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Cognitive Impairments of Aphasics in Picture Sorting and Matching Tasks

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Abstract. On the basis of earlier experiments showing a differential deficit of aphasics in picture sorting and matching tasks, two experiments were conducted to test the conjecture of a specific deficit of aphasics in the analytical appraisal of individual features. Broca's and Wernicke's aphasics—according to clinical diagnoses and the Aachener Aphasie Test—were compared with patients having right-hemisphere lesions or left-hemisphere lesions without aphasia. Both groups of aphasics differed from the control groups in the sorting task, irrespective of the sorting criterion, but the differences were small. The picture matching task did not discriminate between groups. Obviously, the basic assumption has to be modified with respect to specific conditions of task requirements. The experimental literature is reviewed.

Key words: Aphasia – Laterality – Cognition (disorders) – Concept formation

Introduction

The relationship between language disorders and cognitive impairments in aphasia has been a critical issue since the very beginnings of aphasiology (LeBrun and Hoops 1974; Zangwill 1964). It has attracted renewed interest due to the dis-

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semination of experimental methods in neuropsychological research. Since the experiments to be discussed in this paper were derived from earlier experimental work and since their results seem to be at variance with the bulk of the literature it might be worthwhile to first review more thoroughly the experimental literature on deficiencies of aphasics in nonverbal picture sorting and matching tasks.

Among the first and most influential studies demonstrating differential deficits in aphasics with visual tasks that required neither production nor comprehension of verbal stimuli was the work of Teuber and Weinstein 1956; Weinstein 1964. Unfortunately, their finding of an impairment in the Hidden Figures Test could not be replicated consistently (e.g. Corkin 1979; Pizzamiglio and Carli 1974; Russo and Vignolo 1967). While Orgass et al. (1972) found aphasics to be poorer than left-hemisphere controls in a similar task, aphasics were not significantly different from right-hemisphere patients. Results with other visuocognitive performance tasks were equally inconsistent (e.g. Basso et al. 1973; De Renzi and Spinnler 1966; Kertesz and McCabe 1975; Bisiach et al. 1976). Severe impairments of aphasics relative to other groups of brain-damaged patients have been reported for the Weigl Sorting Test (DeRenzi et al. 1966) which requires the sorting of 12 wooden pieces varying in shape, size, colour, thickness and (suit-symbols into different categories. Other studies showed aphasics to be inferior in recognizing random shapes difficult to describe or code verbally (e.g. Ammon 1973; Bisiach and Faglioni 1974). While these experiments used stimuli not immediately related to objects found in everyday life other experiments presented pictures of familiar objects to be matched or sorted according to more or less specified criteria. In a study noteworthy for its sophistication Basso et al. (1976) demonstrated severe problems of aphasics in matching line-drawings of familiar objects with coloured pencils according to the typical colour of the referent. The deficit was not reducible to either a deficiency in colour discrimination or to difficulties in naming or recognizing colours or objects. These basic findings have been replicated by Cohen and Kelter (1979). Correspondingly, experiments using verbal (e.g. Grossman 1981; Zurif et al. 1974) or combinations of verbal and pictorial stimuli (e.g. Gainotti et al. 1979; Goodglass and Baker 1976) have shown aphasics to have particular difficulties in matching or sorting objects on the basis of pictures according to semantic categories (e.g. Gainotti et al. 1979; Grober et al. 1980; Kelter et al. 1977; Semenza et al. 1980), or individual features (e.g. Birchmeier 1980; Cohen and Woll 1981; Kelter et al. 1976).

Previous research from our own group has provided evidence that conceptual matching or sorting per se is responsible for the deficit: Aphasics performed at the level of normals when the matching was based on the comparative overlap of broad associative fields of concepts. Their performance was poorer compared to other groups of brain-damaged patients only when the matching required the identification and appreciation of individual parts, features or typical actions of the objects in question. This finding was replicated in three experiments with different subjects and largely different items (Kelter et al. 1976; Cohen et al. 1980; Naumann 1978).

These and other experiments (Woll et al. 1979; Cohen and Woll 1981) led us to the conjecture that it is the analytical isolation and cognitive handling of single features that poses special problems to aphasics. This assumption appeared well

in line with the abundance of results relating left-hemisphere functioning to serial and analytical modes of information processing. We speculated that these impairments might be closely and functionally related to the difficulties of aphasics in propositional speech (Cohen et al. 1980).

The two experiments reported here have been designed to further explore and delineate these impairments of aphasics in picture matching and sorting tasks. In the first experiment we wished to examine whether such a deficit could be confined to certain kinds of denotative judgments as opposed to connotative or evaluative judgments which are assumed to rely on rather global assessments of whole associative fields, more likely to be deviant in right-hemisphere patients. In the second experiment our aim was to differentiate between analytical and abstract thinking: Since decisions about category membership, considered typical for abstract thinking, can to a large extent be based on rather global assessments of whole "lists of features" (Smith et al. 1974) or "family resemblance" (Rosch and Mervis 1975), aphasics should be less impaired in such categorization than in tasks requiring decisions about highly specific features common to referents of different semantic fields.

Experiment I: Picture Sorting Task

If it were true that aphasics are impaired in the analytical isolation and cognitive handling of individual features, one might wonder whether such an impairment can be found both for quasi-perceptual judgments, e.g., whether the referents are typically larger or smaller than 1 m, and for judgments concerning more abstract features of an object like animate/inanimateness? Do differential deficits disappear when judgments refer to broad associative fields, e.g., with the referents typically being located indoors or outdoors? Above all, we assumed that the impairment might only be found with respect to denotative rather than connotative or evaluative judgments, since the latter do not require analytical appraisals in a strict sense. For right-hemisphere patients one might expect the reverse pattern considering that several experiments (Tucker 1981) have demonstrated that these patients have specific problems in assessing the emotional quality of a stimulus.

Patients

Within a larger series of experiments 4 groups of patients were tested in 9 different neurological clinics and rehabilitation centers: 30 Broca's, 17 Wernicke's aphasics (according to clinical judgments of the staff), 17 left-hemisphere, and 24 right-hemisphere patients without any indication of aphasia at any time in their clinical records. All patients were right-handed according to the Oldfield scale (1971), all were native German speakers and all had lesions restricted to one hemisphere according to clinical information, supported by EEG, neuroradiological and—in 88% of the cases—CAT scan findings.

The groups were comparable with respect to age ($\bar{x}=47.1$ years, $F(3,84)=0.82$), educational and occupational status, and their performance in Form A of

the Trail Making Test ($F(3,84)=1.45$). In each group the ratio of males to females was approximately 3 : 1. Despite all efforts the final groups differed from one another significantly with respect to both etiology and duration of illness: While 80% of the aphasics had a cardiovascular etiology, about half the controls had traumatic lesions; and while the mean duration for Wernicke's aphasics was 1 year, it was approximately 2.5 years for Broca's aphasics and nearly 10 years for controls. We were unable to trace more non-aphasic patients with cardiovascular pathologies and had to include some veterans from World War II. In selecting aphasic patients, clinicians were asked to exclude Globals and Amnestics as far as possible. The classification as Broca's or Wernicke's aphasia was based on all available neurological data as well as the reports of speech therapists. These highly inclusive judgments will be referred to as "Hospital Diagnoses". There were 25 Broca's, 14 Wernicke's aphasics, 15 left-hemisphere and 15 right-hemisphere brain-damaged controls available for this experiment. The reduction in sample size did not affect the comparability of groups with respect to our matching criteria. We also differentiated the patients on the bais of their performance in the Aachener Aphasie Test—here referred to as "Test Diagnoses" (Huber et al. in press). According to a nonparametric discriminant analysis all our aphasic patients were classified "aphasic" with a posterior probability of 100%. Nine patients whose posterior probability of belonging to one of the four major types of aphasia did not exceed 70% were excluded. Of the remaining patients 12 were classified as Broca's, 13 as Wernicke's aphasics, 6 as Globals, and 6 as Amnestics.

Procedure

The experiment comprised 4 tasks. In each one the same 80 line drawings of familiar objects were used. For each task there were several practice trials to make sure the patient had understood the task. He was then given the pile of 80 cards and asked to sort them according to (1) whether the depicted referents are typically smaller or larger than 1 m, (2) whether they are typically found indoors or outdoors, (3) whether the referents are animate or inaninmate (4) whether they are generally pleasant or unpleasant. The categories for each of these tasks were defined on separate layouts by verbal descriptions and typical examples. Each also included a "Cannot Decide" Category indicated by a question-mark. The order of tasks and stimuli was varied across patients.

In order to define what might be considered "normal" responses the same tasks were given to 40 normal controls matched according to age, sex, and education. The results reported refer only to those items that had produced at least 80% agreement on the category (other than the "Cannot Decide" one) which was pertinent to characterize the item for a given task.

For these items deviancy scores were determined: a deviancy score of 1 was given for "Cannot Decide" sortings, a deviancy score of 2 whenever the patient's sorting was opposite to that of the normals. The sum of these scores was divided by the number of items per task, varying from 40 for "pleasant/unpleasant" to 62 for "smaller or larger than 1 m". There were hardly any differences between the groups, with respect to which items within a task appeared easy or difficult to sort. Correlations between the groups across the items of a given task ranged

$0.85 \leqq Q \leqq 0.99$. A two-way ANOVA was carried out with Groups and Tasks as the two factors, and the average deviancy scores as the dependent variable.

Results

The only significant effect was a main effect for Groups ($F(5,84) = 2.84$; $P = 0.02$) if the aphasics were defined according to Test Diagnoses. The results were similar for Hospital Diagnoses, yet differences were significant ($F(1,67) = 4.22$; $P = 0.04$) only when the two groups of aphasics were combined and contrasted with the two control groups combined. This discrepancy is probably due to the Amnestic aphasics according to Test Diagnoses, who achieved the lowest deviancy scores ($\bar{x} = 0.07$) of all groups. The deviancy scores of the Broca's ($\bar{x} = 0.28$) and the Wernicke's ($\bar{x} = 0.22$) aphasics according to Test Diagnoses were approximately twice as high as those of the left-hemisphere ($\bar{x} = 0.12$) and the right-hemisphere ($\bar{x} = 0.13$) controls. Neither the main effect for Tasks nor the interaction Tasks × Groups was close to any acceptable level of significance ($P < 0.10$) irrespective of the method used to define the aphasic subgroups. Correlations of the deviancy scores with the Token Test and other scores from the Aachener Aphasie Test fell short of statistical significance. Deviancy scores were unrelated to both age and duration of illness.

Discussion

The main effect for Groups supports our basic assumption that aphasics have a specific deficit in the analytical isolation and cognitive handling of individual features if referents from rather heterogeneous semantic fields have to be compared with respect to these features. Supportive as this main effect is for our conjecture, it does not account for much of the variance. Apparently, most of the test items were so easy, that a majority of the aphasics could perform on a level comparable to the controls. More dramatic differences might only appear under more demanding conditions. Thus Wilkins and Moscovitch (1978) found patients with left temporal removals impaired at classifying objects as living or man-made when drawings or words appeared at a rate of one every 0.75 s. Yet even under this condition the groups did not differ in classifying objects as being larger or smaller than a referent chair.

Contrary to our expectations there is no evidence for a double-dissociation with right-hemisphere patients being more deviant in their evaluative judgments, and left-hemisphere patients or aphasics being more impaired in denotative judgments. Differences between the groups were about the same for all four tasks. This lack of a difference between connotative and denotative judgments corresponds to results reported by Gardner and Denes (1973) who found aphasics, particularly Wernicke's asphasics, to give more deviant responses to a pictorial version of Osgood's Semantic Differential.

Considering the results of Gardner and Denes, as well as those of other studies, one might have expected more deviant responses for Wernicke's than for Broca's aphasics. The integrity of the semantic fields (Goodglass and Baker

1976) in Wernicke's aphasics has been shown to be deficient in a variety of tasks. Applying multidimensional scaling techniques Zurif et al. (1974) and Kelter et al. (1977) have found fluent aphasics to produce more irregular sortings and to pay less attention to those features of an object which primarily determine the sortings of normals and of aphasics with more anterior lesions. Posterior aphasics also produced or accepted more responses out-of-set or low in typicality for a given superordinate than anterior aphasics or normals (Grober et al. 1980; Grossman 1981). Our results do not support such a differentiation. They are more in line with Gainotti et al. (1979) who found both fluent and non-fluent aphasics to produce more deviant responses than left-hemisphere and right-hemisphere controls in deciding which of three depicted objects was most closely related to a given referent.

But the notion of poorly structured or defective concepts as well as the notion of an impairment in analytical competence are not the only explanations for the difference we found between aphasics and other brain-damaged patients. Perhaps it was the very fact that we used dichotomies—with each category having the same probability of being correct—which put the aphasics at a disadvantage. Gardner et al. (1978) found a loss of sensitivity to antonymic contrasts in a verbal—although not in a non-verbal—task in posterior aphasics. Following Luria (1975) one might think of the impairments as being due to a lack of selective inhibition and an equalization of activation patterns. One might wonder, whether the confrontation with equiprobable alternatives—also a basic feature of the Token Test (DeRenzi 1979)—would not be especially confusing to aphasics in that the activation of one pole of an antonymic contrast does not lead to an inhibition but to an activation of the opposite pole at the same time.

Experiment II: Picture Matching Task

In this experiment we tried to differentiate between analytical and abstract thinking, comparing both abilities to judgments about the typical situational context of a given object. We expected aphasics to show a differential deficit only when required to compare concepts from different semantic fields with respect to highly specific, though characteristic features. According to some of our earlier experiments (Cohen et al. 1980) aphasics should not show deficits in matching objects as to their typical context. We did not have any clear predictions about impairments in the abstraction task. On the one hand judgments about category membership might be just as easy as it is to think of a common situational context, since some rather global and intuitive assessment of "family resemblance" (Rosch and Mervis 1975) may lead to the correct solution. On the other hand there are several reports that many aphasics and particularly aphasics with posterior lesions have unduly widened (Lhermitte et al. 1971) or reduced (Goodglass and Baker 1976) semantic fields which should lead to a poorer performance in abstraction tasks.

Patients

According to Hospital Diagnoses 29 Broca's, 17 Wernicke's asphasics, 17 left-hemisphere and 23 right-hemisphere control patients participated in this ex-

periment. The slight reduction in sample size did not affect comparability of groups with respect to the matching variables mentioned above.

Procedure

There were three sets of items in this task. For each item the subject had to choose which of four pictures, presented in the bottom half of a page, might best go with the three "criterion" pictures presented in the upper half of the page together with an open field. In 16 items the three criterion objects had some characteristic feature in common (size, speed, colour, weight, or material); some of these items were adapted from a study by Birchmeier (1980). In 14 items the criterion objects were members of the same semantic category, (e.g., vegetables, furniture). For the third set of 14 items the referents were typically found in the same situational context (e.g., beach, garden, bathroom). Among the four alternatives for each item, one of the distractors had no obvious relationship to any of the criterion pictures while both of the other two foils had a close associative relationship with one of the criterion pictures. The items of the different sets were mixed and presented in random order to the patients.

Between 6 and 12 practice trials with an equal number of examples for the different sets were given to assure that the patients had understood the task. For each patient the number of correct choices per set was determined. To account for the different number of items per set, the number of correct choices was divided by the number of the items in the respective set. Internal Consistency of the three sets of items ranged $0.73 \leqq \alpha \leqq 0.77$.

Results

Contrary to our expectations there was neither a significant interaction Group × Task ($F(6,164)=1.39$; $P=0.22$ for Hospital Diagnoses; $F(10,128)=1.22$; $P=0.28$ for Test Diagnoses) nor any significant main effect for Groups, whether the aphasic groups were defined according to Hospital Diagnoses ($F(3,82)=0.75$; $P=0.53$) or according to Test Diagnoses ($F(5,69)=1.62$; $P=0.17$). The only effect accounting for most of the systematic variance was a main effect for Tasks ($F(2,164)=140.25$; $P<0.001$ for Hospital Diagnoses; $F(2,138)=94.49$; $P<0.001$ for Test Diagnoses). Patients were correct in matching the pictures according to Situational Context in 77%, in matching them according to Category Membership in 63%, and in matching them according to Characteristic Features in only 37% of their choices.

Discussion

The lack of a difference between the groups in the Characteristic Feature Series is clearly at variance with our expectations and with earlier results (e.g., Cohen et al. 1980). This result cannot be attributed to poor diagnostic classification: all aphasic patients had posterior probabilities of 100% as being "aphasics" according

to the Aachener Aphasie Test and none of the other patients had any indication of aphasia at any time of their illness. Three conclusions have to be considered: (1) the items did not measure what they were supposed to measure, (2) aphasics have none or only negligible differential deficits in what the items were supposed to measure, or (3) if there were a differential deficit in aphasics it did not show up under the specific conditions of our experiment.

The last of these possible conclusions seems the most plausible. If one takes into account that one of the foils had no obvious relationship to any of the criterion pictures, the overall performance in the Characteristic Feature items was only marginally better than chance. The difficulty of these items might have been enhanced by the fact that contrary to previous studies the items of the three different series were presented in mixed order, with the majority of items not requiring an analytical isolation of individual features. For 28 out of 44 items the most plausible solution could be found not by breaking up a concept into different features but by evaluating the whole concept as a possible member of some category or as occurring in a certain context. Success with these items might also have reinforced the search for contextual or class relationships in the Characteristic Feature items.

While all groups were rather poor in the Characteristic Feature series, they were quite successful in the Category Membership and the Situational Context series. The superior performance in the Situational Context series was to be expected from our previous work (e.g., Cohen et al. 1980). The good performance in the Category Membership series corresponds to the findings of Grober et al. (1980) and Grossman (1981) showing aphasics to be deviant only in judgments about untypical members of a category. Such atypical members did not occur in our items. It also supports the second part of a conclusion drawn by Tsvetkova (1975) with respect to the drawing and matching performance of amnestic aphasics: While there is an "impairment of their ability to isolate the identifying features of a specific individual object... the process of isolating distinguishing features not belonging to a particular object but to a whole group of objects of some kind (class of objects) was unaffected" (p. 43). Another explanation for the lack of differences between the groups might be due to the fact that we presented three pictures to delimit the criterion while in earlier experiments we had presented only a single word or a single picture to define the objective for the search. It is well known that the amount of impairment in aphasics is inversely related to the number of situational constraints (Kelso and Tuller 1981) or the amount of redundancy in the instructions (DeRenzi and Vignolo 1962). Our experiment conceded an amount of redundancy not usually encountered in any of the tasks demonstrating significant deviancies in the conceptual structures of aphasics.

General Discussion

The most striking result of both experiments is the small or even negligible difference between aphasics and other groups of brain-damaged patients in tasks that were specifically designed to capture and specify more closely what appeared to be a differential deficit in the cognitive functioning of aphasics. In

both experiments the critical tasks had been construed so as to require the analytical isolation and cognitive handling of individual features across different semantic fields. The expectation that such tasks might convey some differential deficits of aphasics was primarily based on earlier research with brain-damaged patients, an expectation also in line with the prevailing tendency in the literature to interpret a large proportion of the amassed data on hemispheric specialization in normals as indicating a dichotomy of analytical/holistic processing. Thus, even if the reports on cognitive deficits in aphasia were biased by the usual publishing policies of a low submission and acceptance rate for negative results one might have expected more dramatic differences on the basis of experimental studies with normals (Bradshaw and Nettleton 1981) and comissurotomized patients (Levy 1980). But contrary to such expectations the only differences between groups that reached an acceptable level of significance put the left hemisphere patients without aphasia together with the right-hemisphere patients and contrasted them with both the Broca's and the Wernicke's aphasics. Intrahemispheric specializations and their relationship to language functions might be more important than interhemispheric specializations in determining differential deficits in circumscribed groups of brain-damaged patients.

What conditions does a task have to fulfill for the expected differences between groups of patients with unilateral lesions to emerge? According to Moscovitch (1979) functional asymmetries might be more likely to occur under conditions of unusual informational load or with more complex cognitive or motor tasks rather than with simple perceptual tests. In addition Milberg and Blumstein (1981) as well as Cohen et al. (1981) provided some evidence that cognitive impairments of aphasics might only be found if the task requires conscious, volitional judgments about individual features rather than more automatic kinds of processing. Clearly, both of our tasks asked for conscious, volitional judgments and both of them could not be dealt with efficiently on a more immediate perceptual level. Nevertheless, the differences between groups were nothing but small.

The only significant difference found was in our Sorting Task. In this task it did not matter whether referents had to be judged according to size, typical context, animateness or pleasantness. Aphasics were slightly impaired in all four tasks. Possibly, the similarity of these four tasks in eliciting a differential deficit of aphasics is due to the fact that most of the decisions had to be based on the appraisal of non-dominant, but characteristic properties. The differences between aphasics and other groups of brain-damaged patients appear to be drastically reduced (Tsvetkova 1975) if the features amount to defining or even to dominant properties of objects well-known from everyday life. Even the Token Test is reduced in difficulty for aphasics if "circle" and "square" are changed into "flower" or "house" (Kreindler et al. 1971) or when both form and size are converted into verbal chunks: "man", "woman", "boy", "girl" (Naumann et al. 1980).

One of the most crucial factors leading to differential deficits in aphasics might be the amount of redundancy or situational constraints. All standardized and experimental tests which proved powerful in eliciting aphasic or apractic deficits require a performance out of context; and the most powerful test of aphasia—the Token Test—was deliberately constructed by DeRenzi and Vignolo (1962) to provide only an absolute minimum of linguistic or extralinguistic re-

dundancy. The high degree of redundancy in our Matching Task may have allowed the aphasics to function at a level similar to the controls save the Characteristic Feature items which proved to be too difficult for all our patients. In view of the many positive results cited in the introduction, we still speculate that it is particularly the isolation and cognitive handling of individual features which is most intimately intertwined with the availability of verbal codes and therefore most easily deranged in aphasics. The analytical isolation might be a prerequisite for propositional speech and for the retrieval of verbal codes, the availability of verbal associations might be decisive in directing one's thoughts towards specific features, and—last but not least—it might be extremely difficult if not impossible to think of individual features across different semantic fields without any verbal codes.

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