Effects of accent typicality and phonotactic frequency on nonword immediate serial recall performance in Japanese

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Abstract

In a nonword serial recall experiment we found following results: (1) Phonotactically high frequent nonwords were recalled better than low ones in terms of phoneme accuracy; (2) but this phonotactic frequency effect was not observed in accent accuracy. (3) Accent typicality did not have an expected effect on phoneme recall accuracy; (4) but it had an effect on accent accuracy. These results suggest that both long-term knowledge about phoneme sequences and accent patterns have strong influences on verbal short-term memory performance, but those influences might be limited to each particular domain.

Index Terms: short-term memory, prosodic knowledge, pitch accent, accent frequency, nonword immediate serial recall

1. Introduction

Previous studies have shown that various levels of linguistic long-term knowledge contribute to verbal short-term memory performance. For example, real words are recalled more accurately than nonwords[1]. This is explained in terms that, although phonological representations of memory items decay over time and eventually disappear, if participants can access to lexical/semantic representations of those items in long-term memory, lexical/semantic representations drive reconstruction of short-term phonological representations. In addition, high phonotactic frequency nonwords are recalled more accurately than low phonotactic frequency nonwords[2][3]. Phonotactic frequency of nonwords represents a key measure for the phonological structure in a language. Thus high frequent phonemic sequences form a part of long-term phonological knowledge possibly at sublexical levels. It is assumed that phonotactic knowledge might assist to reconstruct decayed phonological representations[2], or to enhance the activation of phonological representations[3]. As a consequence, phonological representations of high frequency phonotactic structures exhibit better recall performance than low.

Thus far, most studies employing short-term memory paradigms have primarily examined lexical/semantic and phonemic aspects but rarely the prosodic aspects of words or nonwords. Both the phonemic and prosodic aspects of speech contain important information in oral language. Specifically in Japanese, for some words, pitch accent position alone can discriminate the meanings of two words. For example, a word */A-me/* means *rain* but another word */a-me/* means *candy* (Capital letter represents high pitch accent and small letter represents low pitch accent). Consequently in Japanese, long-term knowledge about pitch accent pattern is critical in order to discriminate word meanings and this might, in turn, have an impact on recall performance.

In relation to this, Ueno et al. have introduced a concept of accent typicality[4], which reflects the relative frequency of each accent pattern, into the verbal short-term memory domain. In Japanese, words can be classified on the basis of pitch accent position. For tri-mora words, for example, a word */KA-ra-su/* meaning *crow* is accented on the first mora. This type is pronounced with a high-low-low accented pitch pattern (type 1). For another, a word */yu-MI-ya/* meaning *archery* is accented on the second mora. This type is pronounced low-high-low accented pitch pattern (type 2). The word */sa-ka-na/* meaning *fish* is a flat-accented word (flat). Ueno et al.'s analysis from the latest corpus[5][6] reconfirmed the presence of accent pattern typicality in contemporary three-mora nouns. That is, the most frequent accent type is flat, the second is type 1, and by far the most uncommon is type 2 (Figure 1).

Our primary target in this study was to examine effects of long-term accent knowledge on verbal immediate serial recall. Because it is assumed that accent pattern has some lexical roles in Japanese word processing, we used nonwords as memory materials here in order to minimize lexical/semantic influences on recall performance. Specifically, we manipulated accent typicality of three-mora nonwords (accent patterns; flat, type 1, and type 2) and also attempted to explore its interaction with phonotactic frequency (high or low).

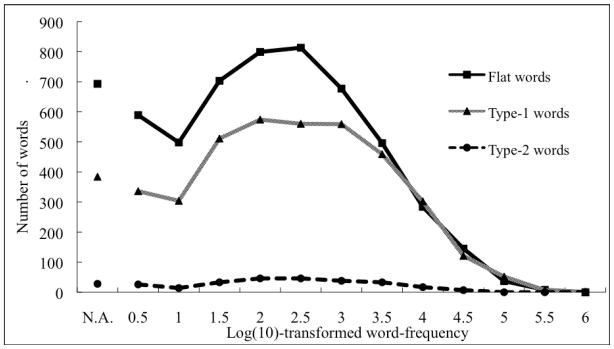

Figure 1: *The number of words with each accent types Note.* N.A. means that the word-frequency of those words is not available in the database probably due to their extremely low frequencies

We employed two separate scoring methods in this study: One was phoneme accuracy and another accent accuracy. The former is an ordinal scoring method for short-term memory assessment and each nonword item is scored correct if the recalled item includes the target phonemes in their correct

sequence. The accent pattern for each nonword was scored correct if the recalled item was repeated with the target accent pattern.

For phoneme accuracy, it was expected that phonotactically high frequent nonwords lead to better recall performance than low frequent nonwords. A novel question for the present study was whether accent typicality factor affects phoneme recall. If phoneme and accent components interact at a phonological level, then it might be the case that the typical accent format (flat) could facilitate phoneme recall. That is, the typical accent pattern could support the establishment of phonological representations because the typical accent pattern co-occurs with multiple phoneme sequences frequently.

There is, however, another possible prediction; the flat accent presentation might result in lower phoneme recall than an accented presentation (type 1 and type 2) for two reasons. Firstly, in the literature of children's nonword repetition, it has been shown that accented nonwords were repeated more accurately than nonwords presented with flat accent in three to four years old children[7]. Because accented presentation makes phonological representation more distinctive than flat presentation in short-term memory or at the perceptual level, it could potentially facilitate short-term retention of nonwords. Another possibility is the negative effect of the high neighbourhood size[8], such that processing of flat nonwords has to overcome the larger number of real words with flat pattern (i.e., many *accent-friends* but *phonemic-enemies*). Thus, flat nonwords might be more readily captured by word attractors, which would reduce phonemic accuracy.

In the accent correct score, we predicted some influence of long-term accent knowledge if the typical accent pattern is processed more efficiently, at least in this specific aspect of Japanese phonology. Thus it was expected that on immediate serial recall, nonwords with typical accent pattern (flat) would more likely be repeated with the same accent pattern than with less typical accent pattern (type 2), which might cause more accent errors in immediate serial recall.

2. Method

2.1. Participants

Twenty-four Kyoto university students were tested individually. They all were native speakers of Japanese.

2.2. Factorial design

The experimental design was a two (phonotactic frequency; high and low) by three (accent type; flat, type1 and type2) repeated factorial. Both were within-participant factors.

2.3. Materials

All nonwords had a CVCVCV structure. Phonotactic frequency of a nonword was calculated from a lexical corpus of Japanese newspaper[9], as the sum of nonword's front bi-mora and end bi-mora frequencies (thus, second moras overlapped). Thirty-six high phonotactic frequency nonwords and 36 low phonotactic frequency nonwords were selected.

Nonwords were recorded in three different accent patterns (flat, type 1 and type 2) by a male Japanese native speaker. In sum, there were 216 stimuli.

2.4. Procedure

Seventy-two sets of 3 nonwords (12 for each condition) were presented randomly from headphones. One list consisted of 3 nonwords with either high or low phonotactic frequency, and included 3 accent patterns. Across participants, 3 nonwords in a list were the same in terms of phoneme structure but their order and nonword-accent pattern combinations were counterbalanced.

Stimulus duration was 750ms and each stimulus was followed by a 1000ms blank. Immediately after the presentation of 3 nonwords, a warning cross appeared and participants were asked to recall the nonwords orally in the presented order.

3. Results

Responses, where all three moras were recalled correctly in the correct serial order position, were counted as phoneme correct. Percentages of phoneme accuracy are shown in Figure 2. A two way ANOVA showed significant main effects of phonotactic frequency ($F(1, 23) = 71.01$, $p < .05$) and accent type ($F(2, 46) = 8.21$, $p < .05$). A multiple comparison (Ryan's method) confirmed that nonwords presented with flat accent were recalled less accurately than both type 1 and type 2 (ts(46) > 3.34, ps <. 05) but there was no difference between the latter two conditions ($t < 1$, *n.s.*). The interaction of the two factors was not significant ($F(2, 46) = 1.31$, *n.s.*).

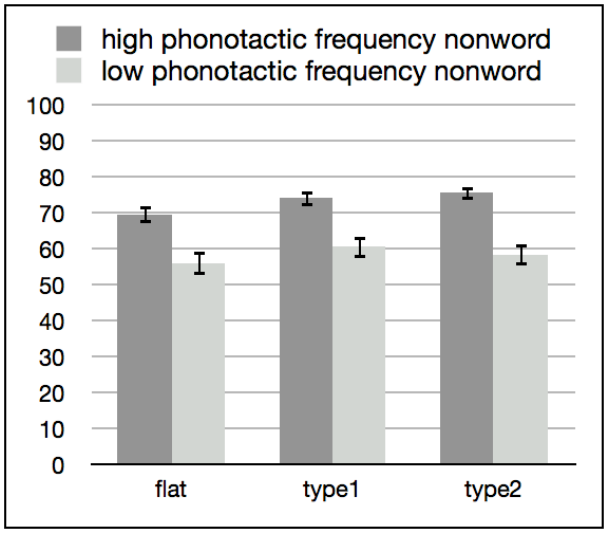

Figure 2: *Percentages of phoneme correct recall of high and low phonotacitic frequency nonwords in three accent type conditions (Erroer bars represent SEs).*

Figure 3 shows percentages of accent accuracy. A two way ANOVA indicated significant main effects of accent type ($F(2, 46) = 12.34$, $p < .05$). A multiple comparison (Ryan's method) confirmed that nonwords presented with type 2 accent was recalled less accurately than both flat and type 1 (ts(46) > 3.83, ps < .05) but there was no difference between flat and type 1 ($t < 1$, *n.s.*). The main effect of phonotactic frequency and the interaction between the two factors were not significant (both Fs < 1, *n.s.*).

In order to explore the lower accent accuracy for type 2 nonwords, we conducted an error analysis. We categorized accent errors according to the direction of accent change. For example, observed errors in flat condition could be potentially divided into two categories, that is, moving to type 1 or to type 2. Figure 4 shows the numbers of errors in two categories in each of three accent type conditions. These six categories are

considered to be independent each other because these categories do not include correct patterns. A two way ANOVA indicated significant main effects of accent type ($F(5, 115) = 10.46$, $p < .05$). A multiple comparison (Ryan's method) confirmed that the error in type 2 condition moving toward flat accent pattern (i.e., an accent "*regularization*") was the most frequent significantly of all categories ($ts(115)>4.89$, $ps<.05$).

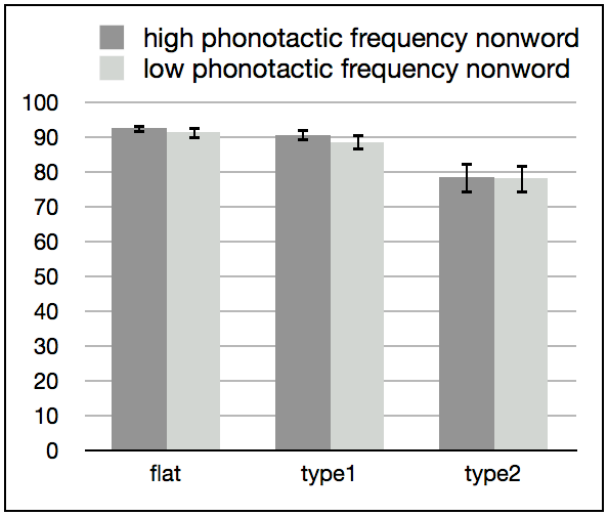

Figure 3: *Proportion of correct accent recall of high and low phonotactic frequency nonwords in three accent type conditions (Error bars represent SEs).*

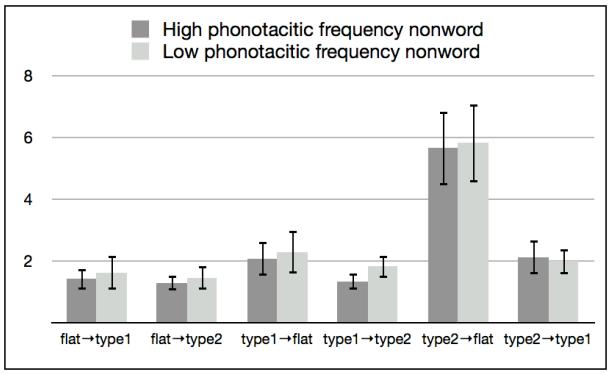

Figure 4: *The mean numbers of each error pattern (Erroer bars represent SEs).*

4. Discussion

The main results obtained from the current experiment were as follows: (1) Phonotactically high frequent nonwords were recalled better than low ones in terms of phoneme accuracy; (2) but the phonotactic frequency effect was not observed in accent correct scores. (3) Accent typicality did not have the expected effect on phoneme recall accuracy but flat accent nonwords showed less accurate accent recall. (4) Accent typicality had an effect on accent recall accuracy. (5) The most frequent accent errors were accent changes from the least typical accent type (type 2) to the most typical accent pattern (flat).

The first finding is a replication of previous studies that showed strong phonotactic frequency effects in nonword recall [2] and confirms powerful influences of long-term phonological knowledge on immediate verbal serial recall.

The fourth and the fifth results indicate that long-term accent knowledge also has some influences on immediate verbal serial recall. Although the influences are limited to accent recall performance, the effect itself is quite strong. It should be noted here that a previous study with word recall experiments reported a similar result[10] in which accent errors in word serial order recall were essentially accent changes from less typical accent toward more typical accent patterns. Thus we can safely conclude that accent typicality in Japanese has a strong influence on verbal immediate serial recall.

The second and the third results indicate a very interesting possibility. Phonotactic frequency only affected phoneme recall accuracy but not accent recall accuracy. In contrast, accent typicality had the opposite results. This may indicate that long-term knowledge of phoneme sequences and of accent patterns might operate independently, and could contribute to short-term memory performance separately. Although this assumption seems to correspond with hypotheses from some psycholinguistic models[11], it should be examined carefully in future research.

5. References

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