

REPRESENTING SENTENCE CONTENT IN APHASIA : STRATEGIES AND LIMITATIONS

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An analysis of several disparate findings from studies on aphasic disorders suggests the possibility of developing a simple unitary account of language comprehension in aphasics based on the idea of disrupted ability to form adequate mental representations. Two experiments, using respectively a sentence completion task and a riddle test, yielded results consistent with predictions of the representational explanation advanced. — It is suggested that anterior aphasics are impaired in the ability to carry out systematic processing of specific aspects of situations or events (irrespective of knowledge), and consequently over-rely on knowledge-based routines. Conversely, posterior aphasics seem to be impaired in the ability to apply knowledge-based routines and, although they are able to carry out systematic processing, the limitation in the availability of routines reduces their processing capacity.

One of the assumptions underlying the concept of mental representation, is the idea of a processing stage in which information coming from different subsystems is integrated into a coherent holistic structure (Bransford & McCarrell, 1974). Conceptually, these momentary representations of situations or events seem a prerequisite for the cognitive system to be able to cope appropriately with the external world.

In the present work we intend to consider the ability of anterior and posterior aphasics to form adequate representations of sentence content. Primarily, this concern arises from an analysis of several findings inconsistent with the dominant assumption that anterior aphasics are "agrammatic" but good comprehenders, and posterior aphasics have a disrupted "semantic system" and preserve their "grammatical competence". More precisely, recent studies show that in matching pictures to sentences (equivalent as to grammatical complexity), anterior aphasics seem to follow essentially pragmatic criteria (Caramazza & Zurif, 1976; Deloche & Seron, 1981). In most cases, their responses are related to the "standardness of situations" irrespective of the precise characteristics of the situation encountered. This pattern of performance occurs in both reversible and implausible situations. Provided with reversible sentences, anterior aphasics assign roles to actors according to greater plausibility. When the roles are interchanged violating pragmatic habits (i.e. The patient takes care of

This work was conducted at the Unité de Recherches Neuropsychologiques et Neurolinguistiques (U-III de l'I.N.S.E.R.M.). Preparation of the manuscript was supported in part by a grant from the Fondation Fyssen to Patrizia Bisiacchi.

the doctor) they apply a normative strategy (Deloche & Seron, 1981) inverting the s-o relation. On the other hand, presented with sentences describing situations consistent with pragmatic knowledge, these patients perform correctly on sentence-picture matching tasks. Obviously, as in all conditions the sentences used were *structurally similar*, an interpretation based on the notion of agrammatism cannot convincingly account for the selective mismatching of sentences describing less plausible situations. In order to offer at least a partial explanation of these findings it is necessary to invoke the notion of a selective impairment "in the stage in which the sentence representation is compared to the picture representation" (Just, Davis, & Carpenter, 1977; see also Deloche & Seron, 1981). Insofar as the factor of the plausibility of situations appears to be crucial in determining successful or unsuccessful matching by anterior aphasics, such an explanation would be necessarily related to the consideration of the patient's use of his or her knowledge of the world. If the results reported by Caramazza and Zurif (1976) and Deloche and Seron (1981) contradict the main prediction which can be made on the basis of the notion of agrammatism (that the subject's misunderstanding is related to the structural complexity of sentences), they seem, in turn, explicable in terms of representational impairment.

However, in a series of papers Schwartz and co-workers (Schwartz, Saffran, & Marin, 1980; Saffran, Schwartz & Marin, 1980) assume that there is no representational impairment in anterior aphasics. They claim evidence for word-order deficit in agrammatic patients and believe it can account for a large amount of data, including the results reported by Caramazza and Zurif (1976) and other related findings (e.g. Heilman & Scholes, 1976). Yet, despite their thorough argumentation, this claim sharply contrasts with the results previously reported by Goodglass (1968) and Kremin and Goldblum (1975) suggesting that processing of word-order is one of the best retained capacities in anterior aphasics. Kremin and Goldblum provided their patients with content words printed separately on cards and asked them to form telegrams. On the syntactic level, the construction of telegrams requires the ability to arrange words in the canonical s-v-o order. Since the authors found their anterior aphasics "good telegraphists" this is a clear counterevidence for the hypothesis of word-order deficit in anterior patients¹.

But a more critical finding contradicting the word-order hypothesis stems from the work of Andreewsky and Seron (1975). They found anterior aphasics able to identify (apparently disregarded) functors *from their position in the sentence structure*. For instance, in the case of

¹ It should be emphasized that all these contradictory findings arise from experiments using different tasks. The phenomenon of inconsistent between-task results casts doubt on the adequacy of the theoretical background according to which the results are contradictory — namely on the criteria related to the explanation in terms of grammatical competence.

homonyms these patients were shown to distinguish the use of the word as a substantive from its use as a functor. Perhaps, then, the interpretation advanced by Schwartz and co-workers should be restated: the apparent deficit in using the *order of arguments* as clues for understanding, observed in certain tasks, reflects an underlying impairment in the ability to form adequate cognitive representations (but see the recent reformulation of the word-order hypothesis in Saffran, 1982). In this context, the results reported by Andreewsky and Seron (1975) could be interpreted to suggest that anterior aphasics are able to perform syntactic analyses of a sentence but are impaired in the ability to incorporate some of this information in their representations². Further evidence supporting this representational hypothesis arises from deficits found in these patients in tasks consisting of classification of words or pictures. Although there is no need here for grammatical analyses, anterior aphasics have difficulty in following certain classification criteria (Bisiacchi, Denes & Semenza, 1976; Semenza, Denes, Lucchese & Bisiacchi, 1980; Rosenthal & Bisiacchi, 1982). The overall assumption underlying any classification task is that one has to conceptualize the target class in order to find out a suitable strategy for performing the task. Hence the ability to develop an appropriate representation of class relationships critically determines the subject's performance. Therefore, selectively unsuccessful classification of words and pictures points unambiguously to a deficit in certain processes of representation.

Similar reasoning holds with respect to disorders found in posterior aphasics. In classifying pictures and words these patients also exhibit great difficulty in following certain classification criteria, although globally their deficiency seems less clear in comparison to that of anterior aphasics (Rosenthal & Bisiacchi, 1982). Caramazza, Berndt and Brownell (1982) claim that the difficulties of posterior aphasics in classification tasks parallel their naming impairment. It is our impression that there is a striking similarity between over-extension of classification criteria (observed in the former task) and the fact that the inappropriate lexical choices that these patients make on different occasions are frequently "out of focus" but still related to the target (Lhermitte, Derouesne & Lecours, 1971; Marin, Saffran & Schwartz, 1976; Zurif & Caramazza, 1977). In the light of this similarity, it would be well-advised to rule out the possibility of a mere lexicalization defect. Furthermore, as observed performances do not really

² Saffran (1982) reports an experiment by Linebarger, Schwartz and Saffran in which "agrammatic" patients "have proved to be remarkably sensitive even to rather subtle violations of structural rules (as in **The workmen were expected would finish by noon* and **How many do you have friends in Philadelphia?*)". She concluded that "under the conditions of the grammaticality task, at least, it appears that agrammatics are capable of parsing sentences". We can add, with respect to the second example, that their "agrammatic" patients seem capable of detecting even subtle violations of the word-order of a sentence.

appear random, it would be unwise to characterize as "asemantic" the linguistic behaviour of posterior aphasics.

Additional clues leading to a "representational approach" stem from reported studies on matching pictures to sentences. Posterior aphasics are found to be insensitive to the "standardness of situations", often mismatching both sentences that describe odd events and those that describe highly plausible events (Deloche & Seron, 1981). This strongly contrasts with the tendency displayed by anterior patients and we are tempted to consider that the overall mismatching results from a difficulty in representing the sentences and/or pictures appropriately. Our hypothesis of representational impairment is grounded in part on the fact that an explanation in terms of a disrupted semantic system seems unconvincing within this context. Indeed, several studies reported that the presence of grammatical functors (e.g. prepositions, conjunctions, verb inflections, etc...) strikingly improves the linguistic performances of posterior aphasics (von Stockert, 1972; Kremin & Goldblum, 1975). To suppose that grammatical parsing can supplant disrupted semantic processing would be at least questionable. Rather, we believe that the processing of functors provides, among other things, some relational information (on time, space, causality, instrumentality, etc...) that can on certain occasions afford important clues for understanding, clues on which posterior aphasics are liable to over-rely.

From a theoretical standpoint, envisioning a representational account of the several deficits observed in aphasic patients should enable us to take further steps in the search for unitary explanation of many apparently contradictory findings. Moreover, as the data reviewed above seem to admit a coherent explanation within the framework of a representational hypothesis, this should allow us to make predictions relevant to the falsification of this hypothesis.

If we assume that the brain damage responsible for the observed aphasic disorders affects selectively the capacity to employ certain cognitive operations while preserving others, we should find a disequilibrium in the processing performed. More precisely, we might expect an over-application of available processes in order to "compensate" for the ineffectiveness of affected operations. However, as this "compensation effect" may be expected to be effective to only a limited degree, the subject should fail to form an adequate representation when the application of deficient processing is critically necessary.

Thus, the over-reliance of anterior aphasics on pragmatic criteria suggests that their internal representations are formed mostly through the application of routines based on pre-existing knowledge structures rather than as a function of actual and specific aspects of the situation encountered. Routines allow us to promptly structure an event and situate it with respect to our general knowledge. Their main advantage lies in the possibility they afford of avoiding systematic

processing of every item of information. This reduces the processing load on the cognitive system and, as a consequence, increases its capacity. Routines based on pre-existing knowledge cannot, however, supplant systematic processing (parsing) of actual and specific aspects of situations. Casting actors for the parts they really play in an event (e.g. agent, recipient), situating an event in time and space, setting up each relevant relation, all this requires systematic parsing that follows strictly determined rules. Anterior aphasics seem impaired precisely in the ability to carry out these operations, yet they strive to form coherent representations and substitute the relations they are unable to set up with others that are most plausible in terms of their knowledge of the world.

The working principles in posterior aphasics seem quite different. As they have a limited ability to structure their representations of events through the application of routines, these patients seem to be guided in their representations by cues arising from the processing they are able to carry out. Hence their over-dependence upon cues related to the specificity of the encountered situation. Moreover, the low availability of knowledge-based routines should seriously restrict their processing capacity. We might predict, therefore, that they would often form incomplete representations, intrinsically coherent, but incongruent with the whole situation.

EXPERIMENT I

SENTENCE COMPLETION TASK

The general assumption underlying the sentence completion technique is that in order to find out the missing element (word) the subject has to form an appropriate internal representation of the situational scenario corresponding to the content of the target sentence. We undertook Experiment I with the aim of obtaining a more thorough understanding of the limitations in the strategies employed by aphasic subjects. We therefore constructed the sentence material so as to dissociate the applicability of knowledge-based routines and of systematic processing. Two examples will illustrate this procedure.

The application of a routine deriving from relevant knowledge about elephants is likely to be sufficient to complete a sentence like: "The elephant has a long...". However, such a routine, while perhaps applicable, seems insufficient in the case of the sentence: "The leaves fall *from*..." since the presumably available knowledge about leaves and gravitation cannot be appropriately used until the particular relation marked by the preposition *from* is set up.

MATERIALS AND METHOD

Stimuli consisted of two series of 8 incomplete sentences constructed according to the criteria specified above. There were 8 sentences with a relational preposition in the last phrase requiring systematic processing

(s+ sentences), and 8 sentences without prepositions, in which knowledge-based routines were supposed to be sufficient to find out the missing word (R+ sentences). The sentences were printed on cards and presented to the subjects together with a multiple choice array of four randomly ordered words.

For s+ sentences this array contained: 1 correct word, 1 unrelated word, 1 word which would fit the sentence if the preposition was removed, 1 word which would fit the sentence if there was another preposition. For R+ sentences the 4-word array contained: 1 correct word, 1 word related to one part of the sentence, 2 unrelated words (see Table 1).

TABLE 1. SENTENCE MATERIAL USED IN EXPERIMENT 1 WITH 2 EXAMPLES OF MULTIPLE CHOICE ARRAYS FOR EACH SENTENCE TYPE

R+ sentences	s+ sentences
1. Le berger garde ses... (The shepherd watches his...)	1. Voici une rose sans... (Here is a rose without...)
2. Le chat poursuit une... (The cat chases a...)	2. Les feuilles tombent de... (The leaves fall from...)
3. L'éléphant a une longue... (The elephant has a long...)	3. Mets ton assiette sur la... (Put your plate on the...)
4. En hiver il fait... (In winter it is...)	4. Il garde les mains dans ses... (He keeps his hands in his...)
5. La souris aime le... (The mouse loves...)	5. J'ai rencontré Frédérique par... (I met Frederic by...)
6. Le boulanger cuit le... (The baker bakes...)	6. Les lunettes sont sur le... (The glasses are on the...)
7. Le soleil réchauffe la... (The sun heats the...)	7. Cette tarte est aux... (This is an... cake)
8. Le toit couvre la... (The roof covers the...)	8. Il mange le sandwich avec... (He eats the sandwich with...)
Two examples of multiple choice arrays for R+ sentences	
	Fauteuils (Armchairs)
Le berger garde ses...	Campagne (Countryside)
	Moutons (Sheep)
	Caviar (Caviar)
	Afrique (Africa)
L'éléphant a une longue...	Tasse (Cup)
	Couverture (Cover)
	Trompe (Trunk)
Two examples of multiple choice arrays for S+ sentences	
	Gomme (Eraser)
Voici une rose sans...	Epines (Thorns)
	Jardin (Garden)
	Rouge (Red)
	La pipe (The pipe)
Les feuilles tombent de...	Vite (Quickly)
	Terre (Ground)
	L'arbre (The tree)

The sentences were chosen according to the performance of 20 control non-brain-damaged subjects ranging in age from 11 to 55 years. They completed the sentences selected for the experiment without hesitation or errors. The items selected for the multiple choice arrays were mostly taken (except for the unrelated words) from real responses produced by aphasic subjects in a previous oral version of the experiment.

Patients were seated in front of the experimenter who presented, one by one, the 16 incompleting sentences alternated in irregular fashion. Their task consisted of pointing out the word which would most appropriately complete the sentence. The stimuli were not removed until the subject pointed to one of the items. This procedure was followed for all 16 sentences and for each subject. Before testing began, an example was presented to ensure that the subject understood the test requirements.

SUBJECTS

The subjects available for the present study were 16 aphasic patients (ranging in age from 34 to 71 years) with tumoral or vascular etiology. The patients were classified as to lesion site and type of aphasia on the basis of neuropsychological examination and laboratory data. There were 9 anterior aphasics (all classified as Broca's), and 7 posterior aphasics (all classified as Wernicke's). At the time of the experiment all anterior patients either presented or had recovered from right hemiplegia. All subjects were right-handed with a unilateral lesion to the left hemisphere.

RESULTS AND DISCUSSION

Table 2 presents the distribution of responses of all subjects for the two types of sentences. Subjects' error responses were classified according to categories determined by the multiple choice provided. A two-way analysis of variance performed on total error responses revealed a significant interaction of patient group by sentence type ($F(1,14)=57.22$, $p < .001$) and no significant main effects for patient group ($F(1,14)=0.856$, $F < 1$) or for sentence type ($F(1,14)=1.416$, n.s.). (See Table 3 for summarized mean errors of both groups for each sentence type). Indeed, Table 3 shows completely inverse results for the two groups. Anterior aphasics performed quite well in completing R^+ sentences and poorly with S^+ sentences, whereas posterior aphasics performed poorly in completing R^+ sentences and were successful with S^+ sentences.

A more detailed analysis of responses (A-test of Sandler, 1955) was conducted separately for sentence types in each aphasic group. In completing S^+ sentences (with prepositions), anterior aphasics made significantly more preposition-suppression errors than preposition-change errors (43.05% vs. 9.72% ; $A(8)=0.18$, $p < .001$), more

TABLE 2. DISTRIBUTION OF RESPONSES OF ALL SUBJECTS IN EXPERIMENT I

		s+ sentences (with prepositions)				R+ sentences (without prepos.)		
		correct	errors			correct	errors	
			prepos. suppres.	prepos. change	random		response related to one part of the sentence	random
posterior aphasics (N=2)	1	1	6	1	0	5	3	0
	2	6	2	0	0	8	0	0
	3	6	2	0	0	8	0	0
	4	5	2	1	0	8	0	0
	5	1	7	0	0	5	3	0
	6	3	4	1	0	6	1	1
	7*	2	3	2	0	8	0	0
	8	5	3	0	0	7	1	0
	9	4	2	2	0	5	3	0
	total	33	31	7	0	60	11	1
mean		3,67	3,44	0,78	0	6,67	1,22	0,11
%		45,83	43,05	9,72	0	83,33	15,28	1,39
anterior aphasics (N=9)	1	8	0	0	0	3	4	1
	2	7	1	0	0	5	3	0
	3	7	0	1	0	5	2	1
	4	7	1	0	0	5	2	1
	5	8	0	0	0	4	3	1
	6	8	0	0	0	4	4	0
	7	5	2	1	0	5	3	0
	total	50	4	2	0	31	21	4
mean		7,14	0,57	0,29	0	4,43	3,00	0,57
%		89,29	7,14	3,57	0	55,36	37,50	7,14

* 1 omission

suppression than random-type errors (43.05% vs. 0%; $A(8)=0.14$, $p < .001$), and more preposition-change than random-type errors (9.72% vs. 0%; $A(8)=0.22$, $p < .05$). In completing R+ sentences (without prepositions) these patients made significantly more correct responses than errors (83.33% vs. 16.67%; $A(8)=0.15$, $p < .005$). However, the comparison of categories of errors did not reveal a significant difference although the random-type errors were still much less frequent (1.39%). Conversely, posterior aphasics made more correct responses than errors in completing s+ sentences (89.29% vs. 10.71%; $A(6)=0.157$, $p < .001$). The comparison of errors in completing R+ sentences shows that they made significantly more responses consistent with one part of the stimulus sentence than random-type

TAB. 3. SUMMARIZED MEAN ERRORS FOR THE TWO TYPES OF SENTENCES BY BOTH APHASIC GROUPS

	anteriors	posteriors
S ⁺ sentences	4,22	0,86
R ⁺ sentences	1,33	3,57

TAB. 4. RIDDLES USED IN EXPERIMENT II WITH 2 EXAMPLES OF MULTIPLE CHOICE ARRAYS

The riddles	
1. a des ailes (has wings) peut chanter (can sing)	5. a des pages (has pages) pour être lu (to be read)
2. froide (cold) peut fondre (can melt)	6. chauffe (heats) dans la maison (in the house)
3. en laine (made of wool) autour du cou (around the neck)	7. pour écrire (for writing) avec une plume (with a quill)
4. pour s'asseoir (for sitting) avec des accoudoirs (with armrests)	8. a deux jambes (has two legs) peut parler (can speak)
Two examples of multiple choice arrays	
	navire (ship)
	encre (ink)
pour écrire	cigarette (cigarette)
	oie (goose)
avec une plume	copiste (copyist)
	stylo (pen)
	crayon (pencil)
	autriche (ostrich)
	plat (flat)
a deux jambes	Monique (Monique)
	caméra (camera)
peut parler	homme (man)
	radio (radio)
	adjudant (adjudant)

errors (37.5% vs. 7.14%; $A(6)=0.169$, $p < .005$). Figure 1 shows the proportion of all response types by both aphasic groups for the two types of sentences.

These overall results are in agreement with our hypotheses concerning the strategies available to anterior and posterior aphasics in representing situational scenarios for sentence content. The data, both regarding the sentences that were completed correctly and the *kinds* of errors that were made, clearly indicate the consistent use of the strategies predicted to be available to the respective patient groups (i.e. knowledge-based routines, in the case of anterior aphasics, and systematic processing in the case of posterior aphasics). The distribution of errors cannot be explained by the multiple choice provided,

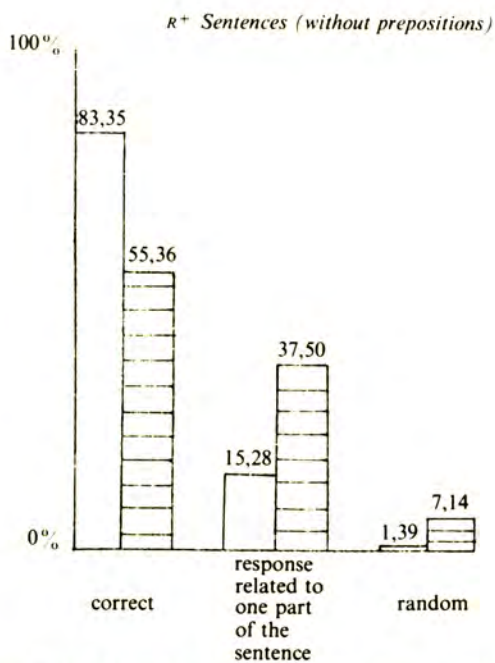
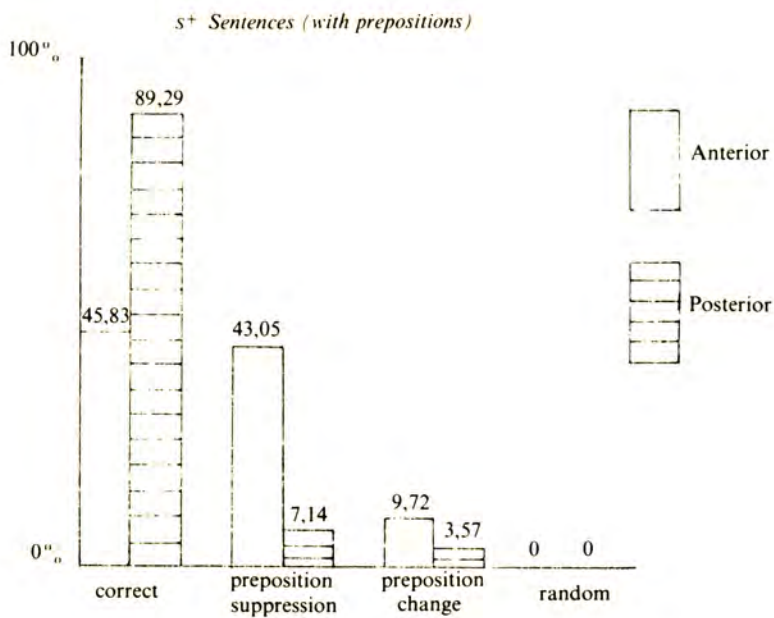


FIG. 1. PERCENTAGES OF ALL RESPONSE TYPES BY BOTH APHASIC GROUPS FOR THE TWO TYPES OF SENTENCES

as we had constructed these arrays on the basis of oral responses obtained in a previous version of the experiment. Furthermore, the precise pattern of results obtained allows us to rule out the possibility of performances on the chance level since random-type errors are extremely rare and the distributions of other types of responses are significantly different within and between patient groups. A more precise analysis of the strategies employed by both aphasic groups can thus be developed.

The assumption that knowledge-based routines are sufficient to complete adequately R^+ sentences describing standard situations (e.g. the roof covers the...) and that anterior aphasics retain the ability to employ this type of computation is in agreement with most of the correct performances of our anterior subjects (83.33% correct completions). However, more critical evidence favouring the hypothesis concerning the strategies available to anterior aphasics stems from their poor performances (only 45.83% correct responses) in completing s^+ sentences (with relational prepositions). It will be recalled that we had hypothesized that the comprehension of anterior aphasics would be restricted to the application of routines based on knowledge-structures. Insofar as the completion of sentences such as: "I met Frederic *by*..." (*J'ai rencontré Frédérique par...*) or "The glasses are *on* the ..." (*Les lunettes sont sur le...*) depends on the ability to set up particular relations marked by prepositions, knowledge-based routines would be insufficient here to meet task requirements. The correct choice of word to fit the sentences requires systematic processing in order to determine the exact nature of the relation between certain relevant components of the described situation. Hence the failure to complete s^+ sentences appropriately points to an inability to carry out systematic processing. This inability does not mean, however, that these patients would form incoherent representations when systematic processing is required. In fact, the analysis of errors committed by anterior aphasics shows a striking predominance of preposition-suppression errors (81.52% of errors), that is, completions that would be correct if there were no prepositions. A difficulty in determining those critical relations that need to be incorporated into the whole scenario naturally favours a selective involvement of knowledge-based routines to form plausible situational scenarios. This strategy seems the most reasonable when the impairment of the systematic parser precludes the subject from incorporating the relation into the scenario developed. It does not imply, however, that anterior aphasics simply disregard relational prepositions. Five of the nine subjects that participated in the experiment made preposition-change errors (18.48% of errors) showing that the processing of relations marked by prepositions was not simply left out.

Obviously, however, we cannot reject the alternative hypothesis of misprocessing functors solely on the basis of these results. Yet, even on the basis of our findings this explanation is open to question, for, if our subjects were really agrammatic and simply misprocessed

prepositions, we could expect a more or less equal distribution of the three types of error. Furthermore, these patients would be less successful in completing sentences containing an article in the last phrase; but we did not find any difference between performances on these sentences and on those without articles. Thus, although the presented results do not constitute unambiguous evidence supporting our hypothesis, we believe that the explanation developed here has the advantage of allowing us to predict the pattern of performance of anterior aphasics with greater accuracy and of accounting for a large variety of results reported in the literature.

Our reasoning relies in part on the assumption that relational prepositions cannot be considered as simple grammatical cues nor as semantically empty words. In fact, the common distinction between content words and functors rests entirely on the assumption that an analysis of single lexical units allows us to dissociate semantically meaningful words and empty grammatical cues. However, this assumption may be unfounded as it is unusual in normal communication both to utter and to hear isolated words. Although it is difficult to define their "common sense meaning" without a contextual example, relational prepositions (as well as other functors or even some content words e.g. beauty, happiness, stupidity) become meaningful in the context of a sentence. In any case agrammatism cannot fully account for the results of anterior aphasics in completing sentences with prepositions. Rather, these results point to an impairment in the ability to employ systematic processing in order to set up adequately the particular relation marked by the preposition³. This impairment in the ability to determine the exact relation (irrespective of pragmatic knowledge of standard situations) was also demonstrated by Goodglass et al. (1979). The authors used compact and expanded versions of sentences in a task of matching pictures to sentences. They found that Broca's aphasics performed much better with expanded sentences that permitted them to avoid dealing with the relationship marked by prepositions (e.g. before/after). However, when the expanded version of the sentence did not allow the subject to avoid processing the particular relation between two terms, Broca's aphasics did not show any improvement in their comprehension of the expanded sentence as compared with the compact version. If we take into account that in the expanded version the critical relation was expressed without using a preposition, these results clearly point to an impairment in

³ Saffran (1982) points out that in matching pictures to sentences such as: *The circle is above the square* the patients' errors almost always consist of the choice of the reversed-role distractor (e.g. a picture of a square above a circle) rather than a depiction of a different locative relation (e.g. a circle beside a square). Again, as this is a case of reversible relations unconstrained by the subject's knowledge, we suggest that this observation supports our view that anterior aphasics are impaired in the ability to set up *adequately* some particular relations in their representations of situations or events rather than unable to process prepositions.

the ability to set up particular relations, rather than to an inability to process grammatical functors.

The results for posterior aphasics similarly show a dissociation of the two strategies. When the application of knowledge-based routines is sufficient to complete the sentence, as in sentences without prepositions (R^+), their performance is very poor (44.64% of errors). Although a systematic parsing can generally supplant the application of routines, the economy of processing provided by the latter cannot be obtained with the former. Hence, as posterior aphasics seem impaired in the ability to employ adequate knowledge-based routines, their capacity of processing should be overall reduced. Indeed, the analysis of errors committed by these patients in completing R^+ sentences clearly shows a predominance of responses consistent with one part of the stimulus sentence (84.03% of all errors). As random-type errors are still rare (15.97% of all errors), the overall pattern of errors committed by posterior patients in completing R^+ sentences is consistent with the hypothesis of their diminished capacity to process resulting from impairment in the ability to use adequate routines.

The very good performances of posterior aphasics in completing S^+ sentences (with prepositions) are however somewhat unexpected. Although we could reasonably expect posterior aphasics to complete sentences with prepositions better than sentences without prepositions, the reduced processing capacity should normally affect their performances in both completion tasks.

However, a more precise analysis of these tasks shows that the correct responses do not necessarily imply an adequate representation of the whole situational scenario. In fact, it seems possible to find out the correct word on the basis of the particular relation determined by systematic processing and *only one* of the other components of the situation described.

We undertook, therefore, a second experiment in order to examine better the hypothesis of reduction in the amount of information that posterior aphasics are able to process at the same time. To this purpose we used riddles composed of two descriptors. The underlying assumption for this technique is that in order to pick out the best target-concept one has to form an adequate representation critically involving the information specified by both descriptors.

EXPERIMENT II

MATERIALS AND METHODS

Stimuli consisted of 8 riddles composed of two descriptors each. The riddles were constructed in such a way that both descriptors were necessary to identify the intended item (see Table 4). All target items described were common concrete nouns. This testing material was chosen according to the performance of 20 control non-brain-damaged

subjects ranging in age from 11 to 55. They identified target items of riddles selected for the experiment without hesitation or error. The patients were tested individually. The pairs of descriptors were presented to the subject visually, printed on cards along with a multiple choice array. This array contained 7 items randomly ordered: 1 correct word; 2 words corresponding each to one of two given descriptors; 2 distantly related words; 2 unrelated words. The items selected for each array were mostly taken (except for unrelated words) from real oral responses produced by aphasic subjects in a previous version of the experiment. In the experimental session subjects were required to point to the most adequate term corresponding to each pair of descriptors. Before testing began each subject was presented with an example to ensure that he understood the general testing requirements.

SUBJECTS

Sixteen aphasic subjects (ranging in age from 40 to 68) were included in this experiment: 9 posterior⁴ and 7 anterior aphasics. The patients were classified as anterior and posterior aphasics according to the criteria specified in Experiment 1. All of them were right-handed with a unilateral lesion to the left hemisphere. Some of them had also participated in Experiment 1.

RESULTS AND DISCUSSION

Table 5 shows frequencies of correct responses and detailed types of errors for all subjects. A comparison of both aphasic groups on total error responses was significant ($t(14) = 4.59, p < .001$). Posterior aphasics made globally 40.27% of errors and this was in sharp contrast with the very good performances of anterior patients (3.58% of errors). Hence further analyses were conducted on the results of posterior aphasics only. The global comparison of correct versus error responses did not reach significance ($A(8) = 0.55$). A more detailed analysis of errors showed that responses based on one descriptor are significantly more frequent than responses to distantly-related words ($A(8) = 0.19, p < .02$) or to unrelated words ($A(8) = 0.14, p < .005$).

These results show a clear difference in the ability of each aphasic group to construct an adequate cognitive representation by including the information specified by both descriptors. The specificity of the riddle test allows us to rule out the possibility of picking out the accurate term without processing all the information relevant in the given context. A failure to perform this task successfully can stem therefore, either from a disruption of lexical semantics or from a reduction in the amount of information that can be handled at the same time. However the distribution of errors committed by posterior

⁴ All classified as Wernicke's on the basis of clinical examination.

TABLE 5. DISTRIBUTION OF RESPONSES OF ALL SUBJECTS IN EXPERIMENT II

	correct	errors			total
		1 descriptor	distantly related	random	
posterior aphasics (N = 9)	1	3	3	1	7
	6	1	0	1	2
	5	3	0	0	3
	5	2	1	0	3
	6	2	0	0	2
	4	3	0	1	4
	6	1	1	0	2
	6	1	1	0	2
	4	3	1	0	4
	total 43	19	7	3	29
	mean 4,78	2,11	0,77	0,33	3,22
	within errors				
	"				
		65,52	24,24	10,34	100
anterior aphasics (N = 7)	8	0	0	0	0
	8	0	0	0	0
	7	0	1	0	1
	8	0	0	0	0
	8	0	0	0	0
	8	0	0	0	0
	7	0	1	0	1
	total 54	0	2	0	2
	mean 7,714	0	0,286	0	0,286

aphasics casts doubt on the explanation based on a disruption of lexical semantics since both error responses to distantly related words and random-type errors are systematically rare (respectively 24.14% and 10.34% of all errors). At the same time, the remaining 65.52% of errors are responses consistent with the information specified by only one descriptor. Furthermore, as the stimuli were not removed until the subject indicated his choice of response, this prevailing pattern of errors cannot be imputed to a memory defect. Nor can this effect be due to an abnormal attention default, for although responses related to the first descriptor are more frequent (63%) than those related to the second (37%), the target items were randomly ordered in arrays. Rather, the results point to the consistent search for an appropriate response (within the processing limitations of the patients).

These findings support, therefore, our hypothesis of lower processing capacity affecting the ability of posterior aphasics to integrate into a unique internal representation all the information relevant in a given context. We feel that along with the hypothesis of reduced availability

of knowledge-based routines, this representational approach better accounts for deficits found in posterior patients than a hypothesis of disrupted lexical semantics. Finally, the results clearly demonstrate that observed limitations in processing capacity are not a general feature of aphasic disorders since the performances of anterior aphasics in the riddle test are not different from those of the control non-brain-damaged subjects used to select the testing material.

CONCLUSIONS

In the present work we have developed an explanation of aphasic disorders within a framework of a functional analysis of strategies necessary to form adequate momentary representations of situations and events. Our approach is based in part on the conviction that an analysis of cognitively complex tasks at the level in which information coming from different subsystems has to be integrated into a coherent holistic structure often provides the opportunity to account for disparate findings and thus to simplify our general view of the phenomena under investigation (see Bransford & McCarrell, 1974). Taken separately, the results reported above do not contradict previous findings concerning different specific deficits found in anterior and posterior aphasics (see Caramazza & Berndt, 1978; Caramazza, Berndt & Brownell, 1982) for which locally attractive and heuristically valuable interpretations are often available. However, in focussing on the ability to form adequate internal representations, we avoid shifting to different explanations to account for each task and the performance of each aphasic group. There is an obvious heuristic interest in envisaging complex cognitive tasks in terms of appropriate goal-directed strategies (Moray, 1978; Young, 1978). Often these strategies are composed of functionally separable computations and there is growing evidence that systematic processes are both clinically and experimentally dissociable from knowledge-based routines (see Shallice, 1981). Within this context the hypothesis of selective impairment in the availability of appropriate systematic processes or knowledge-based routines necessary to form adequate cognitive representations enables a simple unitary account for the results of either aphasic group in our two experiments. As this explanation stems from an analysis of several experimental reports on aphasics' performances in very different tasks, we believe it can cover a relatively large amount of data. The most important point, however, is that this explanation renders conceptually compatible several intriguing findings such as those of Caramazza and Zurif (1976), Rosenthal and Bisiacchi (1982) or those reported by Saffran (1982) and widely accepted descriptions of aphasics' "agrammatism" or "disruption of lexical semantics".

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Received March 1982