Processing of True and False Affirmative Sentences By Aphasic Subjects

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The American Heritage Dictionary (1969) defines comprehension as "the act of or capacity for comprehending or understanding." The first "or" indicates the duality in this definition. "The act" implies that comprehension is an active process of doing something, while "capacity for" indicates a more passive aspect, the "ability to receive, hold or absorb information." But research with normal subjects (see, for example, Tulving, 1968) suggests that active strategies such as rehearsal or coding must be applied if information is to be efficiently comprehended or retained. Thus, these active and passive components of comprehension require a multitude of considerations. Only recently has research in aphasia begun to focus on the strategies (or lack thereof) brought to bear on comprehension tasks by the aphasic patient.

Numerous models of the processes involved in sentence comprehension have been proposed for normal subjects. The studies to be reported here consider the applicability of one such model to comprehension tasks administered to aphasic subjects. The model is referred to as the information processing model of sentence comprehension; it has its origins in work developed by Herbert Clark and his associated (see, for example, Clark and Chase, 1972; Clark, Carpenter and Just, 1973); variations of the basic model have been proposed by Carpenter and Just (1975). Albyn Davis gave a review of this body of work at the 1974 Clinical Aphasiology Conference.

We frequently ask aphasic patients to engage in sentence-picture or word-picture comparisons. We show the patient an array of, let us say, five pictures, say a word or a sentence, and ask the patient to point to the picture that goes with the stimulus we've uttered. As Clark and Chase (1972) point out,

> "the main _a priori_ requirement of any theory of sentence-picture comparison is that for a sentence and picture to be compared they must be represented, ultimately, in the same mental format. One cannot, for example, compare the printed word _orchestra_ directly with a picture of an orchestra and judge them to "mean" the same thing, for there are no properties intrinsic to the graphemic and pictorial modes to indicate that the word and picture represent the same concept." (Clark and Chase, 1972)

To compare a sentence against a picture, people must at some stage represent the sentence and picture in a compatible mental format. Since it is the interpretation, not the direct perceptual characteristics, of the picture or object that is the basis for the verification, it is the interpretation that must be coded and compared against the picture.

In a typical Clark, _et al._, experiment, normal subjects are presented sentences and pictures and are required to judge whether the sentence is true or false with regard to the picture or are required to answer questions about the picture. The subject in this task typically is timed as he makes his response, and it is this response latency that is of interest.

Response latencies are considered to be a direct indication of the number of mental operations necessary in order to verify a sentence. These mental operations are considered to be independent and additive, the sum of which reflects the complexity of the sentence verified. Four stages are usually identified in the comprehension process: the sentence and then the picture (or vice versa) are encoded into abstract mental representations; they are then compared bit by bit to see if they match each other; a response is then produced; "true" if the two representations match, "false" if they do not.

The present experiments used perhaps the simplest application of the Clark, et al., experimental paradigm. Pictures were presented with two types of sentences: true affirmative (TA) sentences identified the picture correctly. Thus if the picture were "shoe", an example of a TA sentence was "this is a shoe." If the sentence were "this is a shoe" and the picture was that of a table, then such a sentence was considered a false affirmative (FA). In the TA condition, the subject would encode the picture of the shoe into a mental format as "shoe"; the sentence "this is a shoe" would be encoded into a comparable mental format. Upon comparison, the two would be judged to be the same and the appropriate response would be "true". In a FA condition, the picture might be "table" and it would be encoded as such; but if then the sentence accompanying it were, "this is a shoe", when the two were compared, the correct response would be "false", the two do not match. It is basic to the Clark, et al., hypothesis, that the "truth index" we carry around within our heads, is always set at "true". Thus, a FA sentence takes longer to verify than a TA sentence, because the subject must change his preset "truth index" to "false". Experiments with normal subjects have also included the conditions of the false negative (FN) and the true negative (TN). In repeated studies, Clark and his associates have determined that the order of difficulty is the following when response latencies are compared:

$$TA \angle FA \angle FN \angle TN$$

The models proposed by the Clark gourp correctly predicted that true negatives would take the most time; true affirmatives, the least amount of time.

How this model might apply to aphasic subjects raises interesting possiblities. Aphasic difficulties might well occur at any stage: at the beginning when the sentence and the picture are put into comparable mental formats, at the comparison stage when short term memory deficits might interfere, at the productive stages, and so forth. We have been interested in looking at what might be happening in the initial stages.

We designed a series of experiments, parts of three of which are being reported here. One was designed to investigate the response latencies for the verification of true affirmative (TA) and false affirmative (FA) sentences, the expectation being that TA's would generate shorter latencies of response as predicted by Clark's model. In another experiment, the hypothesis tested was that the aphasic subject's difficulty in sentence comprehension in a picture verification task would depend upon the mode of presentation of the picture and the sentence. Three presentation modes were used: (1) the sentence before the picture, (2) simultaneous presentation of the sentence and the picture, and (3) the sentence after the picture. In both of these experiments the subjects were asked to decide whether a picture presented visually or auditorily correctly identified a picture. They were to push a "true" button if it did and a "false" button if it did not.

Subjects for all experiments were 21 male aphasics distributed among the clinical types of fluent and nonfluent aphasia, exhibiting mild to severe impairment and ranging in age from 31 to 78 years. Mean age was 53.6 years. All subjects had sustained left CVA's, were right-handed premorbidly, and had no significant history of past cerebral dysfunction. Time post-onset ranged from 3 to 40 months, with a mean post-onset time of 13 months. Fifteen subjects were used in each of the experiments reported here; hence there was subject overlap, some patients appearing in more than one experiment.

Test words consisted of 150 words selected from the corpus of 450 Word Making Picture Cards. These words were divided into five lists of fifty words in a previous study by Leader (1973) who balanced the lists for mean frequency of occurrence, word and syllable length, and determined that they were of equal difficulty. From the five lists, two were chosen to be used as stimuli in the first study and three in the second study.

Individual words were randomly assigned true and false values. The true condition was the accurate verbal description of each item according to the name most commonly ascribed to it. For example, a picture of a dog would be followed by the sentence, "this is a dog." The false affirmative condition was established by randomly assigning each item of List A to an item of List B or C (when three lists were used). A picture of a dog might be followed by the sentence, "this is a sipper." No semantic or phonemic confusions were allowed to co-occur when a false stimulus item was used. For example, if the stimulus was "cat" the picture could not be "dog" or "cap". Final phonemes were, in so far as possible, equally distributed among the lists according to the principles outlined by Wylie's physiologic alphabet (see Mills, 1908).

As each of the original true items now also had a false condition, the result was 200 picture-sentence presentations for Experiment I and 300 in Experiment II. In all instances, the items were distributed over testing sessions so that no more than 50 items were presented in a session; with these restrictions, there were six experimental sessions per subject in Experiment II and four testing sessions in Experiment I.

In addition, we had training sessions with similarly balanced lists which assured that subjects were able to perform the tasks reuqired. A subject was considered to have met study criteria if he was able to correctly verify at least 20 of 25 items at least once. All subjects who qualified for the study met study criteria after one training session.

All selected Word-making cards were made into 35mm colored (Ectachrome) slides. The true and false affirmative sentences corresponding to the designated order of slide presentation were then recorded on cassette audio tapes. A General Electric Audio Visual Response System (AVR) was used to program the audio-visual presentation by the placement of inaudible clicks at selected intervals. All programming on the AVR can be done by pushing buttons in proper sequence thus allowing for simultaneous presentation of visual and auditory stimuli or any combination of visual or auditory stimuli. The AVR apparatus contained a five-choice response panel and it appropriately registered correct responses, the initiation of the slide advance, and the stopping of the audio tape so as to allow an indefinite amount of time for subject responses.

Each subject was then seated before the response panel and a small screen and instructed as to what he would hear and how he should respond. All responses were automatically recorded on an event recorder which registered a permanent, continuous ink tracing. A subject's response showed as a rightward displacement of a tracing corresponding to the buttons on the response panel. A displacement was also registered at sentence offset, and the distance between this offset and the subject's response was then measured.

Our third experiment was a confrontation naming task. The stimuli used were slides corresponding to the original two lists which the subjects were now asked to name. All subject responses were tape recorded. The scoring method employed in the Porch Index of Communicative Ability (1971) was used.

Our equipment, however, had an inherent "lag" problem. It possessed a means of recording responses, but no automatic system for recording a point against which reaction times could be measured. In the first study this point was at the offset of the auditory stimulus and in the second study varied according to the presentation schedule. A system was devised to enter a measuring reference point, but it depended upon the experimenter depressing a switch at the offset of the auditory or visual stimuli after which the subject was required to respond. Reaction time, then, included a constant (k), the experimenter's reaction time. That is, the time from the offset of the audio or visual stimulus to the depression of the indicator switch by the experimenter. We do not consider this problem to be crucial since the issue was the comparison of the response time in the conditions under study and not a subject's absolute reaction time. We are now in the process of verifying the pattern of responses under more exacting conditions and have not found exceptions to the more relative measures reported here.

For the sentence verification tasks, only the latencies for correct responses were analyzed. As Slobin (1966) has indicated, "this procedure seems justified in that the relevant dependent variable is the time required to comprehend sentences; it is not all clear what possible meaning the time required for miscomprehensions may have."

The verification latencies for correct responses to both true and false affirmative sentences over all four experimental sessions for all subjects in Experiment I ranged from .1523 to 7.5 seconds, with a median response time of .9375 seconds. Because of these skewed reaction times, median values were employed as a measure of central tendency rather than the mean (Woodward and Schlosberg, 1955).

The median response latency for the true affirmative condition was .7813 and .9375 for the false affirmative condition. Results of the Wilcoxon Matched Pairs Signed Ranks Test (Siegel, 1956) indicate that true affirmatives were verified significantly faster than false affirmatives ($T = 4.5$; $p < .01$). Thus, as rpedicted, overall performance showed true affirmatives to be verified faster than false affirmatives. Clark (1969) has postulated the concept of "congruence" to account for this phenomenon with normal subjects. This principle states that "two underlying representations can be compared only for identity and there must be extra operations in case there is a mismatch." Congruence is, therefore, immediately present upon the mental representation of a picture and sentence in a true affirmative condition, whereas additional operations are necessary in order to achieve congruence in the false affirmative condition. Response latencies, then, ought to be reflections of the mental operations necessary in order to render picture and sentence "congruent". Furthermore, as Carpenter and Just (1975) have noted, "congruence in the true affirmative case implains why it is easier to process than the false affirmative case". Overall, this hypothesis is borne out in the present study.

We had also predicted that response latencies of aphasic subjects would be significantly different for the three presentation modes of Experiment II. This was not confirmed and is in contrast to the findings of Clark and Chase (1972), although their experiment and stimuli were certainly different from those used here. In their experiments, non-aphasic subjects judged sentence-picture displays under conditions in which they (1) viewed the sentence first and then the picture; and (2) viewed the picture first and then the sentence. For all subjects the picture first condition was found to be more difficult. Thus, because the picture first pattern of processing took longer, an extra mental operation was assumed to be required. It was hypothsized that when the subjects view the sentence first, all subsequent encoding is contingent upon the sentence. That is, if a sentence describing a picture is presented prior to the picture, that sentence will determine the initial encoding or interpretation of that picture. Therefore, only one comparison operation is required: the subject must decide whether this picture is a verification of the preceding sentence. When the picture is presented first, a variety of sentence representations could initially be ascribed to the picture; then the subjects must determine whether or not the experimental sentence matches what they have thought the picture represents. Thus, there is a mental operation added which involves an identify check of the initial representaiton of what the subject thought the picture was and the subsequent sentence. There is then a step to determine whether or not the sentence and the picture "match".

The results of our Experiment II, then, indicated that the aphasic subjects were not utilizing mental operations such as those ascribed above. The results indicated that there was no significant difference obtained in favor of any condition in either the true affirmative or false affirmative case. Thus, for aphasic subjects in this experiment, whether the picture occurred before the sentence, after the sentence, or simultaneously with the sentence, no significant differences accrued.

We speculated that the reasons for this might be attributed to a basic deficit observed in most aphasic subjects: that of impairment in the retrieval of the name of specific items. The information processing model assumes that the individual involved in a sentence verification task recalls the name of the picture. The main focus of the model is on the mental operations that compare the sentence and picture representations. The model postulates that the corresponding constituents from the two representations are retrieved and compared. The number of thesefind-and-compare operations is assumed to be the primary determinant of the pattern of verification latencies. Due to the aphasic subject's failure of naming on confrontation, a find-and-compare operation may not have been used. In all three presentation modes in Experiment II, the aphasic subject seemed to immediately compare the constituents of the sentence and picture without engaging in a process which involved retrieval of the name of the item. Thus, the similar latency of response exhibited in the three conditions (i.e., sentence before the picture, simultaneous presentation of the sentence and picture, sentence after the picture) may be the result of the absence of an essential mental operation, retrieving the name of the picture.

Consequently, we hypothesized that the better a subject's demonstrated word-retireval ability, the greater the difference between verification latencies for the true and false conditions should be. Or to put it another way, as word-retrieval difficulties increase, less difference between true affirmative and false affirmative sentences should be observed. We hypothesized that although true affirmatives would be verified faster than false affirmatives, the difference between the two conditions would be greater, the better an aphasic's word-finding ability. Using a Spearman Rank Correlation Coefficient (Siegel, 1956), a significant correlation ($r_s = .82$; $p < .01$) was found between the difference in response latencies for the true and false affirmative conditions and performance on the confrontation naming task. In other words, those subjects who demonstrated the greatest differences between their response times for the true affirmative and false affirmative conditions were those with the highest (hence "better") PICA naming scores, and vice versa.

Our results give some suggestion that the strategies an aphasic subject brings to a sentence verification task result in a different outcome than that of the normal subject. One possibility to explore is the effect of a short-term memory deficit operating to impair the picture-sentence comparison operations. However, we did find out patients able to perform our task with relative ease; error responses were remarkably low, and, for this paper we have chosen to disregard error responses. Hence, in spite of relatively increased response latencies (when compared to normals), the low error rates indicate that the aphasic subjects were able to hold on to the representations of the picture and sentence long enough to compare them.

The fact that the true affirmative and false affirmative differences held, as in the studies with normals, suggests that meaning at the lexical level is preserved with out aphasic subjects. Our results seem to suggest that the aphasic subject can make the mental representations necessary for comparison, has a short-term memory capacity long enough to allow such comparison, but .... what??? Luria (1966) has described aphasic patients' difficulties in making either/or comparisons and has concluded that perhaps this results in "strategy deficiencies". We are continuing to explore these factors. What we have repeatedly confirmed in these studies is that the technique of sentence verification has great potency as a research tool for exploring comprehension deficits in aphasia. We confirm the accumulating evidence that comprehension is indeed a multi-faceted phenomenon; the effects of aphasia on such abilities is only incompletely known.

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