THE INFLUENCE OF ACCENT PATTERN TYPICALITY ON IMMEDIATE AND DELAYED NONWORD REPETITION

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It is well established that the phonological system captures the quasiregularity of phoneme sequences. For example, repetition performance is better for nonwords composed of phoneme combinations that occur frequently in one's native language. Although phoneme sequences are necessarily accompanied by suprasegmental aspects (e.g., accent patterns), the influence of suprasegmental aspects has not been investigated extensively. This study examined the influence of Japanese pitch-accent pattern on nonword repetition. Exploration of nonwords provides an opportunity to investigate phonological factors largely without lexical and semantic influences. We conducted immediate and delayed nonword repetition experiments, manipulating phonotactic frequency and pitch-accent type. Two experiments revealed that nonwords presented with atypical accent patterns showed more frequent phonemic and accent pattern errors than nonwords with more typical accent patterns. The results indicate that the phonological system captures a range of sublexical phonological characteristics found in each language through linguistic experiences and is not limited to coding phonemic sequences alone. We suggest that although there is diversity in functioning of phonological systems driven by linguistic variability, such diversity stems from universal learning mechanisms in language processing systems.

Key words: nonword repetition, phonotactic frequency, accent pattern typicality

INTRODUCTION

For representing the thousands of words in our vocabulary, we must be able to code and represent many permutations of the speech units (e.g., phoneme) that go to make up each one. This considerable representational problem can be reduced to some degree by organizing an efficient processing system that captures the statistical (semi-)systematicity, called as *quasiregularity* (Seidenberg & McClelland, 1989), of the domain. In the context of phonology, the frequencies of phonemic permutations are not equal. For example, in English, the phoneme permutation /fʌl/ occurs frequently in English environment but /ðʌib/ is infrequent. The influence of capturing and representing the domain-relevant

statistics can be observed in better repetition performance for nonwords composed of frequent phoneme permutations (e.g., for two syllable nonword, /fʌl-tʃʌn/) than infrequent phoneme sequences (e.g., for two syllable nonword, /ðʌib-dʒaiz/), known as the *phonotactic frequency effect* (e.g., Vitevitch, Luce, Charles-Luce, & Kemmerer, 1997).

In addition to phonemic quasiregularity, Ueno and colleagues (e.g., Ueno et al., 2014) suggested that Japanese pitch-accent pattern is another quasiregular modality, which also influences language performance. Pitch-accent of tri-mora words in Japanese, for example, is categorized into flat, type-1, and type-2 accents[1]. Type-1 and type-2 accent words have a fundamental frequency contour which drops, respectively, after the first mora (e.g., /KA-ra-su/ 'crow')[2] and after the second mora (e.g., /yu-MI-ya/ 'bow and arrow'). In contrast, the so-called flat pattern has no contour drops (e.g., /sa-KA-NA/ 'fish'). In Japanese tri-mora words, the flat pattern is the most frequent and type-1 accent is the second but the type-2 accent is infrequent (Sato, 1993). Sakono, Ito, Fukuda, and Fukuda (2011) reported an effect of pitch-accent pattern typicality on repetition of single unfamiliar tri-mora real words in children (ranged from 5; 0 to 6; 7 years old): unfamiliar words presented with the atypical type-2 accent were recalled less accurately than ones presented with flat and type-1. This result suggests that the quasiregularity of Japanese pitch-accent pattern might have an impact on phonological representations utilized in the repetition task. Yet, it is unclear whether the typicality effect operates mainly at the phonological level because performance on real words involves lexical and semantic influences (cf. Patterson et al., 2006; Sekiguchi, 2006; Ueno, Saito, Rogers, & Lambon Ralph, 2011; Ueno et al., 2014). In addition, because Sakono et al. (2011) defined correct responses as those with both correct phoneme sequences and accent patterns, it is unclear whether the lower repetition performance in the type-2 accent condition arose from phonemic sequence errors or accent errors, or both. The question as to which factors have an impact on phonological representations is important for understanding word learning. This is because word learning requires correct representations for novel phonological information, which has no lexical/semantic representations yet, in terms of both phonemic and accent aspects (Gathercole, 2006). Stress-accent languages also showed similar typicality-based phenomena. For instance, English (e.g., Roy & Chiat, 2004) and Dutch studies (e.g., de Bree, Wijnen, & Zonneveld, 2006) have found a typicality/regularity effect of stress position on nonword repetition in children. However, their scoring methods also conflate segmental and suprasegmental features. For example, Roy and Chiat (2004) calculated syllable loss, and though de Bree et al. (2006) employed phoneme accuracy rate, the index included syllable/phoneme addition and omission (due to the fact that their nonword stimuli had various lengths and syllable weights).

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[1] There is also a type-3 accent. The pitch change within a word with the type-3 accent is identical to that with the flat-accent type. However, the pitch of the particle that follows a type-3 word is low whereas that follows a flat word is high. For example, a type 3 word /otoko/ (man) is pronounced with a particle /ga/ as /oTOKOga/ but a flat word /sakana/ (fish) is as /saKANAGA/ (capital letters represent high pitch moras). Therefore, it is impossible to descriminate flat accent and type-3 accent in single words/nonwords presentation procedures.

[2] Capital letters represent high pitch mora.

The present study investigated the interactive influences among phonemic representations and accent representations on performance in repetition of tri-mora, CVCVCV, nonwords. We computed conditional accuracy proportions (i.e., phoneme accuracy within accent correct trials, and accent accuracy within phonemic correct trials) to draw a complete distinction between phonemic and accent accuracies. If the typicality of accent pattern genuinely has an effect on phonemic representations, nonword phoneme sequences accompanied by atypical type-2 accent might result in the lower repetition performance than nonwords with more typical flat and type-1 accent patterns even on the conditional rate of phonemic accuracy on accent correct trials. In particular, the effect of accent pattern typicality might be more salient or only observed for phonotactically low frequency nonwords, because their phonemic sequences might be less strongly represented even for adults and therefore might require stronger support from another dimension of phonology—pitch accent in the case of the Japanese language (see also Ueno et al., 2014, for a similar rationale). On the other hand, if the poorer repetition of less-typical accent words observed in Sakono et al. (2011) simply reflected the lower repetition performance of the atypical accent pattern itself, the conditional rate of phonemic accuracy on accent correct trials might not show any effect of the accent pattern typicality.

A similar rationale can be applied to our prediction on the influence of phonemic aspect on accent representations. Although previous studies have not paid much attention to the influence (e.g., Sakono et al., 2011), it is important to examine the effect of phonotactic frequency on repetition of accent patterns of nonwords in order to fully understand the interaction between phonemic sequence and accent patterns. If the representational quality of phoneme sequences has an impact on accent representations, an accent pattern of a nonword with a low frequency phoneme sequence should result in lower repetition performance than nonwords with a high frequency phoneme sequence, even on the conditional rate of accent accuracy on phoneme correct trials. The effect of phonotactic frequency might be greater for atypical accent nonwords than for typical accent patterns as representations of nonwords with the atypical accent patterns could be weakly represented, and thus require more support from phonotactic knowledge.

EXPERIMENT 1: IMMEDIATE NONWORD REPETITION

Method

Design. The experiment had a 2 (phonotactic frequency; high and low) × 3 (accent type; flat, type-1, and type-2) factorial design. Both factors were manipulated within participants.

Participants. Thirty native Japanese speakers participated (12 females and 18 males). The ages ranged from 18 to 24 years old, with the mean age being 20.3 years old.

Materials. The nonword stimuli were the same as used by Tanida, Ueno, Lambon Ralph, and Saito (2015). All nonword items held a CVCVCV structure, categorized as a phonotactically high or low frequency nonword on the basis of bi-mora frequency data (Tamaoka & Makioka, 2004). The 36 phonotactically high frequency and 36 low frequency nonwords were recorded with three accent types (flat, type-1, and type-2) by a male speaker (the first author). All 216 sound files were edited with Adobe Soundbooth; the duration was 700 ms, the amplitudes of all files were equalized to match a selected benchmark file, and each file was noise-canceled. To check the validity of the resultant stimuli, we confirmed that all files were written to dictation

correctly by five naive pilot participants and assessed correctly in terms of the accent types by four or more of another five pilot participants. Nonword items were divided into three blocks randomly, and constrained so that same phoneme sequences did not appear in the same block (there were three items from one phoneme sequence with different accent types). Nonword items were presented in random order within a block and the presentation order of block was counterbalanced between participants.

In addition, filler real words of a CVCVCV structure with one of three accent types were presented once within every eight nonwords to discourage participants from repeating with a fixed accent pattern throughout the experiment. Twenty-seven tri-mora words (9 flat, 9 type-1, and 9 type-2 words) were selected randomly from a set of words, whose accent pattern validities[3] are reported as maximal in a large-scale Japanese normative corpus (Amano & Kondo, 1999–2000). The sound files were recorded, edited and checked by the dictation and accent assessment tests in the same way as nonword items.

Procedure. After a 500 ms delay from when the space key was pressed by participants, one word or nonword was presented auditorily and participants were asked to repeat the word or the nonword with the same accent pattern as presented. In the Result sections for Experiments 1 and 2, the filler words were excluded from the analyses.

Results

Phoneme sequence accuracy: The conditional proportion of phonemically correct items, i.e., those in which all six phonemes were correct in accent correct trials, is shown in Table 1. Two-way analyses of variance (ANOVAs; phonotactic frequency × accent type) after angular transformation revealed that an interaction between phonotactic frequency and accent type was significant in the by-subject analysis and marginally significant in the by-item analysis [$F_1(2, 58) = 7.41$, $\eta_p^2 = 0.20$, $p < .01$; $F_2(2, 140) = 2.71$, $\eta_p^2 = 0.04$, $p = .07$]. The simple main effect of phonotactic frequency was significant in the type-2 condition with higher performance for phonotactically high frequency than low frequency nonwords [$F_1(1, 29) = 9.30$, $\eta_p^2 = 0.24$, $p < .01$] but not in other accent type conditions [$F_{1s}(1, 29) < 1.55$, $\eta_p^2{}_s < 0.05$, $p_s > .22$]. The simple main effect of accent type was significant in the phonotactically high frequency condition [$F_1(2, 58) = 3.92$, $\eta_p^2 = 0.12$, $p = .03$]. A multiple comparison (Shaffer's method) revealed that nonwords with type-1 accent showed poorer performance than nonwords with type-2 accent [$t_1(29) = 2.89$, $d = 0.45$, *adj. p* $= .02$] but other differences were not significant [$t_{1s}(29) < 1.61$, $d_s < 0.26$, *adj. p_s* $> .12$]. The simple main effect of accent type in the phonotactically low frequency condition was also significant [$F_1(2, 58) = 5.11$, $\eta_p^2 = 0.15$, $p = .01$]. A multiple comparison (Shaffer's method) revealed that nonwords with type-2 accent showed poorer performance than ones with flat accent [$t_1(29) = 2.69$, $d = 0.63$, *adj. p* $= .03$] and type-1 accent [$t_1(29) = 2.21$, $d = 0.45$, *adj. p* $= .04$]. The difference between flat and type-1 condition was not significant [$t_1(29) = 1.09$, $d = 0.20$, *adj. p* $= .29$]. All other effects were not significant (F_1s < 1.96, η_p^2s < 0.06, ps $> .15$; F_2s < 1.07, η_p^2s < 0.02, ps $> .35$). Table 2 also shows the accuracy rate of phoneme sequences, but calculated from all trials (i.e., regardless of accent pattern accuracy). Although ANOVA results from this type of accuracy rate were similar to those from the conditional proportions, the detailed statistical data are not reported here because of the lack of clear interpretation as mentioned in the Introduction section.

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[3] Some Japanese words are pronounced with varying accent patterns. Stimuli were selected from words without any variations among the participants' evaluation in Amano and Kondo (1999–2000).

Table 1. Averages and SDs of phoneme sequence accuracy on accent correct trials and accent pattern accuracy on phonemically correct trials

			Phonotactic frequency	flat		type-1		type-2	
				M	SD	M	SD	M	SD
Phoneme sequence accuracy rate on accent correct trials	Exp. 1	immediate	high	0.966	0.032	0.954	0.046	0.972	0.030
			low	0.970	0.033	0.965	0.033	0.946	0.043
	Exp. 2	short delay	high	0.963	0.030	0.969	0.044	0.967	0.036
			low	0.959	0.033	0.957	0.036	0.930	0.054
		long delay	high	0.962	0.047	0.970	0.035	0.953	0.055
			low	0.961	0.038	0.945	0.053	0.930	0.049
Accent pattern accuracy rate on phoneme correct trials	Exp. 1	immediate	high	0.998	0.007	0.999	0.006	0.996	0.013
			low	1.000	0.000	0.997	0.012	0.993	0.018
	Exp. 2	short delay	high	0.996	0.009	0.997	0.009	0.994	0.014
			low	0.996	0.013	0.997	0.012	0.983	0.037
		long delay	high	1.000	0.000	0.996	0.009	0.993	0.013
			low	0.992	0.018	0.995	0.014	0.986	0.024

Table 2. Averages and SDs of phoneme sequence accuracy on all trials and accent pattern accuracy on all trials

			Phonotactic frequency	flat		type 1		type 2	
				M	SD	M	SD	M	SD
Phoneme sequence accuracy	Exp. 1	immediate	high	0.966	0.032	0.954	0.046	0.971	0.031
			low	0.970	0.033	0.964	0.034	0.946	0.043
	Exp. 2	short delay	high	0.961	0.034	0.968	0.046	0.963	0.039
			low	0.958	0.035	0.955	0.039	0.928	0.054
		long delay	high	0.954	0.058	0.962	0.052	0.941	0.063
			low	0.956	0.042	0.935	0.057	0.922	0.050
Accent pattern accuracy	Exp. 1	immediate	high	0.998	0.007	0.999	0.005	0.995	0.013
			low	1.000	0.000	0.996	0.012	0.994	0.017
	Exp. 2	short delay	high	0.994	0.011	0.995	0.010	0.990	0.016
			low	0.995	0.015	0.995	0.013	0.981	0.036
		long delay	high	0.991	0.021	0.987	0.025	0.980	0.027
			low	0.986	0.023	0.985	0.025	0.978	0.034

Accent pattern accuracy: The conditional proportion of accent correct items, where the accent patterns matched the presented accent, in trials where all six phonemes were correct, is shown in Table 1. Two-way ANOVAs (phonotactic frequency × accent type) after angular transformation revealed a significant main effect of accent type only in the by-item analysis [$F_1(2, 58) = 2.03$, $\eta_\mathrm{p}^2 = 0.07$, $p = .14$; $F_2(2, 140) = 3.10$, $\eta_\mathrm{p}^2 = 0.04$, $p < .05$]. However, multiple comparisons (Shaffer's method) found no significant differences between accent types [$t_{2s}(70) < 2.14$, $d_s < 0.36$, *adj. p_s* > .11]. The other effects were not significant (F_1s < 1.36, η_p^2s < 0.04, ps > .27; F_2s < 1.14, η_p^2s < 0.02, ps > .32). Table 2 also shows the accuracy rate of accent patterns, but calculated from all trials (i.e., regardless of phoneme sequence accuracy). ANOVA results from this type of accuracy rate were similar to those from the conditional proportions.

Discussion of Experiment 1

We found an influence of accent pattern typicality on phonemic representations in nonword repetition. As predicted, phoneme sequences presented with the atypical type-2 accent were repeated less accurately than more typical accent patterns, particularly in the phonotactically low frequency condition when, presumably, the phonological system was under the greatest pressure. The phonemic vulnerability due to presenting a nonword with an atypical accent is reflected in the significant phonotactic frequency effect only in the atypical accent condition. These results suggest that Japanese phonemic representations depend on not only phonemic characteristics but also the quasiregularity of the accent pattern. The efficiency of accent pattern processing was relatively less influenced by accent pattern quasiregularity and was not influenced at all by phonemic quasiregularity. These facts might have reflected the generally higher accuracy for accent pattern than phoneme sequence, suggesting a more stable suprasegmental than segmental representation.

As noted above, the accuracy rates in this experiment were very high and consequently, the presence of a performance ceiling effect might have influenced the results. Accordingly, in the next experiment, we employed a delayed repetition paradigm that could decrease repetition performance, thus, reducing the risk of ceiling effects.

EXPERIMENT 2: DELAYED NONWORD REPETITION

Method

Design. The experiment had a 2 (phonotactic frequency; high and low) × 3 (accent type; flat, type-1, and type-2) × 2 (delay time; short and long) factorial design. All three factors were manipulated within participants.

Participants. Twenty-four native Japanese speakers participated (8 males and 16 females). The ages ranged from 19 to 26 years old, with the average age being 21.5.

Procedure. In each trial, one spoken word or nonword was presented and then a repetition cue was visually presented after a 1 s or 5 s delay from the onset of aural presentation. Participants were required to repeat the word or nonword with the same accent pattern as presented as soon as possible after the onset of the cue (note that, in Experiment 1, we did not require participants to respond as soon as possible). Word and nonword stimuli were the same as used in Experiment 1. They were divided into three blocks as per Experiment 1, but each block was tested twice (resulting in six presentation blocks) in Experiment 2. Thus each of the 216 items appeared twice across the first and the second half of the experiment, once for each delay. The numbers of trials for 1 s or 5 s delay were the same within each block. The presentation order of items was randomized and that of blocks was counterbalanced across participants. The scoring method was same as Experiment 1.

Result

Phonemic sequence accuracy: The conditional proportion of phoneme sequence accuracy is shown in Table 1. Three-way ANOVAs (phonotactic frequency × accent type × delay time) after angular transformation revealed a significant main effect of accent type [F_1(2, 46) = 6.16, η_p^2 = 0.21, $p < .01$; F_2(2, 140) = 3.08, η_p^2 = 0.04, $p < .05$]. The multiple comparisons (Shaffer's method) with the by-subject analysis found that nonword phoneme sequences with type-2 accent were repeated significantly less accurately than nonwords with flat accent [t_1(23) = 3.03, d = 0.34, *adj.p* = .02; t_2(70) = 2.04, d = 0.24, *adj.p* = .12] and type-1 accent [t_1(23) = 2.98, d = 0.33, *adj.p* = .02; t_2(70) = 2.08, d = 0.22, *adj.p* = .12]. The difference between flat and type-1 condition was not significant [t_1(23) = 0.01, $d < 0.01$, *adj.p* = .99; t_2(70) = 0.25, d = 0.03, *adj.p* = .80]. In addition, there was a significant interaction between phonotactic frequency and accent type in by-subject analysis [F_1(2, 46) = 4.37, η_p^2 = 0.16, p = .02; F_2(2, 140) = 1.95, η_p^2 = 0.03, p = .15]. The simple main effects of phonotactic frequency were found in the type-1 [F_1(1, 23) = 5.62, η_p^2 = 0.20, p = .03] and type-2 conditions [F_1(1, 23) = 15.54, η_p^2 = 0.40, $p < .01$], with better performance for phonotactically high frequency than low frequency nonwords, but not found in the most typical flat accent condition [F_1(1, 23) = 0.27, η_p^2 = 0.01, p = .61]. A simple main effect of accent type was found in the phonotactically low frequency condition [F_1(2, 46) = 11.32, η_p^2 = 0.33, $p < .01$]; nonwords presented with type-2 accent exhibited poorer performance than nonwords presented with flat [t_1(23) = 4.78, d = 0.69, adj. $p < .01$] and type-1 accents [t_1(23) = 2.86, d = 0.45, adj. $p < .01$]. Nonword presented with type-1 accent did not show a significant difference with flat [t_1(23) = 1.59, d = 0.21, adj. p = .13]. The simple main effect of accent type was not significant in the phonotactically high frequency condition [F_1(2, 46) = 1.04, η_p^2 = 0.04, p = .36]. The main effect of phonotactic frequency was significant only in the by-subject analysis with better performance for phonotactically high frequency than low frequency sequences [F_1(1, 23) = 10.43, η_p^2 = 0.31, $p < .01$; F_2(1, 70) = 1.08, η_p^2 = 0.02, p = .30]. The other effects were not significant [F_1s < 1.16, η_p^2s < 0.05, ps > .32; F_2s < 1.97, η_p^2s < 0.03, ps > .16]. Table 2 also shows the accuracy rate of phoneme sequences, but calculated from all trials (i.e., regardless of accent pattern accuracy). ANOVA results from this type of accuracy rate were similar to those from the conditional proportions.

Accent pattern accuracy: The conditional proportion of accent pattern accuracy is shown in Table 1. Three-way ANOVAs (phonotactic frequency × accent type × delay time) after angular transformation revealed a significant main effect of accent type [F_1(2, 46) = 4.64, η_p^2 = 0.17, p = .01; F_2(2, 140) = 8.89, η_p^2 = 0.11, $p < .01$]. The multiple comparisons (Shaffer's method) revealed that type-2 accent showed significantly poorer performance than flat [t_1(23) = 2.18, d = 0.37, *adj.p* = .08; t_2(70) = 3.22, d = 0.39, *adj.p* < .01] and type-1 accent [t_1(23) = 2.40, d = 0.39, *adj.p* = .08; t_2(70) = 3.45, d = 0.42, *adj.p* < .01] in the by-item analysis, and these differences were marginally significant in the by-subject analysis. The difference between flat and type-1 accent was not significant [t_1(23) = 0.16, d = 0.02, *adj.p* = .87; t_2(70) = 0.19, d = 0.02, *adj.p* = .85]. In addition, the main effect of phonotactic frequency was significant with better performance for phonotactically high frequency than low frequency sequences [F_1(1, 23) = 6.19, η_p^2 = 0.21,

$p = .02$; $F_2(1, 70) = 14.45$, $\eta_p^2 = 0.17$, $p < .01$]. No other effect was significant [F_1s < 1.63, η_p^2s < 0.07, ps > .21; F_2s < 2.42, η_p^2s < 0.03, ps > .09]. Table 2 also shows the accuracy rate of accent patterns, but calculated from all trials (i.e., regardless of phoneme sequence accuracy). ANOVA results from this type of accuracy rate were similar to those from the conditional proportions.

Discussion of Experiment 2

By switching to a delayed repetition paradigm, we replicated the effect of accent pattern typicality more robustly on phoneme sequence accuracy and accent pattern accuracy. The phonotactic frequency effect was found not only in phoneme sequence accuracy but also accent pattern accuracy. Based on the observed interaction between segmental and suprasegmental factors, we can assume the presence of a complex dynamic phonological process, where the efficiency of the suprasegmental process is affected by that of the segmental process, and *vice versa*.

GENERAL DISCUSSION

In two nonword repetition experiments, we found an effect of accent pattern typicality on repetition performance of both phoneme sequences and accent patterns. Nonwords with an atypical accent pattern exhibited more frequent phonemic errors and accent pattern errors, indicating that the performance of the phonological system is sensitive to the quasiregularity of suprasegmental features (in this case accent pattern typicality).

The effect of accent pattern typicality was especially salient for phonotactically low frequency phoneme sequences in both experiments, suggesting that accent pattern typicality has an impact on phonemically unstable representations, even in adults. The results for children's repetition of tri-mora words reported by Sakono et al. (2011) showed the accent typicality effect because phonemic representations of words in children could be weaker than those in adults. This hypothesis might generalize across languages as it would also explain the children's data obtained for words in stress-accent languages (de Bree et al., 2006; Roy & Chiat, 2004). Thus, it is possible to argue that accent patterns have an impact on word-learning/language acquisition through establishing phonological representations in short-term memory (Gathercole, 2006), as well as segmenting phrases using suprasegmental probability (e.g., Mattys, Jusczyk, Luce, & Morgan, 1999) and facilitating children's vocal learning in their first languages (e.g., Mampe, Friederici, Christophe, & Wermke, 2009).

Our data are consistent with prosody-dominant word segmentation reported by Mattys et al. (1999). They found that 9-month infants from English speaking families preferred (in terms of listening duration) two-syllable nonwords composed of *phonotactically atypical but prosodically typical* patterns (strong stress on the first syllable and weak stress on the second syllable) over *phonotactically typical but prosodically atypical* nonwords (weak stress on the first syllable and strong stress on the second syllable) patterns. In line with the developmental psychology literature, Mattys et al. (1999) interpreted this longer listening

time as reflecting the fact that the infants had developed the predominant phonological features (i.e., word-likeness) in their native language. Thus, these results suggest that infants compute word-likeness based more on suprasegmental than segmental features. The current study indicates that the predominance of suprasegmental probability over segmental probability might be driven by the representational stability of accent patterns and phoneme sequences. As is evident from Table 2, accent repetition performance was generally higher than phonemic repetition performance, indicating that suprasegmental representations are more stable than segmental representations. Of course, this pattern could be explained by a difference in variations within a stimulus set—we presented only three accent patterns while using 72 nonwords (i.e., phoneme sequences) in our experiments. Even with this small set size (or because of this small set size), the statistical regularity of prosodic patterns might be stably represented within the language system (and easily acquired in infants). This could lead to the prosody-dominant phonological processing in word segmentation (Mattys et al., 1999) and nonword repetition (the current study).

The nonword repetition tasks employed here require both perception/recognition and production of speech sounds. Allen and Hulme (2006) demonstrated a correlation between performance on delayed repetition and speech production, suggesting that individual differences in adult word repetition performance might be affected more strongly by production aspects of the task. This has raised a possibility that the observed accent typicality effects on phoneme processing might depend more on production than recognition processes. This aspect of the effect of accent typicality requires further examination in future studies.

We note that the phenomena observed here were not due to the influences of learning during experiments and dialect of participants. First, though the same phoneme sequences were presented three times in Experiment 1 and six times in Experiment 2, we confirmed that the effects of accent pattern typicality on phoneme accuracy were present in the data from trials in the first block (i.e., the first presentations for all stimuli). Second, though our participants came from a range of regions in Japan, the significant effect in the by-subject analysis indicates that all participants showed the consistent pattern. This is probably because Japanese people are familiar with accent patterns of the Tokyo dialect due to the national broadcasting (Otake & Cutler, 1999) and their active inter-prefectural/city movement around Japan.

One clarification must be noted here that the current study does not address the details of the mechanisms for the interactive processes across phonemic and accent representations. Although recent research has been establishing the precise mechanisms how phonemic representations are established on phonological short-term memory (e.g., Gupta, 2009; Page & Norris, 2009), proposed models have not been considering a prosodic feature. It is known that the prosodic feature is an important factor especially for an early phase of language acquisition and its effect on phonemic representations remains even for adults as we showed. The current findings provide directions for future research, pointing to the need for detailed modeling of the interactive pathways between phonemic and accent representations on phonological short-term memory.

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