

Articulability of Two Consecutive Morae in Japanese Speech Production: Evidence from Sound Exchange Errors in Spontaneous Speech

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ABSTRACT

In the present study, we would like to discuss how the articulability of two consecutive morae plays an important role in speech production. Our assumption is based on the analysis of Japanese sound exchange error data which are collected from the spontaneous speech of adults and infants. Three experiments were also carried out to confirm the reality of a unit of two consecutive morae. Phonological/Phonetic characteristics were shown through the results of experiments and related observations.

1. INTRODUCTION

Since Garrett (1975), research in speech errors has made great progress and tended to focus on specific processes and their mechanisms in sentence production. Research on phonological components in the models has developed since the connectionist era, when comparative studies between slot filler models and interactive activation models were made. There are, however, serious limitations in the scope of current work on speech errors, the most notable of which is that reported data has been collected exclusively from English and a few related languages. Accordingly, proposed models and hypotheses have been based on an insufficiently broad data base. In this paper, we would like to present observations from speech errors in Japanese, a mora-timed, pitch accent language, which is different from any language on which observations of speech errors have been published.

2. DATA -SOUND EXCHANGE ERRORS-

The main database used in this study consists of about 3200 adult speech errors collected by one of the authors(Terao). It should be noted that the most common

phonological error is substitution for another element. (e.g. *monogane uta gassen*, correct form is monomane (mimicry), in which /m/ is substituted for /g/ or /ma/ is substituted for /ga/. Terao 1992) However, sound exchange errors, in which two phonological elements are exchanged, have attracted a lot of attentions in the previous researches although they occur rarely in spontaneous speech. (Garrett 1975) There are 114 instances of adult sound exchanges in Terao's corpus, accounting for 3.6% of the total.

Typical examples of sound exchange errors are given in the following, with the correct forms shown in the parentheses.

(1) a. bootakabito

(bootakatobi (a pole jump))

b. kaiken (kankei (relationship))

(2) a.jakan pappu

(japan-kappu (the Japan Cup))

b. Hataka (Hakata (a place name))

(3) kentakusago (sentakukago (laundry basket))

(4) mitemo (mitome (admitting))

(5) mome (memo (memorandum))

The examples in (1) represent errors in which one mora is exchanged with another mora. In (1b), it appears that the vocal element /i/ and consonantal element /n/ (moraic nasal) are exchanged. It should be noted that this kind of phonological error is said to be extremely rare in English. Assuming the example is not a segmental error but a moraic error, this kind of example seems to provide strong evidence that moraic units play an important role in Japanese phonological processing. It is also to be noted that whole syllable exchange errors rarely occur in English. We think that the simplicity of the Japanese syllable structure allows for such errors in Japanese. We should consider that the number of consonants which can follow the main vowel in a Japanese syllable is extremely limited, and so most of the

syllabic units have a very simple CV structure. The examples in (2) represent errors in which two consonants are exchanged but two identical vowels accompany them. They are ambiguous in classification in that they can be interpreted either as exchanges of consonants or as moraic exchanges. We must say that we have no way to distinguish these two types of errors automatically, but it is necessary to develop a model which can easily classify this ambiguous type of error, for this type of exchange is the most common, accounting for 65 instances (57%) of the total exchanges. The examples in (3) represent errors in which two consonants are exchanged. Since their accompanying vowels are not identical, it is impossible to consider them cases of moraic exchange. This type of error is relatively rare, having only 15 instances (13.2%). The examples in (4) and (5) are errors in which two vowels are exchanged. The examples in (5) have two identical consonants accompanying each of the vowels. These types of errors in which vowels are exchanged are very rare: only 8 instances (7%) were found in the corpus. Apparently, that rarity seems to reflect the different status of vowels and consonants in the phonological component.

3. DISCUSSION OF EXCHANGE ERRORS

The most obvious finding in these data is that the ambiguous exchanges shown in (2) are highly predominant. Although they can be interpreted as consonant exchanges, we cannot ignore the role of vowels in causing the exchange. Thus, it seems appropriate to say that the moraic unit should be taken into account when we try to make a model of the phonological component in Japanese. If we adopt a mora-based assumption, we can group together examples of the types illustrated by (1), (2) and (5). The assumption then account for a sum of 93 instances, or 82% of the total sound exchanges as shown in Table 1.

Table 1: Units exchanged in errors (N=114)

mora	26 (22.8%)	type (1)
consonant or mora	65 (57%)	type (2)
consonant	15 (13.2%)	type (3)
vowel	6 (5.3%)	type (4)
vowel or mora	2 (1.7%)	type (5)

The mora-based assumption above may also be supported by the following analysis. We measured the phonological

similarity of two consonants exchanged in (2)-type instances in terms of feature value. The result to show no notable tendency is as follows:

Table 2: Phonological similarity of two exchanged consonants (N=65)
(measured by their feature difference)

1	11 (16.9%)
2	4 (6.2%)
3	14 (21.5%)
4	13 (20.0%)
5 or more	23 (35.4%)

In addition, we measured the phonological quality of two exchanged consonants by the vulnerability of coronal sounds predicted from underspecification theory, but no significant tendencies were found. (Terao 1996)

These results seem to suggest that the phonological environment rather than the phonological quality of the exchanged segments plays an important role at the stage in which sound exchange errors occur. In addition to the result that 57% of instances have the same vowel shown above, Table 3 below shows that over 60% of sound exchange errors occurred between two adjacent morae. See Table 3 in which the distance between two exchanged elements in the table is measured in terms of the number of intervening mora(e):

Table 3: Distance between two exchanged elements (N=114)
(measured by the number of intervening morae)

0	69 (60.5%)
1	29 (25.4%)
2	10 (8.8%)
3 or more	6 (5.3%)

4. INFANT DATA

In addition, we have the same type of errors found in infant speech. Although the observations based on the data are preliminary, they seem to have some implications both for the present discussion and for a model of the phonological component in language production. We analyses 259 sound exchange-type errors found in 750 spontaneous speech

errors made by children (aged from two to six).

The phonological environment where errors occurred was almost the same as that of adult errors, but it is interesting to note that sound exchange errors seem to occur with higher frequency than do those in adult speech.

It is also to be noted that error frequency of some particular combinations of two consecutive morae was relatively high, as if they formed one difficult or unnatural unit for children to articulate. For example, we observed 8 instances out of 259 errors, of the error shown below.

(6) e-be-re-e-ta-a (I:erebeetaa (elevator))

('|' means mora boundary)

Secondly, sound exchange errors were rarely subject to self-repair. This type of error might be difficult for both speaker and hearer to perceive. In other words, we might say the erred forms in sound exchange errors are too natural to be detected. We can find evidence of this difficulty in some dialects in some places in the Kansai area where error form "kadara" instead of "karada (body)" is common even among adults.

5. ARTICULABILITY OF TWO CONSECUTIVE MORAE

Given the observations shown above, we assumed that the articulability of two consecutive morae plays an important role in the stage in which sound exchange occurs. Taking (6) as an example, we hypothesized that /re be/ in /erebeetaa/ was less articulable or a less phonetically stable sequence than /bere/, resulting in a sound exchange. "The Degrees of Articulabilities" was originally proposed in Murata (1993, 1995), in which he analyzed the differences of the durations between the first sounds of paired Japanese combinations. The shorter sounds were considered to be easier to articulate than the longer ones. Adopting the same method, three experiments were carried out to confirm our idea in this study as follows.

6. EXPERIMENTS

We selected 34 pairs of two-mora combinations based on the frequency of infant errors. Each pair included a target unit, that is, a correct form of two consecutive morae (XY) and an error form (YX). (See Appendix 1) Our working hypothesis

was that the first mora in the error form, which is regarded as a more articulable sequence, is easier to utter and its duration is shorter than the one in the correct form. In experiment 1, two adult subjects were asked to utter the correct form and the error form alternatively, with a flat pitch accent, and as fast as possible. For example, "karada, kadara, karada, kadara...". The utterances were digitally recorded, and selected target units, in this case /dara/ and /rada/ were analyzed with Sound Scope II. In 66 out of 89 instances, subjects tended to take a shorter time to articulate the first mora in an error form. Applying the chi-squared test to these figures, we obtain a chi-squared value of 19.8, which means that the null hypothesis that there is no significant difference between XY and YX is rejected at the level of $p < 0.001$, thus supporting our working hypothesis.

In experiment 2, the same two subjects were asked to utter the same pairs with a natural accent. We had two recording sessions for the experiment. In 41 out of 68 pairs, subjects tended to take a shorter time to articulate the first mora in an error form. Applying the chi-squared test to these figures and neglecting the inconsistent reactions, we obtain a chi-squared value of 20.08, which means that the null hypothesis that there is no significant difference between XY and YX is rejected at the level of $p < 0.001$, thus supporting our working hypothesis that subjects tended to take a shorter time to articulate the first mora in an error form.

It should be noted that no significant differences were found between flat and natural accent patterns. This seems to suggest that pitch accent patterns associated with each mora do not play an important role.

In experiment 3, taking the discussion of Japanese bimoraic foot (Kubozono 1995) into consideration, the duration of two consecutive morae in each form was compared. We set a tentative foot boundary between every two morae from the word onset. For example:

(7) a. ha-na | ka-sa (I:hanasaki (flower bloom))

b. e-be | re-e | ta-a

('|' means foot boundary)

We compared the duration of each foot in the correct form and the error form. In 35 out of 68 pairs, subjects tended to take a shorter time to articulate the foot which contains the first mora in the error form. Applying the chi-squared test to these figures and neglecting the inconsistent reactions, we obtain a chi-squared value of 7.84, which means that the null hypothesis that there is no significant difference

between XY and YX is rejected at the level of $p < 0.01$, thus supporting our working hypothesis that subjects tend to take a shorter time to articulate the first mora in an error form.

For the future research, it would be necessary to collect more adult error data for analysis according to the articulability of two consecutive morae shown above.

7. CONCLUSIONS AND IMPLICATIONS

The results and findings in the present study are summarized as follows: (i) Some characteristics of Japanese sound exchange speech error are made clear. Phonological environment rather than phonological quality is relevant to those errors. (ii) A unit of two consecutive morae based on articulability is proposed. It is considered to be useful in describing how sound exchange errors take place. It suggests that the unit seems to play an important role in language production. (iii) The results seem to have further implications for the study of language production models. Especially, our findings seem to suggest that phonetic aspects should be taken into account more seriously in building a model of the phonological components of mora-timed language such as Japanese.

8. REFERENCES

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APPENDIX 1

Two-morae combinations used in Experiment 1

ro-ko vs. ko-ro	re-be vs. be-re
bu-ru vs. ru-bu	mo-no vs. no-mo
ku-su vs. su-ku	ka-ta vs. ta-ka
ku-tsu vs. tsu-ku	tsu-mu vs. mu-tsu
ra-da vs. da-ra	mo-ro vs. ro-mo
ma-ra vs. ra-ma	mo-do vs. do-mo
de-me vs. me-de	zo-no vs. no-zo
ja-ga vs. ga-ja	sa-ma vs. ma-sa