Acquisition of sound symbolic values of vowels and voiced obstruents by Japanese children: Using a Pokémonastic paradigm*

有声性と母音の音象徴の：ポケモン名付けタスクを使った実験

Abstract

Recent studies on sound symbolism have demonstrated that in Japanese Pokémon names, the number of voiced obstruents in their names positively correlates with their evolution levels. This correlation is likely to have its roots in the sound symbolic relationship between voiced obstruents and largeness/heaviness/strengths. This study shows that when Japanese children are provided with two non-existing names and a pair of pre-evolution and post-evolution Pokémon characters, they are more likely to associate names having voiced obstruents with post-evolution Pokémon characters. The experiment also shows that Japanese children associate post-evolution characters more with [a] than with [i], which shows that they are sensitive to vocalic sound symbolism as well.

1 Introduction

In modern thinking about languages, it is almost taken for granted that the relationships between sounds and meanings are arbitrary. This dictum was clearly made explicit by Saussure (1916), and reiterated by Hockett (1959) as an important property of human languages, which have had a substantial influence on modern linguistic theories. On the other hand, there has been an observation, which even dates back to the time of Plato (the dialogue *Cratylus*), that certain sounds can be—even if stochastically but yet systematically—associated with certain meanings. In modern era, for example, Jespersen (1922) and Sapir (1929) both argue that the vowel [i] invokes images of "smallness," especially as compared to vowels like [a] and [o]. In Japanese, voiced obstruents are often associated with images of largeness, heaviness or dirtiness (e.g. Hamano 1986; Kawahara

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2015, 2017; Kawahara et al. 2008; Kubozono 1999; Shinohara and Kawahara 2016; Suzuki 1962), an observation that is shown to hold in English as well (Newman, 1933; Shinohara and Kawahara, 2016). These systematic associations between sounds and meanings are now referred to as "sound symbolism," and are now actively studied in the phonetic and psycholinguistic literature (see Dingemanse et al. 2015; Lockwood and Dingemanse 2015; Sidhu and Pexman 2017 for recent reviews).

Sound symbolism is an interesting topic for phonetic inquiry, because most if not all sound symbolic patterns make phonetic sense; i.e. the images of the sounds seem to derive from—or at least be compatible with—phonetic properties of these sounds (see Kawahara 2017 for recent exemplification). Take the case of [i] being associated with the image of being small, for example. This image can arise from the small aperture of the oral cavity for the articulation of [i] (Sapir, 1929), or its high F2, which results from the small size of the oral cavity in front of the tongue blade (Jespersen, 1922; Ohala, 1984, 1994). As a general principle that dictates sound symbolic patterns in natural languages, Ohala proposed a hypothesis—now referred to as Frequency Code Hypothesis—stating that sounds with low frequency energy are associated with images of largeness, whereas sounds with high frequency energy are associated with images of smallness (see also Bauer 1987; Gussenhoven 2004, 2016). These associations reflect the physical law of vibration—larger objects emit lower frequency sounds, everything else being equal.[1]

Frequency Code Hypothesis explains why voiced obstruents are associated with images of largeness, as voiced obstruents are characterized with low frequency energy: during constriction, voiced obstruents often exhibit low frequency energy (a.k.a. "voice bar") as a result of vocal fold vibration; voiced obstruents are also known to show lower f0 in F1 in surrounding vowels, compared to voiceless obstruents and sonorants (see Hombert et al. 1979; House and Fairbanks 1953; Kingston and Diehl 1994; Lehiste and Peterson 1961; Lisker 1986; Stevens and Blumstein 1981 among many others). A series of work by Kingston and his colleagues (Kingston and Diehl, 1994, 1995; Kingston, Diehl, Kirk and Castleman, 2008; Kingston, Lahiri and Diehl, 2008) has argued that [+voice] feature should be characterized by a perceptually integrated property of low frequency energy, to which all of closure voicing, low f0 and low F1 contribute. This low frequency energy can be the basis of the images of largeness of voiced obstruents.[2]

[1]The fundamental frequency (f_0) of an ideal string is:

$$f_0 = \frac{1}{2L}\sqrt{\frac{\sigma}{\rho}} \qquad (1)$$

where L is length, σ is tension, and ρ is density. Crucially, f_0 and L are disproportional to each other.

[2]An alternative, articulation-based, explanation of why voiced obstruents are associated with the images of largeness is possible (Kawahara, 2015, 2017). Due to aerodynamic conditions that need to be met in the production of voiced obstruents, speakers expand their oral cavity during the production of voiced obstruents (Ohala, 1983; Ohala and Riordan, 1979; Proctor et al., 2010). This expansion of the oral cavity may result in the images of largeness.

While there is an extensive body of literature on sound symbolism uncovering many patterns of sound-meaning relationships, one eminent remaining question within the research of sound symbolism is its acquisition. Maurer et al. (2006) studied a so-called the "bouba-kiki" effect (Ramachandran and Hubbard, 2001) in which nonce words like *bouba* are more likely to be associated with a round object, while nonce words like *kiki* are more likely to be associated with an angular object. Maurer et al. (2006) show that 2.5-year-old children show such sound-shape associations, just like adult speakers. Imai et al. (2008) demonstrated that nonce verbs that follow sound symbolic principles are more easily learned by Japanese children than nonce verbs that do not. Kantartzis et al. (2011) showed that a similar result is obtained even if Japanese-sounding nonce words are used for English-speaking children. Ozturk et al. (2013) demonstrated through a looking time experiment that 4-month old infants look at congruent sound-shape pairs longer than incongruent sound-shape pairs. Asano et al. (2015) demonstrate through an EEG experiment that 11-month-old infants may be sensitive to sound symbolic associations. Building on these results, Imai and Kita (2014) raise the possibility that sound symbolism may guide language acquisition process to some non-negligible extent (though see Monaghan et al. 2012).[3] Studying how children acquire sound symbolic patterns is thus an important topic in general linguistic inquiry, which has so far been understudied, despite these recent illuminating results.

To put the questions in more concrete terms, do children have knowledge of sound symbolic associations just like adults? If so, are they able to use that knowledge to name new objects? This paper provides a case study which examined whether Japanese six-year-old children possess sound symbolic knowledge about vowels and voiced obstruents, and whether they are able to make use of that knowledge to name new objects.

We made use of a research paradigm "Pokémonastics," initiated by Anonymous (2018*b*), later followed up on by various scholars (Anonymous, 2018*a*, 2019; Shih et al., 2018; Suzuki, 2017). This paradigm explores the sound symbolic nature of Pokémon characters. In Pokémon games, fictional creatures, themselves called "Pokémon," evolve into related characters. When they undergo evolution, they are called by a different name (e.g. *himbasu* → *mirukarosu*); they also generally get bigger, larger, and stronger. It has been found that there is a positive correlation between the number of voiced obstruents in the Pokémons' names on the one hand and their evolution levels on the other (Anonymous, 2018*b*). In other words, Japanese adults seem to associate voiced obstruents with the images of largeness, heaviness, and strengths, and use these sound symbolic associations when naming Pokémon characters. Later studies (Anonymous, 2018*a*, 2019) show that these sound symbolic patterns are productive in that adult Japanese speakers reproduce these sound symbolic patterns in experimental settings, when they are asked to name new, non-existing Pokémon characters. The current paper is a direct follow-up of these experimental studies, but

[3] See Nygaard et al. (2009) for the potential role of sound symbolism in second language learning.

with a new focus on Japanese children.

2 Method

In the current study, we presented Japanese children with pairs of (non-existing, nonce) Pokémon characters, in which one character is the pre-evolution version and the other one is the post-evolution version. They were also presented with two possible names and asked to choose which name is more appropriate for the pre-evolution version, and which name is more appropriate for the post-evolution version.

2.1 Stimuli

This experiment had five conditions, following Anonymous (2018*a*):

(1) Experimental conditions
- (a) [i] vs. [a]
- (b) [u] vs. [a]
- (c) voiceless obstruents vs. voiced obstruents
- (d) Combination of (a) and (c)
- (e) Combination of (b) and (c)

The first condition tested whether [a] would be more likely to be associated with the post-evolution version of Pokémon characters than [i]. This would be the case, if Japanese children possess sound symbolic knowledge in which [a] is bigger than [i] (Jespersen, 1922; Sapir, 1929; Ultan, 1978; Shinohara and Kawahara, 2016), and are able to apply that knowledge when naming new characters. Whether [u] is associated with image of size larger than [a] is less clear from the previous studies of sound symbolism, although there have been observations that high vowels are generally considered to be larger than low vowels (Newman, 1933; Shinohara and Kawahara, 2016).[4] The third condition tested the sound symbolic values of voiced obstruents in Japanese children; as discussed in the introduction, Frequency Code Hypothesis (Ohala, 1984, 1994) predicts that, due to their low frequency energy, voiced obstruents should be associated with images of largeness and heaviness. Recall also that in actual Pokémon names, there is a positive correlation between the number of voiced obstruents in their name and their evolution levels. The last two conditions (d) and (e) tested the combined effects of the vocalic sound symbolism and the consonantal sound symbolism.

[4] In the corpus of existing Pokémon names, high vowels in initial syllables tend to be associated with lower evolution levels; however, the effect size is very small and not significant statistically (Anonymous, 2018*b*).

Table 1: The stimuli

(a) [i] vs. [a]	(b) [u] vs. [a]	(c) voiceless vs. voiced obstruents
[kiiki] vs. [kaaka]	[tsuutsu] vs. [taata]	[jasaha] vs. [ɡebiki]
[ɕiiɕi] vs. [saasa]	[nuunu] vs. [naana]	[mesonu] vs. [dadera]
[miimi] vs. [maama]	[kuuku] vs. [kaaka]	[kejajo] vs. [zedotɕi]
		[tsusoki] vs. [zoʑike]
		[munere] vs. [zadoja]
		[ɸureju] vs. [ʑiboru]
(d) (a)+(c)	(e) (b)+(c)	
[piipiɴ] vs. [baabaɴ]	[pumpuu] vs. [bambaa]	
[kiikiɴ] vs. [ɡaaɡaɴ]	[sunsuu] vs. [zanzaa]	
[ɕiiɕi] vs. [zaazaɴ]	[tsuntsuu] vs. [dandaa]	

The actual stimuli used in the experiment are provided in Table 1. Within each pair, two nonce words always have the same prosodic structure (mora-wise and syllable-wise). In conditions (a) and (b), the phonemic status of consonants were controlled, although affrication and palatalization in front of [i] and [u] were unavoidable, due to phonotactic constraints in Japanese phonology (Vance, 2008). For condition (c), we made use of an online nonce word generator that randomly combines Japanese syllables;[5] this was in order to avoid any bias that experimenters may have in selecting the stimuli for experiments on sound symbolism (see Westbury 2005 for a cautionary remark about choosing stimuli for sound symbolic experiments).

2.2 Task

Within each trial, the participants were visually presented with a pair of pre-evolution and post-evolution Pokémon characters. To make clear to the participants that post-evolution Pokémon characters are generally larger, they were 1.5 times larger than the pre-evolution version. An example pair of the visual stimuli is given in Figure 1. These visual stimuli were drawn by a digital artist, *toto-mame*, whose Pokémon pictures are judged to be very authentic by Pokémon practitioners.[6]

The participants were also provided with a pair of two nonce names in Japanese orally read by a female experimenter (those in Table 1), and asked to choose which name is better suited for the pre-evolution character and which name is better suited for the post-evolution character.

[5] `http://bit.ly/2iGaKko`

[6] These pictures were used with permission from the artist. Her website, where one could view other original Pokémon characters, can be found at `https://t0t0mo.jimdo.com`.

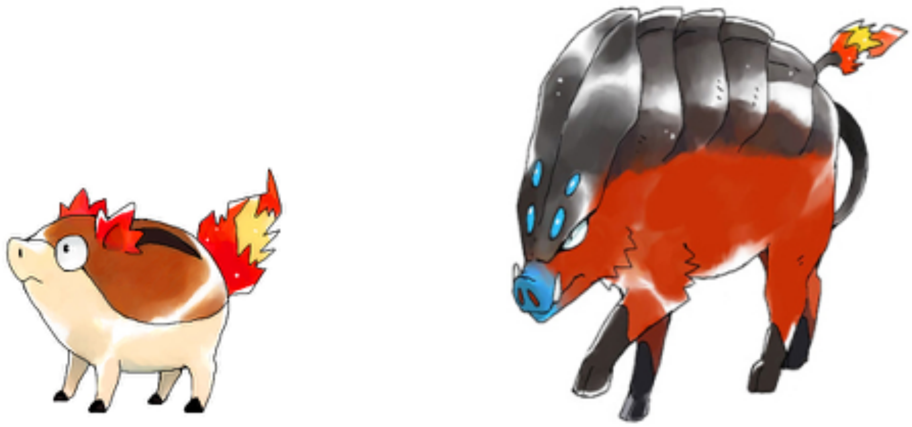

Figure 1: An example of visual stimuli. Left, pre-evolution character; right, post-evolution character.

2.3 Participants

The participants were 24 native speakers of Japanese (6;1-6;11, average 6;7), all from Tokyo or surrounding area. They participated in the experiment in March before they start elementary school. They were all female, as this experiment was conducted as a part of a larger projected, and for other aspects of the project, it was necessary that they were all female.

2.4 Procedure

All the trials were registered using Surveymonkey. One female experimenter sat with each participant to walk through the experiment. The experimenter first asked if they knew Pikachu, and all the participants did. The experimenter then asked if they knew more about Pokémon, and if their response was negative, the experimenter explained what Pokémon is, including the fact that when Pokémon characters evolve, they generally become bigger, larger, and stronger. After that, we showed the participants a website with many Pokémon pictures, and asked how many Pokémon characters they can name. This response was coded on a 7-point scale where one end was "they can name almost all characters" and the other end was " they only know Pikachu". The participants were also asked if they were watching the Pokémon anime that was on the air at the time of the experiment.

The participants went through all the trials with the experimenter(s). Although the two name choices were written in Japanese *katakana* orthography on Surveymonkey, these orthographic prompts were not shown to the participants, and instead they were read aloud by the experimenters, so that the participants base their judgments based on auditory information rather than on orthography. The order of two choices, as well as the order of the trials, were randomized per participant by Surveymonkey.

3 Result and discussion

Table 2 shows the ratios of expected responses; i.e., responses in which [a] is associated with the post-evolution characters and/or in which voiced obstruents are associated with the post-evolution characters. Since the responses were binary, 95% Confidence Intervals (CIs) are calculated based on binomial distributions. If these CIs do not overlap with 0.50, it implies that responses are skewed in such a way that they are higher than chance level.

Table 2: Expected response ratios. Averages and 95% confidence intervals.

	(a)	(b)	(c)	(d)	(e)
average	0.65	0.47	0.85	0.71	0.79
95% CIs	0.60-0.71	0.41-0.52	0.82-0.88	0.65-0.76	0.74-0.83

We observe that in all conditions expect for (b), the responses are above chance level. The result for condition (a) suggests that Japanese children consider [a] to be a better much for post-evolution characters than [i]. This result is likely rooted in the sound symbolic relation identified by Sapir (1929) that [a] is perceived larger than [i].

The result for condition (b) did not significantly deviate from chance level. It may be the case that as Ohala (1984, 1994) hypothesizes, the images of size are largely dictated by F2 at least for Japanese children; since Japanese [a] and [u] do not differ much in terms of F2 ([a]=1383 Hz; [u]=1419 Hz, according to the measurement reported in Keating and Huffman 1984), they did not differ in terms of images of size, hence the current results. With this said, a similar study by Anonymous (2018*a*) found that Japanese adults tend to associate names with [a] with the post-evolution characters than names with [u]—it may be possible that children attend to acoustic properties only, whereas adults attend to articulatory properties as well so that they take degrees of oral aperture into account and judge [a] to be larger than [u]. This is admittedly a post-hoc speculative hypothesis, which needs to be tested against other sound symbolic patterns in other languages.

The expected responses in condition (c) are highest amongst all the conditions tested—recall that this condition consisted of pairs of three light syllables, one name containing no voiced obstruents, and the other name containing voiced obstruents in the first two syllables. The expected responses ratios are 85%, which indicates that Japanese children can associate voiced obstruents with post-evolution characters.

The results for conditions (d) and (e) were also higher than chance, although they were lower than condition (c). The fact that the conditions (d) and (e)—which tested the combined sound symbolic effects of vowels and voiced obstruents—showed lower expected response ratios than condition (c) is somewhat surprising. We need to remain speculative at this point, but it may be the case that condition (c) involved two types of voiced obstruents (except for [dadera]), whereas (d) and (e) involved two occurrences of one voiced obstruent. That is, repeating the same type of voiced obstruents twice may not have as much impact as having two different types of voiced obstruents.[7] This speculation is worth testing in future studies of sound symbolism.

One final question that needs to be addressed is whether the positive results obtained in this experiment came from exposure to the actual Pokémon names, rather than from abstract sound symbolic knowledge.[8] To examine this possibility, Figure 2 shows the correlation between familiarity with Pokémon (which was asked before the experiment) and the expected response ratios, together with a linear regression line and its 95% confidence intervals. If the patterns of sound symbolism observed in the current experiment derive from the existing Pokémon names, there should be a positive correlation between the two. We observe that there is absolutely no correlation between the two measures ($r = 0.01, n.s.$); i.e. it is unlikely that the current results arise from knowledge with actual Pokémon names.

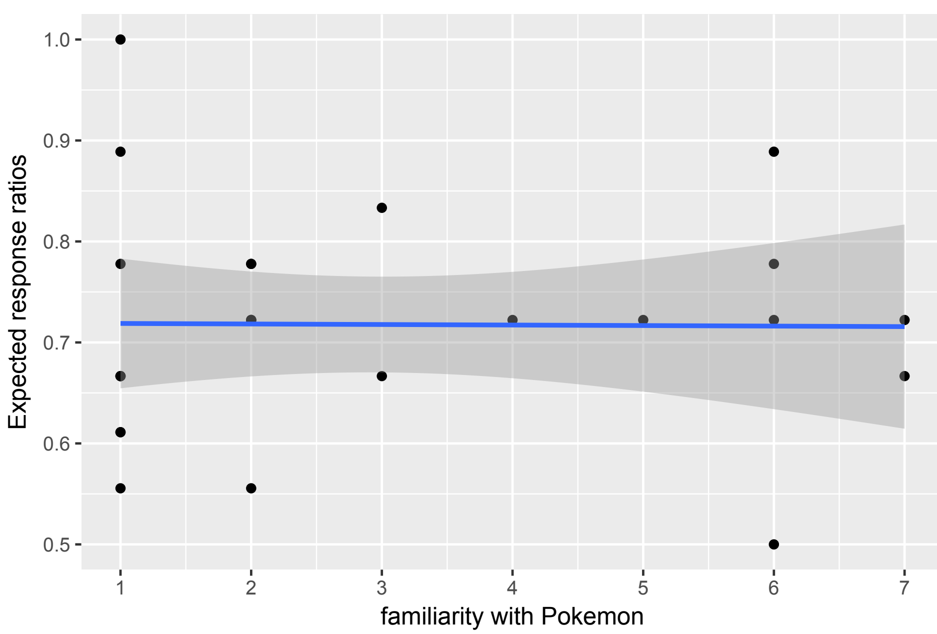

Figure 2: The correlation between familiarity and expected response ratios.

Figure 3 compares the distribution of expected response ratios between the two groups: (1)

[7] This speculation predicts that [dadera] should show lower expected responses than the other items that involve two voiced obstruents. This prediction is unfortunately not borne out.

[8] This question is a reminiscent of a similar question in theoretical phonology: whether phonotactic knowledge is based on abstract phonological grammar or they can be learned from the statistics in the lexicon (see e.g. Berent et al. 2007 vs. Daland et al. 2011).

those children who watch the Pokémon anime and (2) those who do not. There does not seem to be any substantial differences between the two groups (Wilcoxson test, $W = 67.5, p = 1$).

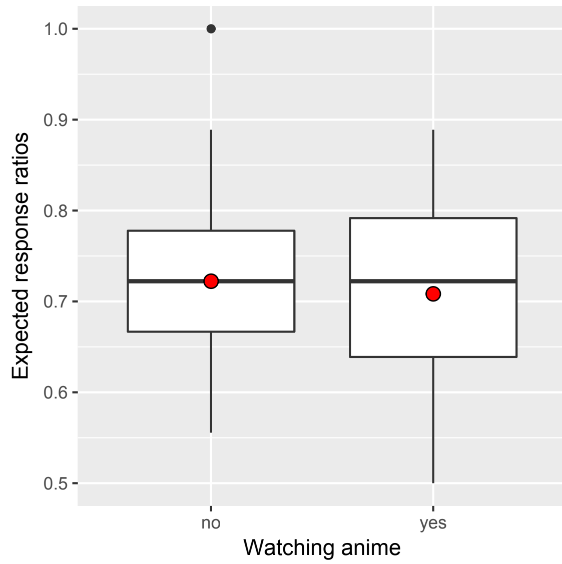

Figure 3: Comparison between those who watch the Pokémon anime and those who do not.

4 Conclusion

The contribution of the current paper may be modest; yet it is important in that we have shown that (i) Japanese children, before explicit school education on Japanese in elementary school, possess knowledge of certain sound symbolic patterns, and (ii) they can use that knowledge to name new objects (i.e. Pokémon characters). Since the study of acquisition of sound symbolism pattern is yet limited in its empirical coverage, we believe that it is a non-trivial contribution in and of itself. The difference between children and adults in terms of the comparison between [a] and [u] is also intriguing—it shows that at least the current participants do not yet possess the sound symbolic knowledge that [a] is larger than [u] (or maybe they do but they fail to execute it), which Japanese adults demonstrably have. This observation raises an important question of what triggers the acquisition of sound symbolic patterns.

Another contribution of the current project is to have shown the lack of correlation between familiarity with Pokémon and observed effect sizes of the sound symbolic patterns, which implies that knowledge of sound symbolism is sufficiently abstract. We do not deny the possibility that sound symbolic knowledge can be learned from the lexicon; indeed, the current participants may have learned the sound symbolic values of vowels and voiced obstruents from the Japanese lexicon, and this scenario is even likely, given that not all sound symbolic patterns are universal (Blasi et al., 2016; Diffloth, 1994; Kim, 1977). Our conclusion is more nuanced—they can apply their sound symbolic knowledge in order to choose Pokémon's names, even if that knowledge itself may not come from the exposure to Pokémon.

We would like to end this paper with a final remark on experimental methodology. This Pokémonastic paradigm is fun to do for children (as well as adults, for which see Anonymous 2019). Our impression is that among all the experiments conducted at the same setting, the children enjoyed this experiment the most. We thus hope that this Pokémonastic paradigm is used more widely in future acquisition studies more generally.

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