The correlation between word order and the position of syntactic markers: Time course analysis of sentence production¹

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The temporal patterns of utterances obtained by Nagata (1981) for the three types of syntactic structures, a VX (or VSO) type of language with prepositional markers (VX-Pre), VX with postpositional markers (VX-Post), and a type for which word order and the position of markers were randomly placed (Mixed), were analyzed by a latency measurement apparatus to relate the duration of pause time to the processing of the three types of structures. The results showed that: (1) differing patterns of time course for the three groups were found, indicating the presence of different processing units; (2) while greater production time for VX-Post and Mixed derived primarily from pause duration among constituents of a sentence, it tended to derive also from the production duration of the constituents. The difference in production time as an index of processing load is interpreted as reflecting a varying degree of syntactic and/or semantic processing involved in organizing the sentences.

Key words: correlation, word order, preposition, postposition, Universal, processing load, time course analysis.

A universal concerning the basic word order and the position of syntactic markers was suggested by Greenberg (1963) based on a distributional analysis. His Universal three states that languages with dominant VSO order are always prepositional. Nagata (1981) attempted to explain the universal from a processing viewpoint. He hypothesized that (1) a congruent ordering of word order and syntactic markers imposes less of a cognitive processing load upon subjects when they are required to process a given syntactic structure than when given an incongruent one, and (2) differences in processing load is reflected in the time needed to complete

sentences with different syntactic structures. He showed that a congruent VX (or VSO) word order combined with preposition (VX-Pre) could be described faster than an incongruent VX word order combined with postposition (VX-Post). The former type of syntactic structure also was described faster than the third type of syntax (Mixed) in which word order and the position of markers were randomized. VX-Post and Mixed did not differ from each other. These results were interpreted as indicating that psychological mechanisms actually underlie the forementioned universal.

The dependent measures used in the Nagata study were reaction time (RT) and description time (DT). RT was defined as the time from the onset of the presentation of a pictorial situation to the first syllable of a subject's production of a sentence, and DT was the time from the same point to the last syllable of a description. Although an overall difference of processing load during the production can be inferred, it must be mentioned that DT is not adequate for investigating the exact nature of the time course of the description.

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The time course of description can be followed through the use of a latency measurement apparatus which measures both the passage of time during the production of the constituents of a sentence and the pause time between them. It has been confirmed that there is a positive correlation between pause time during the speech sequence and the level of processing required by the task (Goldman-Eisler, 1968; Taylor, 1969; Rochester, 1973; Kowal, O'Connell, & Savin, 1975; Reich, 1980). Thus this study attempts to analyze the temporal patterns of DT obtained in the Nagata study by using a latency measurement apparatus. Its purpose is to relate the duration of pause time to the processing of the three levels of syntactic complexity and to determine the degree of processing load imposed on subjects in a task of sentence production.

Method

Procedure

The data analyzed in this study were those gathered in the previous study (Nagata, 1981). A brief summary of the method is given here.

Thirty Japanese students served as subjects. Three groups of 10 subjects were each required to learn pre-assigned syntactic structures. An artificial syntax was used, where the content words comprising the sentences were actual Japanese words but the function words were nonsense monosyllables. The first group (VX-Pre) learned the VX-word order with prepositions; the second (VX-Post) learned the VX word order with postpositions; the third learned the structure where word order and adposition (pre- and postposition) features were randomly mixed. The reason why the only VX-word order type of language was employed was to minimize as much as possible the effect of the subjects' prior specific linguistic experience. (Japanese is a XV type of language.) The sentences consisted of four

words describing objects, three adpositional markers and a single verb. The subjects acquired their pre-assigned syntax under identical reference situations. The reference situations consisted of four object classes, ACTOR, VEHICLE, PLACE and BAGGAGE, along with one ACTION relation. Only one instance, *man*, was prepared for ACTOR. Three instances, *car*, *bicycle* and *motorcycle*, were assigned to the class VEHICLE. For PLACE two instances, *hospital* and *church*, were used. There were four different instances, *clock*, *bag*, *television set*, and *flowers* for the class BAGGAGE. The ACTION relations were defined by two alternatives, *went* and *came back*. The object class PLACE was involved in one of the two semantic relations, TO and FROM. For the object class BAGGAGE two semantic relations, WITH and WITHOUT, were used. In this manner the adpositional markers and verb defined the semantic relations into which the object words entered. A variety of reference situations were constructed by combining the members of the different classes.

The reference situations were displayed pictorially by a projector while sentences describing them were delivered auditorily. Each slide was projected for 15 s with an ISI of 5 s. There were study phases during which six slides were presented and subjects were required to learn the pre-assigned syntactic structure. During the test phases, subjects were required to describe, as quickly as they could, each of the four situations by using the syntax they learned during the study phases. The responses given by each subject were tape-recorded.

Data Analysis

Analysis was made for the criterion trial on which a subject could describe correctly all four test situations. The tape-recorded responses were analyzed through the use of the Latency Measurement Apparatus (TKK). The sensitivity of the

apparatus was kept at a maximum to ensure that as much phonetic information as possible was transformed into phonation and pause time durations. The onset of the shutter of the projector initiated the operation of the apparatus. The time course of responses was analyzed in 10 milliseconds and printed out.

The data obtained in this manner showed two types of time durations, on and off. On-durations or phonation were produced by the uttering of words, adpositional markers and other irrelevant utterances (eg., eh, ah). Off-durations were produced by pauses among the constituents of a sentence. They could also occur within a single word, since the apparatus analyzed as off-durations both the duration of low phonetic energy between syllables of a word and the duration produced by the phonetic characteristics such as stop consonants within a word. However, in this study on-durations were defined as both the time durations for producing the relevant words comprising a sentence and off-durations occurring within a single relevant word, while off-durations were defined as time durations produced by unfilled pauses, filled pauses (eg., eh, ah), false starts, etc., that is, all phonation excepting the relevant words.

Since, for each subject, each test phase contained four situations, four time course responses were obtained. The mean of the four responses was employed as the dependent measure for each subject.

Results

Time Course of Production

Figure 1 shows the on- and off-duration results for the three groups. The time duration represented by an open circle indicates off-duration. Close inspection of Fig. 1 reveals that in uttering a sentence there is a different rhythmic pattern for the three groups. Specifically, for VX-Pre a primary pause was made after uttering a BAGGAGE word. In other words,

subjects in VX-Pre tended to produce the first four words (Verb, Subject, BAGGAGE marker, and BAGGAGE) at a breath, followed by a pause with some duration, which in turn was followed by producing two units of prepositional phrases. Thus the utterances appear to consist of two processing units of production.

For VX-Post, however, utterances seem

Fig. 1. Time course of production. V: Verb; Sub.: Subject; BAG: BAGGAGE; BAGm: BAGGAGE marker; PLA: PLACE; PLAm: PLACE marker; VEH: VEHICLE; VEHm: VEHICLE marker.

Table 1
Five types of time duration of production (in second)

Group		RT	DT	Subject+Verb	Adpositional relation			
					Adposition+ pause+ word			
VX-Pre	Mean	1.14	6.25	.97	.51	.89	1.43	2.45
	SD	.14	.92	.18	.07	.42	.22	.78
VX-Post	Mean	1.31	7.41	1.10	.51	1.15	1.68	2.88
	SD	.30	1.03	.13	.15	.23	.18	.87
Mixed	Mean	1.75	7.87	1.14	.58	1.49	1.68	2.98
	SD	.40	1.30	.11	.08	.46	.25	.95

to consist of four processing units, since rather similar durations of pauses were found following Subject, BAGGAGE marker, and PLACE marker. The greatest reaction time (RT) was obtained for the Mixed group. The processing unit appears to consist of two or three processing units, since a primary pause was made after the Verb, and a secondary one seemed to fall after the Subject.

Five Types of Production Time Duration

Table 1 shows time durations decomposed into five types: (1) RT, (2) description time (DT), which was defined (differently from Nagata, 1981) as the time from the first syllable of a sentence to the last one of it, (3) Subject + Verb duration, (4) adpositional relation (markers + pauses + object words) duration, and (5) any other pause duration. Table 1 shows the mean duration for each group.

RT. A one-way ANOVA showed a significant main effect due to groups, $F(2,27)=9.69$, $p<.001$. Ryan's technique revealed that Mixed was significantly slower in RT than VX-Pre, $t(27)=4.31$, $p<.001$, and than VX-Post, $t(27)=3.11$, $p<.01$. However, no difference was found between the latter two groups. These results were the same as those of Nagata (1981).

DT. There was a significant difference among the groups, $F(2,27)=5.18$, $p<.01$. VX-Pre was faster in DT than VX-Post, $t(27)=5.18$, $p<.01$, and than Mixed,

$t(27)=3.13$, $p<.01$.

Subject+Verb duration. The overall difference due to groups was significant, $F(2,27)=3.74$, $p<.05$. Although Mixed used a longer duration than VX-Pre to produce Subject and Verb combined, $t(27)=2.57$, $p<.05$, there was no difference either between VX-Pre and VX-Post nor between VX-Post and Mixed.

Adpositional relation. This measure concerns the time duration needed to produce three adpositional markers and their corresponding object class words, BAGGAGE, PLACE, VEHICLE and pause durations between them. This measurement was made in order to examine the possible effects of the three syntactic structures on an integration of adpositional relations into which object words entered. A two-way ANOVA with repeated measures on one factor yielded a significant main effect due to groups, $F(2,27)=9.99$, $p<.01$, and adpositional relation, $F(2,54)=109.29$, $p<.001$, and a significant interaction between the two, $F(4,54)=2.57$, $p<.05$. Pause duration was shorter in VX-Pre than in VX-Post, $t(27)=2.11$, $p<.05$, and than in Mixed, $t(27)=4.88$, $p<.001$, and VX-Post was shorter than Mixed, $t(27)=2.76$, $p<.05$. VX-Pre tended to need less time to produce object class words than VX-Post, $t(27)=2.03$, $.05<p<.10$, and than Mixed, $t(27)=2.03$, $.05<p<.10$.

Other pauses. A one-way ANOVA showed that no significant difference was found among the three groups, although

an expected increasing tendency in the duration from VX-Pre through VX-Post to Mixed was observed.

Discussion

A discrepancy between the data obtained in this study and those in the previous one (Nagata, 1981) may be noted. Particularly, the RTs in this study were about .2 s shorter than those in the previous study. This discrepancy would come from the difference in measuring procedure between the two studies. In the previous study RT was measured by the three raters, while in this study the latency measurement apparatus was employed. It can be considered that the RT data in the previous study should have contained as a separate constituent the reaction time needed for the raters to detect the first syllable of a sentence and to execute responses. This extra time was reflected in the increase in RT in the previous study. It should, however, be mentioned that the *SDs* between the two studies were almost the same, indicating the reliability of the measurement taken by the raters.

Nagata (1981) assumed that the time for producing the object words and marker elements did not differ among the three groups, and that differing DT found among the groups came primarily from the pause duration. However, a difference in DT tended to derive also from the time duration needed to produce the words. In other words, as compared with subjects in VX-Pre a considerably greater processing load was imposed on those in VX-Post and Mixed even when they were producing words. This finding requires a revision of the above assumption. Previous research on the cognitive function of pause in a temporal sequence of speech production has focused primarily on pause itself excluding an functional analysis of phonation duration. (See Rochester, 1973 for a review on pause research.) The

present results suggest that phonation duration cannot be ignored in an analysis of speech planning and its execution.

O'Connell and Kowal (1972) argued that the unfilled pause has a syntactic and semantic function. The syntactic function concerns perceptual structuring of strings of words in accord with the grammatical structure and the semantic function concerns an active search for single words. Since, in the present experiment, a time course analysis of productions was made on the criterion trial, it seems valid to assume that the linguistic level of subjects did not differ among the three groups. Thus VX-Post would not differ from VX-Pre in semantic function in searching and selecting lexical items at the transition points. Moreover, the direction of visual scanning among the objects in the reference situation was the same for the two groups and the number of choice alternatives from the object classes was fixed. Hence the difference obtained in the temporal patterns and in DT for these two groups could be said to derive primarily from the processing load carried by subjects in syntactically organizing a VX word order with postpositional markers. For Mixed, on the other hand, semantic as well as syntactic factors appear to be involved. The slowest RT obtained for Mixed can be explained in terms of the greater semantic load imposed when subjects had to choose one of the two alternatives from the object class PLACE before organizing the linguistic string that followed. Hence these two factors, syntax and semantics, might have governed the production of the three types of processing units used in organizing and executing utterances (See Fig. 1.). For pause influencers, Rochester (1973) has listed cognitive, affective-states, predispositional anxiety, situational anxiety and social interactional variables. However, these variables, excepting the cognitive one, could be irrelevant in the interpretation of the results of this study.

As to the processing of prepositional phrases one related finding must be noted. McNeill (1979) analyzed speech dysfluencies in utterances and found that in 11 out of 14 prepositional phrases, the preposition was processed with its antecedent rather than with the rest of the phrase. That finding is clearly inconsistent with the results obtained in this study where prepositions tended to be produced together with the words that followed them rather than with those that preceded them (cf. VX-Pre in Fig. 1). The marked difference between the two studies, however, lies in the fact that the corpus McNeill analyzed was a two-person free conversation, while the corpus analyzed here was a quick description of the reference situation comprised of a fixed and small number of objects and relations. Also, the different number of lexical choices and the different task required for the two studies could account for the varying results.

Regarding the analysis of temporal patterns of utterances by using a latency measurement apparatus in this study, it should be noted that most of the previous studies on pause have been performed on the basis of on-off speech patterns oscillographically traced. It should be mentioned, however, that since speech events are acoustically continuous in time, one cannot measure graphically recorded temporal patterns to the nearest millisecond. It seems thus unreasonable to argue that two different instrumentations would produce different patterns of results.

In conclusion, an analysis of the time course of speech productions made of the VX-Pre, VX-Post and Mixed groups showed that while the greater processing load obtained for the latter two groups

derived primarily from pause duration among the constituents, it tended to derive also from the production duration of such constituents. The differences in load can be interpreted as reflecting a varying degree of syntactic and/or semantic processing involved in organizing syntactic structures.

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