 reversible, 40 nonreversible) were presented three times, for a total of 360 stimuli. Thus, performance on this task required the production of 180 sentences in the active voice and 180 sentences in the passive voice.

The results obtained by E.B. are summarized in Table 7.³ He produced full sentences to all stimuli but one (99.8%).

E.B. produced many role reversal errors on reversible sentences

² This performance is significantly *worse* than chance ($\chi^2 = 6.914$; $p < .01$).

³ This task was also administered as a written production task. E.B.'s performance on this task was comparable to his performance in the oral production task, except that because of his spelling difficulties and his difficult-to-read handwriting, performance was somewhat more "noisy." That is, often it was not possible to determine whether the final letter was an "o" or an "a," or an "e" or an "i."

TABLE 7

ERRORS MADE BY E.B. IN THE CONSTRAINED ORAL PRODUCTION OF SENTENCES OF THE REVERSIBLE (120 IN THE ACTIVE VOICE, 120 IN THE PASSIVE VOICE) AND OF THE NONREVERSIBLE TYPE (60 IN THE ACTIVE VOICE, 600 IN THE PASSIVE VOICE)

Error type	Reversible		
	Active (<i>n</i> = 120)	Passive (<i>n</i> = 120)	Total (<i>n</i> = 240)
Role reversal	10 (8.3)	30 (25.0)	40 (16.7)
Morphological	3 (2.5)	4 (3.3)	7 (2.9)
Lexical	1 (0.8)	2 (1.7)	3 (1.2)
Fragment	1 (0.8)	—	1 (0.4)
Total	15 (12.5)	36 (30.0)	51 (21.2)
Error type	Nonreversible		
	Active (<i>n</i> = 60)	Passive (<i>n</i> = 60)	Total (<i>n</i> = 120)
Role reversal	—	—	—
Morphological	—	—	—
Lexical	5 (8.3)	2 (3.3)	7 (5.8)
Total	5 (8.3)	2 (3.3)	7 (5.8)

Note. Percentages are in parentheses.

(40/240, 16.7%), but none for nonreversible sentences. Seven self-corrected role reversals for reversible sentences (5 on active sentences and 2 on passive sentences) were not scored. As in the comprehension and the sentence anagram tasks, the incidence of reversal errors was higher on passive (30/120, 25%) than on active sentences (10/120, 8.3%). This difference is statistically significant ($\chi^2 = 10.83$; $p < .001$). All role reversal errors consisted of the production of the target sentence in the inappropriate voice. For example, E.B. produced the passive sentence "La ballerina è applaudita dal pagliaccio" (The dancer is applauded by the clown) instead of the expected active sentence "La ballerina applaude il pagliaccio" (The dancer applauds the clown) and, conversely, produced the active sentence "I bambini salutano i dottori" (The boys greet the physicians) instead of the expected passive target "I bambini sono salutati dai dottori" (The boys are greeted by the physicians). Role reversal errors never resulted from the production of an incorrect lexical verb, such as "The man precedes the girl" instead of "The man follows the girl."

In addition to role reversal errors, E.B. also produced a few morphological ($N = 7$) and semantic errors ($N = 12$).⁴ The former type of

⁴ Note that the incidence of morphological errors is very small if one considers the number of possibilities for such errors in the sentence types produced by the subject. A conservative

errors consisted of det–noun agreement violations ($N = 3$; e.g., “I bambine,” (The (m.pl.) girls)), incorrect number of one of the arguments ($N = 2$), and incorrect agreement between subject and past participle ($N = 2$; e.g., “I bambini sono accarezzati dalla nonna” (The boys are kissed by the grandmother) → “I bambini sono accarezzata (f.sg.) dalla nonna”).

Noun phrase processing. As in the comprehension task, E.B. made a number of morphological errors in production. We have suggested that most of these errors result from his memory impairment. To further assess this possibility, he was asked to perform a production task that minimizes memory load—three-word noun phrases—while including the type of morphological factors—within-phrase agreement—that gave rise to errors in performance.

The *noun phrase production test* consisted of the same 64 stimuli used in the comprehension task (above). Four pictures were simultaneously shown to the patient. They depicted the target noun phrase (e.g., “La bottiglia vuota”) and three other pictures, in order to create the contrastive set necessary to produce the intended det–noun–adjective sequence: a morphologically related picture (“Le bottiglie vuote” (The empty bottles)), a semantically related adjective (“La bottiglia piena” (The full bottle)), and a morphologically related stimulus that contained the same semantically related adjective (“Le bottiglie piene” (The full bottles)). E.B. produced correctly all the noun phrases required by this task, suggesting that he is essentially unimpaired in processing within-phrase morphological structure.

Interim Discussion of Production Tasks

Several features of E.B.’s production performance are of importance here:

1. he produced a large number of role reversal errors in both the constrained picture description and the sentence production/anagram tasks, but virtually only for reversible sentences;
2. he produced more role reversal errors on passive than active sentences, but his performance was impaired for both types of sentences;
3. although he produced a significant number of morphological errors, these seemed to have resulted principally from his memory impairment;
4. in all but a very few cases, he produced grammatically well-formed sentences, including passives.

E.B.’s selective difficulty in assigning thematic roles in the production of reversible but not nonreversible sentences suggests that the deficit

estimate allows us to calculate that E.B. had 8 opportunities to make a morphological error in each active sentence, and 12 in each passive sentence. Since there were 180 sentences of each type, he had 3600 opportunities to produce morphological errors, but produced only 7 (0.2%) errors.

responsible for his performance is to be located at the level of mechanisms that assign thematic roles to arguments, probably at the functional level of sentence production (Garrett, 1980). This conclusion is strengthened by the fact that E.B.'s difficulty in assigning thematic roles was observed in the context of preserved ability to produce grammatically well-formed active and passive sentences, ruling out as the basis for the reversal errors a deficit at the level of S-structure. And, finally, it is important to note that E.B.'s production impairment was very similar to his comprehension impairment, suggesting the possibility of a common underlying deficit. This possibility is discussed under General Discussion.

GENERAL DISCUSSION

The principal fact that has emerged from the reported analyses is the particularly pure pattern, on the one hand of a **dissociation** between impairment in processing thematic roles and spared ability to process the morphological structure of sentences and, on the other hand, of an **as-sociation** in impairment of production and comprehension of active and passive reversible sentences. This pattern of performance poses interesting challenges for current conceptions of the nature of language breakdown in aphasia and for models of normal sentence processing.

One issue concerns the implications of the dissociation between impairment of thematic role processing and spared ability to process the surface structure of sentences for claims about the underlying causes of various forms of aphasia. The reported dissociation demonstrates that the impairment of sentence comprehension referred to as "asyntactic comprehension"—the selective impairment of semantically reversible sentences—may occur independently of impairments in processing grammatical morphemes (closed-class elements). This result does *not*, by itself, rule out the possibility of a causal link between processing difficulties of the closed-class elements and asyntactic comprehension when these two features are found to cooccur in a patient (e.g., Bradley, Garrett, & Zurif, 1980; Caramazza et al., 1981b; Zurif, 1984). Thus, for example, Caramazza et al. argued that the asyntactic comprehension observed in the context of a clinical picture of agrammatic production has a different underlying cause than that for asyntactic comprehension occurring in the context of other clinical pictures (e.g., in the context of a phonological working memory deficit; see also Saffran, 1990; Vallar & Baddeley, 1984). However, there are also several reports of patients clinically classified as agrammatic aphasics who do not present with asyntactic or any other form of comprehension impairment (Caramazza & Hillis, 1989; Kolk et al., 1985; Miceli et al., 1983; Nespoulous et al., 1988). Once again, this result does *not*, by itself, require that we reject the hypothesis of a causal link between impairment of grammatical morphemes and asyntactic comprehension when these cooccur. When the two patterns of dissociation are

considered together, however, it is clear that processing of grammatical morphemes (closed-class elements) and thematic role assignment may *both* be damaged independently of the other. In light of these observations, it is difficult to maintain the hypothesis of a single underlying cause for the cooccurrence of two impairments without independent justification. For, in this case, we would have to assume that there are three different types of underlying deficits associated with the different patterns of impairment reviewed here: one associated with the pattern consisting of asyntactic comprehension and spared ability to process closed-class elements; one associated with the pattern consisting of impaired processing of grammatical morphemes and spared ability to comprehend sentences; and one associated with the pattern consisting of impaired sentence comprehension and impaired ability to process closed-class elements. Unless one could show that asyntactic comprehension and/or the closed-class processing impairments take different forms when they cooccur than when they occur independently of each other, we should prefer the more parsimonious account of only two types of deficits responsible for all three patterns of impairment—damage to mechanisms that process morphological information, damage to mechanisms that assign thematic roles, and damage to both. Thus, until positive evidence to the contrary is forthcoming, we may take the double dissociation of asyntactic comprehension and difficulties in processing closed-class elements as undermining unitary accounts of the clinical syndrome of agrammatic Broca's aphasia.

A second issue concerns the specific nature of the damage responsible for E.B.'s performance—that is, where in the language processing system are we to locate the damage responsible for the observed selective impairment in processing semantically reversible sentences? One possibility, suggested by E.B.'s reduced repetition span, is that the sentence processing impairment results from damage to phonological working memory. It has been suggested that asyntactic comprehension may result from damage to phonological working memory (or auditory-verbal short-term memory; see Caramazza et al., 1981a,b; Saffran, 1990; Saffran, & Martin, 1990; Vallar & Baddeley, 1984). Aside from the fact that the status of this hypothesis remains uncertain (see Caplan & Waters, 1990; Martin, 1987, 1990; Saffran, 1990; Saffran & Martin, 1990), it is not obvious that it could serve as the basis for explaining E.B.'s performance. First, we have noted that E.B. showed no difficulty in repeating the same sentences he had trouble understanding. Of course, it could be maintained that repetition is somehow a "simpler" task than comprehension—that is, that greater demands are placed on memory in comprehension than in repetition—leading to a dissociation between impairments of comprehension and repetition performance when phonological working memory is not damaged severely. This account is unsatisfactory, however. It relies on a poorly specified notion of processing "simplicity" which does not have

independent justification. Thus, if phonological working memory is sufficiently preserved to support good repetition performance, why should it not be sufficient to support comprehension? Appealing to the notion of greater memory demands for comprehension than for repetition begs the question of what it is about sentence comprehension that is so taxing for phonological working memory. Until this assumption is given substance, we must remain skeptical of its explanatory value.

The hypothesis of a phonological working memory deficit as the basis for E.B.'s sentence processing impairment also encounters difficulties in explaining his performance in the sentence production/anagram and constrained production tasks. Recall that in both tasks E.B. made role reversal errors. It is not obvious what role phonological working memory would play in the production/anagram task. Furthermore, the production of role reversal errors is not a standardly reported feature of patients with putative deficit in phonological working memory (but see Caramazza & Berndt, 1985). Independently of this, there is the matter of what role phonological working memory would play in determining thematic role assignment in sentence production. Models of sentence production (Bock, 1982; Dell, 1986; Garrett, 1980; Stemberger, 1985) typically assume that thematic role assignment occurs at a stage of processing prior to the retrieval of lexical-phonological forms. Thus, even if E.B. were to have a deficit in phonological working memory, it is far from obvious that such a deficit would lead to role reversal errors. If anything, it should lead to the loss of "positional frame" information and errors in the production of grammatical morphemes (Caramazza & Hillis, 1989). But, the latter features of sentence structure were essentially normal in E.B. Thus, we must conclude that E.B.'s selective impairment in processing reversible sentences—in production and comprehension—is unlikely to be the result of damage to phonological working memory.

An alternative formulation of the basis for the observed impairment in processing thematic roles is to assume damage to a more abstract type of short term memory—a memory system that does not represent information in phonological form (Martin, 1987). Although this proposal would seem to encounter fewer difficulties than the proposal of a phonological working memory deficit, it too is less than compelling. Thus, it is difficult to see how this account could explain the fact that E.B. did *not* show a repetition impairment for visually presented stimuli, or how it could account for the extremely poor performance in the production/anagram task where memory demands would seem to be at a minimum. It would seem, then, that a memory deficit hypothesis is not a likely explanation for E.B.'s impaired performance in processing thematic roles.

A possible account for the reported results is based on the assumption that E.B. has suffered damage to the procedures that map thematic roles onto the grammatical categories "subject" and "object," and vice versa

(Linebarger et al., 1983; Saffran et al., 1980a, b; Scwhartz et al., 1985). On this view, E.B. is able to process the surface structure of sentences and to determine the grammatical categories "subject" and "object." However, he cannot use this information normally to map grammatical functions onto thematic roles, and vice versa, leading to comprehension and production failure in the context of normal processing of the surface structure of sentences. Although such an account has been proposed in order to explain observed differences in performance between active and passive sentences, and between reversible and nonreversible sentences, it fails to explain various aspects of E.B.'s performance with active and passive nonreversible sentences.

In order to explain the dissociation between reversible and nonreversible sentences, we might assume that E.B. can use a heuristic based on semantic properties of nouns (the animacy contrast) to determine their thematic roles in sentence contexts. Although this hypothesis can account for comprehension performance, it would fail in the case of production. In comprehension, the heuristic would successfully assign the role agent to the animate noun, leading to correct performance for active and passive nonreversible sentences. In the case of production, however, if he were to assign the animate noun the thematic role agent, this would still require the further mapping of the thematic role onto a grammatical function. But since, by hypothesis, this procedure is damaged, the subject should fail in assigning the correct grammatical role on the basis of thematic role information, leading to role reversal errors for nonreversible sentences. On this view, we expect that the subject should make role reversal errors in the production of nonreversible sentences—a pattern of performance not observed for E.B. This hypothesis would fail even if augmented by the assumption that semantic information can be used to select grammatical functions directly. In the latter case, if he were to assign the animate noun to "subject," he would always be correct on active sentences, but would, then, be systematically wrong on passive constructions—a pattern of performance not observed. If we assumed, instead, that this heuristic were used probabilistically, then, we would expect less than perfect performance on simple active, nonreversible sentences. But this is not what was observed. Thus, the hypothesis that E.B.'s difficulty in processing thematic roles is *exclusively* the result of a selective deficit to procedures for mapping thematic roles onto grammatical roles, and vice versa, would not seem to be correct.

The final proposal we will consider is to assume that the basis for the reported performance is selective damage directly to the representation of the argument structure of verbs (Byng, 1988; Jones, 1984; Saffran, 1982; Saffran et al. 1980b). That is, the hypothesis could be entertained that E.B. can retrieve the semantic information for verbs, but that he is unable to process the predicate–argument structure of these lexical items.

In order to account for E.B.'s performance, this hypothesis must be augmented by the assumption that he can rely on the semantic information in nouns (the animacy contrast) to assign thematic roles: for example, boys, but not apples, can be agents in "The boy is eating the apple." On this view, nonreversible sentences are understood and produced correctly because animacy information can be used to assign correctly the roles agent and theme to the two nouns in the sentences used in our experiments. Thus, in comprehension, he can directly use the animacy contrast to assign thematic roles, leading to the observed correct performance with nonreversible, active and passive sentences. In the case of production, E.B. would be able to assign the correct thematic roles on the basis of the animacy contrast and, subsequently, correctly map thematic roles onto grammatical ones, since, by hypothesis, he is able to normally carry out the latter operation.

The situation is more complex in the case of reversible sentences. For, here, the two nouns do not differ in animacy and, therefore, it is not possible to rely on semantic information to circumvent the deficit in processing thematic roles. In this case, the patient should fail to understand and produce both active and passive sentences because, even though he can correctly compute grammatical functions, he cannot recover the thematic roles associated with the verb. This hypothesis cannot, on its own, account for the observed superiority of active over passive sentences in both comprehension and production. Thus, this hypothesis predicts equally poor performance in processing active and passive sentences but, as reported, E.B. was considerably worse in processing passive than active sentences. The latter hypothesis fails even when augmented by the assumption that E.B. can use the heuristic of *canonical ordering* of thematic roles in sentences processing. On this assumption, the noun phrase preceding the verb is standardly interpreted as agent and the noun phrase following the verb is standardly interpreted as theme. This hypothesis predicts better performance for actives than for passives. The discrepancy in levels of performance between actives and passives depends on the severity of impairment of the verb. If all verbs were to be damaged, the assignment of the role agent to the first noun phrase would lead to correct interpretation of actives, but systematically incorrect performance with passives. If only about 70% of the verbs used in our tasks were damaged, the approximate split of correct performance on active and passive sentences would be 100 and 70%, respectively. Thus, although we can get better performance on active than on passive sentences, this hypothesis, too, fails to predict the specific pattern of performance reported for E.B. Specifically, it predicts perfect performance for active sentences contrary to the obtained results. (Although we have discussed the difficulties encountered by this only in terms of comprehension, it should be noted that it also encounters difficulties in explaining E.B.'s production performance.)

In summary, it would seem that none of the hypotheses that have been proposed as the basis for asyntactic comprehension can, individually, explain the pattern of performance reported for E.B. The difficulties we have encountered in our effort to explain E.B.'s performance are not to be treated as a specific problem restricted to this patient. Similar difficulties are encountered by the various hypotheses considered here in explaining the performance of other well-studied patients reported in the recent literature. The more optimistic views expressed by various authors about the explanatory value of the "thematic role mapping hypothesis," the "verb deficit hypothesis," the "working memory hypothesis," and the "short term memory hypothesis" principally reflect their willingness to remain vague about the detailed manner in which particular hypotheses are actually able to fully explain the relevant features of patients' performance. Unwilling as we are, we must conclude that at this time we do not have reasonably well-worked out, *unitary* explanations for the complex patterns of thematic role processing impairments in various types of patients. This state of affairs may simply be due to limitations of our current theoretical perspectives. Alternatively, it may reflect a more serious problem: the possibility that the reported deficits in processing thematic role assignment are the result of damage to multiple components of the language processing system. In the latter case, we will have to find means for unpacking the relative contribution of the various components on the complex performance observed in individual patients.

This negative assessment of the current state of theorizing about the nature of comprehension and production deficits in aphasia should not obscure the positive empirical developments achieved in this area of study. Thus, for example, the results obtained with E.B. unambiguously document the dissociability of deficits of thematic role assignment from deficits of morphological (and function word) processing mechanisms (e.g., Caramazza & Hillis, 1989; Nespoulous et al., 1988, for the latter type of deficit). Taken together with other results of well-studied individual patients (see Berndt, 1991, for a recent review) the picture that emerges is one characterized by a modular system in which different components of the language processing system are individually dissociable. In the specific case of E.B., it would seem that we must postulate a thematic role assignment mechanism that operates independently of lexical and other grammatical processing mechanisms. Furthermore, it would seem that thematic role assignment deficits may occur in different clinical pictures—in the context of the complex clinical category of Broca's aphasia as well as in fluent types of aphasia.

REFERENCES

- Ansell, B., & Flowers, C. 1982. Aphasic adults' use of heuristic and structural linguistic cues for analysis. *Brain and Language*, **16**, 61–72.
- Badecker, W., & Caramazza, A. 1985. On considerations of method and theory governing

- the use of clinical categories in Neurolinguistics and Cognitive Neuropsychology: The case against agrammatism. *Cognition*, **20**, 97–125.
- Badecker, W., Nathan, P., & Caramazza, A. 1991. Varieties of sentence comprehension deficits: A case study. *Cortex*, in press.
- Berndt, R. S. 1987. Symptom co-occurrence and dissociation in the interpretation of agrammatism. In M. Coltheart, G. Sartori, & R. Job (Eds.), *The cognitive neuropsychology of language*. New Jersey: Erlbaum.
- Berndt, R. S. 1991. Sentence processing in aphasia. In M. Sarno (Ed.), *Acquired aphasias*, 2nd edition. Orlando: Academic Press.
- Berndt, R. S., & Caramazza, A. 1980. A redefinition of the syndrome of Broca's aphasia: Implications for a neuropsychological model of language. *Applied Psycholinguistics*, **1**, 225–278.
- Berndt, R. S., & Mitchum, C. C. 1990. Auditory and lexical information sources in immediate recall: Evidence from a patient with deficit to the phonological short-term store. In G. Vallar & T. Shallice (Eds.), *Neuropsychological impairments of short-term memory*. New York: Cambridge Univ. Press.
- Berndt, R. S., Salasoo, A., Mitchum, C. C., & Blumstein, S. E. 1988. The role of intonation cues in aphasic patients' performance of the grammaticality judgment task. *Brain and Language*, **34**, 65–97.
- Bock, J. K. 1982. Towards a cognitive psychology of syntax: Information processing contributions to sentence formulation. *Psychological Review*, **89**, 1–47.
- Bradley, D. C., Garrett, M. F., & Zurif, E. B. 1980. Syntactic deficits in Broca's aphasia. In D. Caplan (Ed.), *Biological studies of mental processes*. Cambridge, MA: MIT Press.
- Byng, S. 1988. Sentence processing deficits: Theory and therapy. *Cognitive Neuropsychology*, **5**, 629–677.
- Caplan, D., Baker, C., & Dehaut, F. 1985. Syntactic determinants of sentence comprehension in aphasia. *Cognition*, **21**, 117–175.
- Caplan, D., & Hilderbrandt, N. 1988. *Disorders of syntactic comprehension*. Cambridge, MA: MIT Press.
- Caplan, D., & Waters, G. S. 1990. Short-term memory and language comprehension: A critical review of the neuropsychological literature. In G. Vallar & T. Shallice (Eds.), *Neuropsychological impairments of short-term memory*. New York: Cambridge Univ. Press.
- Caramazza, A. 1984. The logic of Neuropsychological research and the problem of patient classification in aphasia. *Brain and Language*, **21**, 9–20.
- Caramazza, A. 1986. On drawing inferences about the structure of normal cognitive systems from the analysis of impaired performance: The case for single-patient studies. *Brain and Cognition*, **5**, 41–66.
- Caramazza, A., & Badecker, W. 1989. Patient classification in neuropsychological research. *Brain and Cognition*, **16**, 256–295.
- Caramazza, A., Basili, A. G., Koller, J. J., & Berndt, R. S. 1981a. An investigation of repetition and language processing in a case of conduction aphasia. *Brain and Language*, **14**, 235–271.
- Caramazza, A., & Berndt, R. S. 1985. A multicomponent deficit view of agrammatic Broca's aphasia. In M. L. Kean (Ed.), *Agrammatism*. London: Academic Press.
- Caramazza, A., Berndt, R. S., Basili, A. G., & Koller, J. J. 1981b. Syntactic deficits in aphasia. *Cortex*, **17**, 333–348.
- Caramazza, A., & Hillis, A. E. 1989. The disruption of sentence production: Some dissociations. *Brain and Language*, **35**, 625–650.
- Caramazza, A., & Zurif, E. 1976. Dissociations of algorithmic and heuristic processes in language comprehension: Evidence from aphasia. *Brain and Language*, **3**, 572–582.
- Dell, G. 1986. A spreading-activation theory of retrieval in sentence production. *Psychological Review*, **93**(3), 283–321.

- Gallagher, A. J., & Canter, G. J. 1982. Reading and listening comprehension in Broca's aphasia: Lexical versus syntactic errors. *Brain and Language*, **17**, 183–192.
- Garrett, M. F. 1980. Levels of processing in sentence production. In B. Butterworth (Ed.), *Language production. I*. New York: Academic Press.
- Goodglass, H., Blumstein, S., Berko, J., Gleason, J., Hyde, M., Green, E., & Statlender, S. 1979. The effect of syntactic encoding on sentence comprehension. *Brain and Language*, **7**, 201–209.
- Grodzinsky, J. 1986. Language deficits and the theory of syntax. *Brain and Language*, **27**, 135–159.
- Grodzinsky, J. 1990. *Theoretical perspectives on language deficits*. Cambridge, MA: MIT Press.
- Heeschen, C. 1980. Strategies of decoding actor–object relations by aphasic patients. *Cortex*, **16**, 5–19.
- Heeschen, C. 1985. *The notion of "conventionality" of an expression in cross-linguistic research on aphasia*. Presented at Royaumont Conference Center, Paris, France.
- Heilman, K., & Scholes, R. 1976. The nature of comprehension errors in Broca's, conduction and Wernicke's aphasics. *Cortex*, **12**, 258–265.
- Howard, D. 1985. Agrammatism. In S. Newman & R. Epstein (Eds.), *Current perspectives in dysphasia*. London/New York: Churchill Livingstone.
- Jones, E. V. 1984. Word order processing in aphasia: Effect of verb semantics. In Rose F. C. (Ed.), *Advances in neurology: Vol. 42. Progress in aphasiology*. New York: Raven Press.
- Kean, M. L. (Ed.). 1985. *Agrammatism*. New York: Academic Press.
- Kolk, H. H. J., van Grunsven, M. J. F., & Keyser, A. (1985). Agrammatism as a variable phenomenon. *Cognitive Neuropsychology*, **2**(4), 347–384.
- Linebarger, M. 1990. Neuropsychology of sentence parsing. In A. Caramazza (Ed.), *Cognitive neuropsychology and neurolinguistics*. Hillsdale, NJ: Erlbaum.
- Linebarger, M., Schwartz, M. F., & Saffran, E. M. 1983. Sensitivity to grammatical structure in so-called agrammatic aphasics. *Cognition*, **13**, 361–392.
- Martin, R. C. 1987. Articulatory and phonological deficits in short term memory and their relation to syntactic processing. *Brain and Language*, **32**, 159–192.
- Martin, R. C. 1990. Neuropsychological evidence on the role of short-term memory in sentence processing. In G. Vallar & T. Shallice (Eds.), *Neurological impairments of short-term memory*. New York: Cambridge Univ. Press.
- Martin, R. C., & Blossom-Stach, C. 1986. Evidence of syntactic deficits in a fluent aphasic. *Brain and Language*, **28**, 196–234.
- Martin, R. C., Wetzel, W., Blossom-Stach, C., & Feher, E. 1989. Syntactic loss versus processing deficit: An assessment of two theories of agrammatism and syntactic comprehension deficits. *Cognition*, **32**, 157–191.
- Miceli, G., & Caramazza, A. 1988. Dissociation of inflectional and derivational morphology. *Brain and Language*, **35**(1), 24–65.
- Miceli, G., Laudanna, A. & Burani, C. 1991. *Batteria per l'analisi dei deficit afasici: Vol. I*. Milano: Associazione per la Ricerca Neuropsicologica.
- Miceli, G., & Mazzucchi, A. 1990. Agrammatism in Italian: Two case studies. In L. Menn and L. K. Obler (Eds.), *Agrammatic aphasia: Cross-language narrative sourcebook*. Chapt. 10, Pp. 717–816.
- Miceli, G., Mazzucchi, A., Menn, L., & Goodglass, H. 1983. Contrasting cases of Italian agrammatic aphasia without comprehension disorder. *Brain and Language*, **33**, 273–295.
- Miceli, G., Silveri, M. C., Nocentini, U., & Caramazza, A. 1988. Patterns of dissociation in comprehension and production of nouns and verbs. *Aphasiology*, **1**(2), 351–358.
- Miceli, G., Silveri, M. C., Romani, C., & Caramazza, A. 1989. Variation in the pattern

- of omissions and substitutions of grammatical morphemes in the spontaneous speech of so-called agrammatic patients. *Brain and Language*, **36**, 447–492.
- McCloskey, M., & Caramazza, A. 1988. Theory and methodology in cognitive neuropsychology: A response to our critics. *Cognitive Neuropsychology*, **5**, 583–623.
- Nespoulous, J.-L., Dordain, M., Peron, C., Ska, B., Bub, D., Caplan, D., Mehler, J., & Lecours, A. R. 1988. Agrammatism in sentence production without comprehension deficits: Reduced availability of syntactic structures and/or grammatical morphemes? *Brain and Language*, **33**, 273–295.
- Saffran, E. M. 1982. Neuropsychological approaches to the study of language. *British Journal of Psychology*, **73**, 317–337.
- Saffran, E. M. 1990. Short-term memory impairment and language processing. In A. Caramazza (Ed.), *Cognitive neuropsychology and neurolinguistics*. Hillsdale, NJ: Erlbaum.
- Saffran, E. M., Berndt, R. S., & Schwartz, M. 1989. The quantitative analysis of agrammatic production: Procedure and data. *Brain and Language*, **37**, 440–479.
- Saffran, E. M., & Martin, N. 1990. Short-term memory impairment and sentence processing: A case study. In G. Vallar & T. Shallice (Eds.), *Neurological impairments of short-term memory*. New York: Cambridge Univ. Press.
- Saffran, E. M., & Schwartz, F. M. 1988. "Agrammatic" comprehension it's not: Alternatives and implications. *Aphasiology*, **2**(3/4), 389–394.
- Saffran, E. M., Schwartz, M. F., & Marin, O. S. M. 1980a. Evidence from aphasia: Isolating the components of a production model. In B. Butterworth (Ed.), *Language production*. New York: Academic Press. Vol. 1.
- Saffran, E. M., Schwartz, M. F., & Marin, O. S. M. 1980b. The word order problem in agrammatism. II. Production. *Brain and Language*, **10**, 263–280.
- Schwartz, M. F. 1987. Patterns of speech production deficit within and across aphasia syndromes: Application of a psycholinguistic model. In M. Coltheart, G. Sartori, & R. Job (Eds.), *The cognitive neuropsychology of language*, New Jersey: Erlbaum.
- Schwartz, M. F., Linebarger, M., & Saffran, E. M. 1985. The status of syntactic deficit theory of agrammatism. In M.-L. Kean (Ed.), *Agrammatism*. New York: Academic Press. Pp. 83–124.
- Schwartz, M. F., Linebarger, M., Saffran, E. M., & Pate, D. S. 1987. Syntactic transparency and sentence interpretation in aphasia. *Language and Cognitive Processes*, **2**, 85–113.
- Schwartz, M. F., Saffran, E. M., & Marin, O. S. M. 1980. The word order problem in agrammatism. I. Comprehension. *Brain and Language*, **10**, 249–262.
- Shankweiler, D., Crain, S., Gorrell, P., & Tuller, B. 1989. Reception of language in Broca's aphasia. *Language and Cognitive Processes*, **4**(1), 1–33.
- Stemberger, J. P. 1985. An interactive activation model of language production. In A. Ellis (Ed.), *Progress in psychology of language*, Vol. 1. London: Erlbaum.
- Vallar, G., & Baddeley, A. 1984. Phonological short term store. Phonological processing and sentence comprehension: A neuropsychological case study. *Cognitive Neuropsychology*, **1**, 121–141.
- Vallar, G., Basso, A., & Bottini, G. 1990. Phonological processing and sentence comprehension. In G. Vallar & T. Shallice (Eds.), *Neurological impairments of short-term memory*. New York: Cambridge Univ. Press.
- Zurif, E. B. 1984. Psycholinguistic interpretations of the aphasias. In D. Caplan, A. R. Lecours, & A. Smith (Eds.), *Biological perspectives on language*. Cambridge, MA: MIT Press.
- Zurif, E. B., Gardner, H., & Brownell, H. 1989. The case against the case against agrammatism. *Brain & Cognition*, **10**, 237–255.