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Processing of Ambiguous Sentences in Schizophrenics

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Abstract

Cognitive deficits of schizophrenic subjects were delineated in terms of their eye-tracking patterns and response-selection patterns when they were requested to read short complex, ambiguous sentences and select answers from among prepared choices responding to questions raised beforehand in relation to meaning of the sentences. The results indicate that: (1) the selection of responses made by the patients was not random, but rather was coupled with analyses of sentence meanings, (2) the delayed responses made by the patients were caused by prolonged post-read-through periods due to confusion in meaning analyses, and (3) the patients' confusion with meaning analyses had already begun in the initial read-through period which was not delayed.

Introduction

On the basis of our finding that schizophrenic patients' characteristic behavioral patterns and cognition-related problems tend to be manifested clearly in the processing of ambiguous information, we attempted to elucidate the features of sentence processing in schizophrenics, using the results of judgment and the tracing of fixation points during the reading of polysemous and ambiguous short sentences. Some of these results have already been published.[2)] They can be summarized as follows: (1) Among the patients, confusion develops in the analysis of polysemous and ambiguous sentences. The patients do not resolve the ambiguity of the sentences in terms of the correlation of word meanings; instead they tend to adopt the method of analyzing normal and simple sentences; and (2) the response time of these patients is significantly longer than that of normal subjects. The reason for this is that, although there is no difference in the initial read-through time between the two groups, normal subjects require less response time after the initial read-through. The present article is the second in a series and reports on: (1) the relationship between the response selection pattern and fixation points as examined through analysis of the tracing of fixation points within the time from the completion of the initial read-through to the time of response, and (2) the major characteristics in the early stages of sentence processing as determined through the analysis of the fixation point tracing within the initial read-through period, which was not delayed even among patients.

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Subjects and Methods

Since the subjects and methods used in this study are the same as those employed in the previous study, only an outline is presented here.

Subjects

The patients participating in this study were 17 outpatients who satisfied the diagnostic criteria of schizophrenic disorders as defined by DSM-III-R. Most of the 17 patients, 10 males and 7 females, were relatively stable in terms of symptoms. Their ages ranged from 23 to 60 (average age, 42.7±10.9 SD). As controls, 10 healthy subjects, 8 males and 2 females, were also tested. The ages of the control group ranged from 20 to 25, with an average age of 22.4±1.7 SD.

Methods

As stimuli, we used ambiguous sentences such as "Arnold hit Bill who shot Charley with a gun," or "Arnold hit Bill who was watching Charley with binoculars." The basic sentence pattern of these sentences in Japanese is as follows: (person 1) wa (noun) de (person 2) wo (verb 1) shita (person 3) wo (verb 2) shita. Here, wa, de, wo, and shita in Japanese represent postpositional words functioning as auxiliaries to main words (wa, de, and wo) and as a conjugation inflectional suffix (shita). Wa comes after the subject, de comes after a word which shows the means by which the action of the verb is accomplished, and wo comes after the word which functions as the grammatical object. During the test, the question "Who held the gun (or binoculars)?" was asked, and the stimulus sentence was presented to the subjects on a CRT display while records of the tracing of the fixation points were made by means of an eye-mark recorder. The subjects were asked to respond to the question with either "Arnold," "Bill" or "Charley" by pushing the button that represented the person of their choice.

As described in the previous report, there were six stimulus sentences containing a variable correlation of meaning among verb 1, verb 2, and noun. In the present report, we discuss the results obtained by employing two types of polysemous and ambiguous sentence patterns as follows.

Pattern examples:
Sentence A:

(Arnold) wa (gun) de (Charley) wo (shot) shita (Bill) wo (hit) shita.
(Arnold hit Bill who shot Charley with a gun.)
(Arnold) wa (binoculars) de (Charley) wo (watching) shita (Bill) wo (hit) shita.
(Arnold hit Bill who was watching Charley with binoculars.)

Sentence B:

(Arnold) wa (gun) de (Charley) wo (hit) shita (Bill) wo (shot) shita.
(Arnold shot Bill who hit Charley with a gun.)
(Arnold) wa (binoculars) de (Charley) wo (hit) shita (Bill) wo (watching) shita.
(Arnold was watching Bill who hit Charley with binoculars.)

In both patterns A and B, the verb for the inserted clause (verb 1), the verb of the

main clause (verb 2), and the noun are related in terms of meaning, and the answer to the aforementioned question can be either Arnold or Bill; thus, the sentences are polysemous and ambiguous.
In the evaluation of the relationship between the response selection pattern and the tracing of the fixation points, the number of stops made when the fixation point returns to each clause is counted. Only when the duration of fixation is longer than 0.2 sec is the stop counted.

In the current study, the visual angle of each character is 0.8° and several characters are considered to be recognized within a visual field. Therefore, when the stimulus sentences are divided into clauses, it is sometimes difficult to accurately determine which clauses are being fixated upon. However, the fixation clause was automatically determined on the basis of the location of the fixation point. The definition of the initial read-through time and that of the post-read-through time were determined to be as follows: The initial read-through time is the period until the fixation point reaches the last word for the first time, and the post-read-through time is the time between the completion of the initial reading and the pressing of the button.

Experimental Results

(1) Distribution of answers of sentence patterns A and B

In both sentence patterns (A and B), the noun, the verb of the inserted clause (verb 1), and the verb of the main clause (verb 2) are related in terms of meaning. In pattern A, the relationship between the meaning of the noun and the verb of the inserted clause is strong, but the relationship between the noun and the verb of the main clause is relatively weak. Accordingly, the normal subjects most often selected the subject of the inserted clause, doing so 90% of the response in the case of the word "gun" and 93% of the response for "binoculars." In the schizophrenic patients, however, the selection of the executor of the action of the main clause was relatively more frequent, i.e., 28% (gun) and 44% (binoculars). A significant difference was thus observed between the two groups (gun: $P<0.05$, binoculars: $P<0.01$).

The relationship between the noun and verb is reversed in the case of sentence pattern B as compared with that in pattern A. The percentages of selection on the subjects of main clause in the normal controls and patients were 80%, 86% (gun) and 77%, 49% (binoculars), respectively. The subject of the main clause was selected by both groups in many cases; thus, no statistical differences were observed.

(2) Number of backtrackings during post-read-through period

Table 1 shows the number of backtrackings for each clause during the post-read-through period of patterns A and B. When the noun was the gun in the case of sentence pattern A, the total numbers were 0.77 and 1.72 for normal controls and patients, respectively; thus, the backtracking to the executor of the action of the main clause was significantly higher in the patients than in the controls. However, there were no differences between the two groups with regard to sentence pattern B when the noun was the gun.

When the noun was the binoculars in the case of sentence pattern A, the total number of backtrackings was 1.91 for normal controls and 3.4 for patients. This difference was statistically significant; however, there was no difference in the backtracking for sentence pattern B. Furthermore, the number of backtrackings to the main subject was higher for both sentence patterns A and B for the patient group (A: normal controls, 0.68, patients, 1.89; B: normal controls, 1.05, patients, 1.91). Differences in responses between the two tested groups were particularly notable with regard to those responses to sentence pattern A.

(3) Number of backtrackings during initial read-through period

The patterns in the analysis of sentence meaning within the initial read-through period were studied through analysis of the tracing of the fixation point, as well. Table 2 shows the number of backtrackings to each clause of sentence patterns A and B within the initial read-through period. In the case where the noun was the gun, for sentence pattern A, the number of backtrackings for patients was 1.53, higher than 0.64 for normal controls. Furthermore, backtrackings to the subject of the main clause were more frequent for the patients (0.77) than for the normal controls (0.36). For sentence pattern B, except for the object person in the inserted clause, there were no differences in the number of backtrackings.

However, when the noun was the binoculars, the total number of backtrackings was high in both sentence patterns (A and B) for the patient group (A: normal controls, 0.86, patients, 1.86; B: normal controls, 0.62, patients, 1.97). For pattern B, in which no difference in the response selection was found between the two groups, the number of backtrackings to the main subject was higher for patients (1.11) than for normal controls (0.29).

Discussion

The relationship of the meaning between the noun and the verb of the inserted clause in sentence pattern A is strong, while that between the noun and the verb of the main clause is relatively weak; therefore, the sentence in Japanese can be parsed at the point before the noun. Thus, we expected that the selection of the subject of the inserted clause would be frequent. As shown in the response selection pattern, in the case of the normal controls, the selection of the subject of the inserted clause was quite high. With regard to the patient group, however, the selection of the subject of the main clause was relatively frequent. Therefore, this sentence pattern appears to be more ambiguous to the patients.

In the case of sentence pattern B, the relationship between the noun and the verb is reversed as compared with that of pattern A; thus, it was predicted that the sentence in Japanese would tend to be parsed after the noun, and that the subject of the main clause would frequently be selected as the answer. From the results of the current study, we can infer that the location of the verb, which has a relatively strong relationship with the noun, and the sentence structure seem to affect the level of the ambiguity for the patients. It is also speculated that schizophrenic patients judge the meaning of complex sentences

such as those employed in the present study, parsing them perseverately as usual simply structured sentences, instead of analyzing them according to relationships between word meanings.

Patients frequently selected the subject of the main clause as the answer with regard to sentence pattern A, and from the results of the actual analysis, it was found that the fixation points frequently returned to the subject of the main clause after the initial read-through period. This confirms that the selection of responses by many of the patients was not random. The post-read-through delay, which caused the delay in response exhibited by these patients. can be attributed to confusion regarding the analysis of meaning. The results obtained by the current study support the hypothesis proposed by McConkie[1] and Rayner[3], whereby the charting of fixation recording is useful in the understanding of the processing of sentences.

As described in the previous report, there were no differences with regard to the read-through time between the normal controls and the patients. Based on this finding, the patients were considered to process sentences only at a shallow level; thus, it was also speculated that the number of backtrackings within the initial read-through period was small. However, the results of the analysis of the fixation point within the initial read-through period showed that the number of backtrackings was larger within the read-through period, and the number of backtrackings to the subject of the main clause was larger in the patients than in the controls. Judging from these results, we can speculate that, even among schizophrenic patients, the processing of meaning is begun at a certain depth during the initial read-through period, thus already producing confusion in the early processing stage.

References

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Table 1. Number of backtrackings in post-read-through period
[Mean (S.D.)]

sentence A	gun		binoculars	
	controls	**patients**	**controls**	**patients**
subject of main clause	0.77(1.34)	1.72(1.52)*	0.68(0.72)	1.89(1.68)*
noun	0.91(0.92)	0.78(1.04)	0.59(0.80)	0.91(1.34)
object of inserted clause	0.27(0.46)	0.72(1.14)*	0.14(0.35)	0.40(0.78)
verb 1	0.27(0.63)	0.28(0.55)	0.50(1.10)	0.11(0.40)
subject of inserted clause	0.05(0.21)	0.07(0.26)	0	0.09(0.28)
totals	2.27(1.96)	3.56(3.33)	1.91(1.66)	3.40(2.96)
		**p<0.05		*p<0.05

sentence B				
	controls	**patients**	**controls**	**patients**
subject of main clause	1.32(1.34)	2.00(1.41)	1.05(0.79)	1.91(2.12)*
noun	0.82(1.05)	0.67(1.03)	0.55(0.60)	0.59(0.86)
object of inserted clause	0.32(0.48)	0.60(1.11)	0.46(0.74)	0.50(1.31)
verb 1	0.14(0.35)	0.45(0.77)*	0.36(0.95)	0.24(0.43)
subject of inserted clause	0.18(0.50)	0.14(0.35)	0.23(0.53)	0.09(0.38)
totals	2.77(1.88)	3.88(2.93)	2.64(1.99)	3.32(3.36)
		*p<0.05		*p<0.05

Table 2. Number of backtrackings in initial read-through period
[Mean (S.D.)]

sentence A	gun		binoculars	
	controls	patients	controls	patients
subject of main clause	0.36(0.58)	0.77(0.97)*	0.36(0.79)	0.89(1.08)
noun	0.23(0.43)	0.35(0.69)	0.23(0.43)	0.66(1.11)*
object of inserted clause	0 (0)	0.26(0.49)	0.09(0.29)	0.26(0.74)
verb 1	0 (0)	0.11(0.32)	0.18(0.50)	0.06(0.24)
subject of inserted clause	0.05(0.21)	0.05(0.21)	0	0
totals	0.64(0.79)	1.53(1.94)*	0.86(1.17)	1.86(2.34)*
		*p<0.05		*p<0.05

sentence B				
	controls	patients	controls	patients
subject of main clause	0.59(0.96)	0.71(0.97)	0.29(0.73)	1.11(1.64)*
noun	0.23(0.53)	0.21(0.57)	0.19(0.40)	0.51(0.95)
object of inserted clause	0.05(0.21)	0.29(0.64)*	0.10(0.44)	0.31(0.58)
verb 1	0.14(0.47)	0.17(0.49)	0.05(0.22)	0.03(0.17)
subject of inserted clause	0 (0)	0.02(0.15)	0	0
totals	1.00(1.31)	1.40(1.72)	0.62(1.12)	1.97(2.38)*
		*p<0.05		*p<0.05