Expressing evolution in Pokémon names: Experimental explorations[*]

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Abstract

There has been a growing interest in sound symbolic patterns in natural languages, in which some sounds are associated with particular meanings. A previous corpus-based research identified some specific sound symbolic relationships in Pokémon naming patterns in Japanese (Anonymous, 2016). One of the main findings was that the names of Pokémon characters are more likely to contain voiced obstruents and are longer in terms of mora counts, when the Pokémon characters undergo evolution (e.g. *nyoromo* → *nyorozo*; *poppo* → *pijotto*). The current study reports three experiments that test whether (i) these patterns are productive in the minds of general Japanese speakers, and whether (ii) the same tendency holds with English speakers. The results show that the effect of phonological length was clearly observed both with Japanese and English speakers; the effects of voiced obstruents were observed clearly with Japanese speakers, but less clearly with English speakers. Along the way, we address other general issues related to sound symbolism: (iii) to what extent the sound symbolic effects identified in Anonymous (2016) rely on familiarity with Pokémon, and (iv) whether word-initial segments invoke stronger images than word-internal segments. In addition to its research value, we emphasize that this general project on Pokémon names can be useful for undergraduate phonetics education.

[*]The materials presented in this paper have been used in introductory phonetics/linguistics class at International Christian University, Keio University, Kwansei Gakuin University, Otsuma University and Tokyo Metropolitan University; this paper was also presented as invited lectures at Keio University, Meio University, Seoul International Phonology Conference, and Tokyo Institute for Advanced Studies of Language (TEC). Students and audience at these occasions provided extremely helpful feedback for this general project on the sound symbolic effects in Pokémon names; they also helped us confirm that this is a great teaching material to use to introduce phonetic concepts and statistical techniques. We thank two anonymous reviewers, as well as Lisa Davidson and Yasuyo Minagawa, who provided constructive written comments on previous versions of this paper. We are grateful to Donna Erickson for proofreading the manuscript. Last but not the least, we would like to thank Ms. *toto-mame* for letting us use her pictures for the current experiments, and for letting us reproduce some of them in this paper. The remaining errors are ours.

1 Introduction

1.1 Synopsis of the paper

This paper reports on an experimental case study of sound symbolism, patterns in which particular sounds are associated with particular meanings (Sapir 1929 *et seq*). The empirical target of the current study is the names of Pokémon characters, building on the corpus-based study previously reported in Anonymous (2016). Pokémon is a game series which has been very popular, especially among young children. Its first series was released in 1996, and continues to be very popular in Japan and across the world. The name "Pokémon" is etymologically a truncated compound of *poke(tto)* 'pocket' and *mon(sutaa)* 'monster'; in Pokémon games, players collect and train Pokémon monsters, and battle with others.

In the Pokémon games, many though not all Pokémon characters undergo evolution, and parameter-wise, they generally get stronger, heavier and larger after evolution (see below for detailed illustration). When Pokémon characters undergo evolution, they are called with new names; some actual examples are given in (1)

(1) Name changes observed in Pokémon character evolution. Voiced obstruents are underlined.

a. *nyoromo* → *nyoro<u>z</u>o*

b. *poppo* → *pi<u>j</u>otto*

c. *mokoko* → *<u>d</u>enryuu*

d. *manene* → *<u>b</u>ariyaa<u>d</u>o*

Anonymous (2016) studied more than 720 Japanese Pokémon names (all the characters in the 1st - 6th generations, excluding some duplicates) from the perspective of sound symbolism, and found that the names of post-evolution Pokémon characters are (i) more likely to include voiced obstruents and (ii) are longer in terms of mora counts. As a next step after this corpus study, this paper reports a series of experiments that explore the productivity of these sound symbolic associations.

1.2 Theoretical background: Studies on sound symbolism

We start this paper with a brief overview of the studies of sound symbolism in order to situate the current work in a broad theoretical context. Whether sounds themselves have meanings or not has been a matter of debate since the time of Plato; in the dialogue *Cratylus*, we find the discussion of whether particular sounds can be associated with particular meanings. For example, Socrates argues that Greek ρ (=r) is often used to represent words that are related to movement, η (= ee) represents something long, and that σ (=s) and ζ (=z) represent "winds" and "vibrations"

(Plato, *Cratylus*; in particular, see 423B, 426-427). In modern linguistics, the relationship between sounds and meanings was assumed to be arbitrary, which was formulated as the first principle of languages by Saussure (1916) (see also Hockett 1959 for a similar claim). Possibly due to the influence of Saussure's thesis, the study of sound symbolism did not flourish in theoretical linguistics. In generative frameworks of linguistics, the separation between sounds and meanings is usually taken for granted—PF (Phonetic Form) and LF (Logical Form) are separate levels of representation, mediated by syntax (Chomsky, 1981, 1986, 1995), but as far as we know, there is nothing in syntax—or in the lexicon, for that matter—that systematically connects sounds and meanings (except for possible cases like [+focus] feature that connects phonetic prominence and semantic focus; see e.g. Selkirk 1995).

However, not everybody who works on languages embraces the view that sound-meaning relationships are strictly arbitrary. A pioneering experimental study by Sapir (1929) shows that English speakers are more likely to associate *mal* with a bigger object and *mil* with a smaller object. Later studies following up on Sapir's work have shown that generally speaking, across many languages, front vowels tend to be perceived to be smaller than back vowels, and higher vowels tend to be perceived to be smaller than lower vowels (e.g. Berlin 2006; Coulter and Coulter 2010; Jakobson 1978; Jespersen 1922; Newman 1933; Shinohara and Kawahara 2016; Ultan 1978 among many others; see Diffloth 1994 for a potential counterexample). Another classic observation was made by Köhler (1947) within the tradition of Gestalt Psychology, who showed that a nonce word like *maluma* is likely to be associated with a round object, whereas a nonce word like *takete* is likely to be associated with a spiky, angular object. Studies inspired by Köhler's observation generally show that again in several different languages, obstruents tend to be associated with angular objects, whereas sonorants tend to be associated with round objects (Hollard and Wertheimer, 1964; Kawahara et al., 2015; Koppensteiner et al., 2016; Lindauer, 1990; Nielsen and Rendall, 2013; Shinohara et al., 2016). This observation is now also actively studied under the rubric of the *bouba-kiki* effect (Ramachandran and Hubbard, 2001), in which labiality of /b/ and /u/ may cause the image of roundness (D'Onofrio, 2014; Fort et al., 2015; Maurer et al., 2006; Ramachandran and Hubbard, 2001; Sidhu and Pexman, 2015).

Recent work has moreover explored the implications of sound symbolism in both first and second language acquisition (Tzeng et al., 2016; Imai et al., 2008; Nygaard et al., 2009), its interaction with formal grammatical systems (Alderete and Kochetov, 2017; Kochetov and Alderete, 2011), language evolution (Berlin, 2006; Ramachandran and Hubbard, 2001), language universals (Blasi et al., 2016; Dingemanse et al., 2013; Wichmann et al., 2010), and even the application of sound symbolism in marketing (Abels and Glinert, 2008; Bolts et al., 2016; Coulter and Coulter, 2010; Klink, 2000; Peterson and Ross, 1972; Yorkston and Menon, 2004). Currently, many phoneticians, psychologists and cognitive scientists are conducting research on sound symbolism (see the website by Kimi Akita for comprehensive bibliography lists: `http://bit.ly/2jsm5WG`). See Dingemanse (2012), Dingemanse et al. (2015), Lockwood and Dingemanse (2015) and Sidhu and Pexman (2017) for more extended reviews. In short, while languages can associate meanings and sounds in an arbitrary way, as Saussure (1916) and Hockett (1959) formulated, there can be stochastic tendencies to connect sounds and meanings in systematic ways as well. This non-arbitrary connection between sounds and meanings is now actively examined from a variety of perspectives.

Against this general theoretical background, Anonymous (2016) studied sound symbolic patterns in the actual Japanese Pokémon names. One of the main findings, reproduced here as Figure 1, is that when a Pokémon character undergoes evolution, its name is more likely to contain voiced obstruents and its name is more likely to be longer in terms of mora counts. Many Pokémon characters undergo evolution, at most twice, and when they do, they generally get stronger, heavier, and larger (see Figure 3 for details). In Figure 1, these evolution levels are coded as "0" (no evolution), "1" (1 step of evolution), and "2" (2 steps of evolution). Some Pokémon appeared as a pre-evolution version of an already existing Pokémon in a later series, which is called "a baby Pokémon". In Figure 1, such "baby" Pokémon characters are coded as "-1". The y-axes represent the average number of voiced obstruents (left) and the number of mora counts (right) in their names. Moras are basic prosodic units in Japanese, which include a vowel (optionally preceded by a consonant), a coda nasal, and the first half of a geminate (Ito, 1989; Kubozono, 1999).[1]

[1] Moras, rather than segments or syllables, are used in Anonymous (2016) and in this paper as a measure of length, because moras are demonstrably the most psycholinguistically prominent prosodic units for Japanese speakers (Otake et al. 1993, though cf. Cutler and Otake 2002 and Kawahara 2016). Most importantly, Japanese speakers use moras, instead of segments or syllables, when they consciously count "the number of sounds".

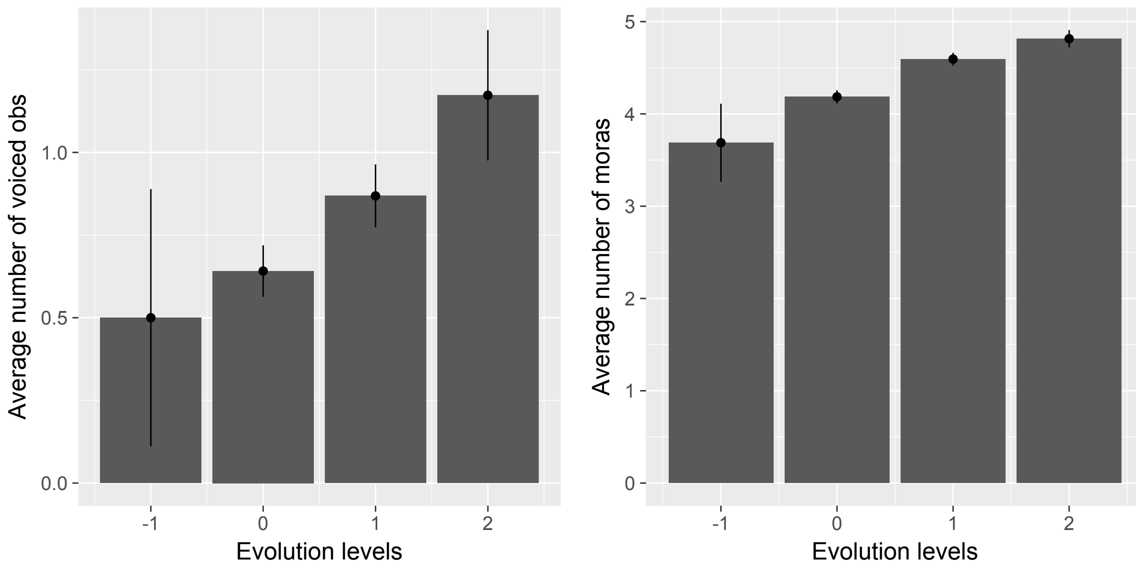

Figure 1: The correlations between evolution levels on the one hand and the number of voiced obstruents in their name (left) and the number of moras (right), found in the corpus study (Anonymous, 2016). The error bars represent 95% confidence intervals.

Anonymous (2016) thus observes that in the existing set of Pokémon characters, evolution is sound-symbolically represented by the presence/number of voiced obstruents in their names, as well as by the number of mora counts. However, one question that is unresolved in Anonymous (2016) is whether these effects are simply conventions deployed by the Pokémon designers, or intuitions shared by general Japanese speakers more broadly. In this paper, we therefore explore whether the specific sound symbolic patterns found in Anonymous (2016) are productive in the minds of general Japanese speakers.

We would like to emphasize at this point in the paper that, in addition to its research value, this project can be extremely useful in phonetics education. Phonetics is sometimes hard to teach in undergraduate education, because it could be overwhelming to some students, as it involves physiology (e.g. the structure of a larynx), mathematics (e.g. dB as a log function of Pascal) and physics (e.g. FFT in acoustic analyses). However, since many students are familiar with Pokémon, this project is useful in lowering the psychological boundary to learning phonetic concepts for some students. It is hoped that this paper also helps students to experience how linguistic experiments can be conducted using fun materials, like Pokémon names. We will come back to the potential educational application of these materials at the end of the paper.

1.3 Specific hypotheses tested

In the experiments that are reported in this paper, we aim to test some specific hypotheses about sound symbolism. The first is the Frequency Code Hypothesis, proposed and developed by Bauer (1987) and Ohala (1984, 1994), and later extended by other researchers (Berlin, 2006; Gussenhoven, 2004, 2016; Nuckolls, 1999; Shinohara and Kawahara, 2016). This hypothesis states that sounds with low frequency energy imply large objects, while sounds with high frequency energy imply small objects. These connections arise because of the physical law of vibration, in which the size of a vibrator is inversely proportional to the frequency of the sound that it generates; a bigger object emits lower-pitched sounds. Since voiced obstruents involve low frequency (closure voicing during constriction and low f0 and low F1 in surrounding vowels) (Diehl and Molis, 1995; Kingston and Diehl, 1994, 1995; Lisker, 1978, 1986; Raphael, 1981; Stevens and Blumstein, 1981), the Frequency Code Hypothesis predicts that voiced obstruents should invoke images of largeness. Indeed the acoustic study reported in Kawahara (2006) shows that Japanese voiced obstruents involve low frequency; Shinohara and Kawahara (2016) show that Japanese speakers judge voiced obstruents to be larger than voiceless obstruents. In the context of Pokémon characters, since evolved characters tend to be larger, it is predicted that voiced obstruents are more likely to appear in the evolved Pokémon names. Anonymous (2016) has shown that this prediction is indeed born out in the existing corpus of Pokémon names (Figure 1, left)—our study is set out to test the productivity of the sound symbolic relationship between voiced obstruents and largeness, predicted by the Frequency Code Hypothesis. Since the Frequency Code Hypothesis is based on psychoacoustics, it should in principle hold in any language, unless it is overridden by some other principles. We thus target Japanese speakers (Experiments I and 2) and English speakers (Experiment 3) to test this hypothesis in the current paper.

The second specific hypothesis that is tested in this paper is what Anonymous (2016) refers to as the "longer-is-stronger" principle. Anonymous (2016) found that in the existing Pokémon names, more evolved Pokémon characters tend to have longer names (Figure 1, right). This "longer-is-stronger" principle, found in the Pokémon names, may be a specific case of what is more generally known as "iconicity of quantity" (Haiman, 1980, 1985), in which "largeness" is expressed via phonological length. An example of quantitative iconicity in natural languages is found, for example, in comparatives and superlatives in Latin (e.g., long(-us) 'long' $<$ long-ior 'long-er' $<$ long-issim(-us) 'long-est'). Many languages, including Japanese, express plurality, repetition and intensification using reduplication, which is also an example of quantitative iconicity (Haiman, 1980). Both in Japanese and Siwu, vowel lengthening expresses "long-ness" (Dingemanse et al., 2015). In short, there is some evidence that in natural languages, longer words tend to imply larger magnitude. To what extent this "longer-is-stronger" principle is productive in Pokémon names is the second hypothesis that is tested in this paper.

An alternative explanation of the observation in the right panel of Figure 1 is that in Japanese, male names tend to be longer than female names (Mutsukawa, 2016). Post-evolution characters usually have high physical strength parameters—in the existing Pokémon character set, the correlation between the evolution levels and the sum of strength parameters is significant ($\rho = 0.51, p < .001$). In addition, "being physically strong" may be prototypically associated with masculinity. Therefore, since male names are longer in Japanese, evolved Pokémon names could become longer, mediated by the fact that masculinity and Pokémon evolution are both associated with physical strengths. This hypothesis makes a prediction that is testable with English speakers: in English, male names tend to be shorter than female names (Cutler et al., 1990; Wright et al., 2005), and therefore, if this hypothesis is correct, English speakers should prefer shorter names for post-evolution Pokémon characters. Distinguishing between the "longer-is-stronger" principle and the sound symbolic relationships generally deduced from the length differences in male names and female names is thus addressed in Experiment 3 with English speakers.

Another issue that is addressed in the current research is whether the sound symbolic patterns found in Anonymous (2016) are something that naive Japanese speakers—those who are not familiar with Pokémon—also have. In other words, are the sound symbolic patterns solely in the minds of Pokémon designers? Or do they exist more generally in Japanese speakers? We address this question by examining the familiarity with Pokémon among the participants in Experiment 2. This is particularly important, because, for example, the Frequency Code Hypothesis predicts that voiced obstruents should invoke large images, regardless of the speakers' language background, or familiarity with Pokémon. Similarly, to the extent that quantitative iconicity—or the "longer is stronger" principle—is at work in natural languages, the effects of name length should also be observed for those speakers who are not familiar with Pokémon. By examining the behavior of those speakers who are not familiar with Pokémon, we can address the generality of the sound symbolic effects found in Anonymous (2016).

Finally, experimentation allows us to address one important question regarding sound symbolism, which has not been extensively discussed in the previous literature on sound symbolism: namely, positional effects. We know from a large body of psycholinguistic experiments that word-initial elements—be they segments or syllables—impact speech production and processing more than word-internal elements (Browman, 1978; Brown and MacNeill, 1966; Cole, 1973; Kawahara and Shinohara, 2011; Marslen-Wilson, 1975; Mattys and Samuel, 2000; Nooteboom, 1981). We also know that this psycholinguistic prominence of initial elements affect the phonology of many languages in non-trivial ways (Beckman, 1998; Becker et al., 2012; Hawkins and Cutler, 1988; Kawahara et al., 2002; Smith, 2002). A natural question that arises is whether the same positional asymmetry holds in sound symbolism. As far as we know, there is only one study that directly addressed this issue. Kawahara et al. (2008) showed via experimentation that in Japanese, voiced obstruents invoke stronger images in word-initial position than in word-medial position. Experiment 2 in the current study, by varying the position of voiced obstruents, helps us to address the issue of whether word-initial voiced obstruents cause stronger images than word-internal voiced obstruents, ála Kawahara et al. (2008).

2 Experiment 1

The first task was a free elicitation task. In this task, the participants were presented with a pair of novel Pokémon characters, one pre-evolution version and the other post-evolution version. Within each trial, they were asked to name the pre-evolution and the post-evolution versions. This free elicitation task has been deployed in some previous studies of sound symbolism (e.g. Berlin 2006; Kumagai and Kawahara 2017; Shinohara et al. 2016). A more common paradigm in the studies of sound symbolism may be a forced-choice task, which we report in Experiment 2, but it has a potential danger of the sound symbolic effects potentially "depend[ing] largely on the experimenter pre-selecting a few stimuli that he/she recognizes as illustrating the effects of interest" (Westbury, 2005, p.11) (see also Dingemanse et al. 2016 for related discussion). To avoid this problem, we started with a free naming task.

2.1 Method

2.1.1 Procedure

The participants were first told that the experiment was about naming new, non-existing Pokémon characters. They were asked to freely name each Pokémon character, given a few restrictions. First, they were asked to use *katakana* orthography, which is used for nonce words in the Japanese orthographic system. This instruction was given to discourage the participants from using real words, as sound symbolic patterns would be more likely to emerge with nonce words than with real words, because the sound-meaning relationships in real words are generally arbitrary (Hockett, 1959; Saussure, 1916). The participants were also asked not to simply decribe the Pokémon characters using English words (e.g. *baado* for a bird-looking Pokémon character, or *doggu* for a dog-looking character). They were also asked to avoid using existing Pokémon names (to the extent that they know them). They were also asked to avoid expressing evolution with existing prefixes like *mega* "mega", *gureeto* "great" or *suupaa* "super", or expressing pre-evolution versions with such prefixes as *mini* "mini" or *beibii* "baby". They were instructed to use different forms for a pre-evolution and a post-evolution version.

In the main trial session, within each trial, they were given a pair of pre-evolution and post-evolution versions of Pokémon characters; a few examples of the visual prompts are provided in

Figure 2 for the sake of illustration. All the visual stimuli were drawn by a semi-professional digital artist, *toto-mame*.[2] The pictures were judged by many Pokémon players to "look like real Pokémon." Within each pair, the two Pokémon characters are drawings of the same motif (e.g. bat or dog), so that it is clear that each pair is related via evolution.

Figure 2: Sample stimulus pairs of pre-evolution and post-evolution Pokémon characters, which were used in the three experiments reported in this paper. The pictures are produced in the paper with the permission of the drawer.

2.1.2 Participants and data analysis

The experiment was conducted as an online survey using SurveyMonkey.[3] A total of twenty pre- vs. post-evolution Pokémon pairs were presented. The order of the trials was randomized per participant. Two participants reported that they had studied sound symbolism; their data were excluded, in order to exclude any potential bias due to their knowledge about sound symbolism. One participant used the same name for both pre-evolution and post-evolution characters, and another participant used too many mono-moraic names, which were judged to be too unnatural for Japanese names; although there are mono-moraic common nouns in Japanese (e.g. *ki* 'tree': Ito 1990), Japanese proper names are usually at least two-mora long (see Poser 1990). Responses

[2] The artist's website can be found at: `https://t0t0mo.jimdo.com`.

[3] `https://www.surveymonkey.com`

from these speakers were excluded. The data from 108 participants remained for the following analysis.

In addition, some specific responses were also excluded. For example, some post-evolution characters were expressed via affixation (e.g. *girasu* → *dosu-girasu*). We excluded all of these cases of affixation in order to be conservative, regardless of whether these affixes are existing affixes in Japanese or not. Prefixation with *dosu*, for example, necessarily increases the number of voiced obstruents and mora counts.[4] There were some cases in which the post-evolution name is a complete superset of the pre-evolution name (i.e. it looks like infixation; e.g. *kurin* → *kurion*). Although infixation does not exist as a productive morphological process in Japanese, we also excluded such cases, again to be conservative (infixation necessarily results in increased mora counts).[5] Cases in which pre-evolution and post-evolution were expressed via different existing prefixes (*ko* "small" vs. *oo* "big") were also excluded, because such cases were clearly semantics-driven. Finally, a few cases in which the responses did not follow Japanese phonotactics, such as superlong vowels or sequences of two coda nasal consonants, were excluded. The remaining responses consisted of 1,855 pairs of Pokémon names.

2.2 Results

Consistent with the results of Anonymous (2016), the overall average mora counts increased from the pre-evolution version (3.90) to the post-evolution version (4.56). Likewise, the overall average number of voiced obstruents increased from 0.44 to 0.80. Some illustrative examples are given in (2) (where "-" represents a mora boundary; voiced obstruents are shown with underlines):

(2) Some illustrative examples

a. *ri-ri-i-ra* (4 moras) → *yu-re-i-do-ru* (5 moras)

b. *hu-p-po* (3 moras) → *hu-pi-i-gu-ru* (5 moras)

c. *gu-u-su* (3 moras) → *gu-re-go-ri-a-su* (6 moras)

d. *hu-mi-ru-ka* (4 moras) → *bu-u-ze-ru-ga* (5 moras)

[4]We would like to note, however, that the use of this prefix (*dosu*) is in conformity with the sound symbolic patterns that we are investigating (in particular, the Frequency Code Hypothesis) in that it contains a voiced stop, /d/. Therefore, the exclusion of all affixes may be too conservative, as participants may have chosen (pseudo-)affixes that are appropriate, in terms of sound symbolism, to express evolution. We nevertheless decided that being conservative is the best choice in the current experiment. If and how morphological derivation can be used to express evolution is an interesting topic of its own, which is, however, beyond the scope of the current investigation. See Ohyama (2016) for some relevant discussion.

[5]There are cases in real Pokémon pairs in which evolution is expressed via affixation (e.g. *koiru* → *rea-koiru*; *sando* → *sando-pan*). Therefore, it is not too surprising that the current participants sometimes resorted to morphological affixation to express evolution. However, we believe that it is more conservative to exclude such cases. See also Anonymous (2016) for the discussion of how (quasi-)morphological derivations may or may not be involved in real Pokémon naming patterns.

The results thus support the findings by Anonymous (2016) that the post-evolution Pokémon characters are more likely to be assigned with names that have voiced obstruents and also have higher mora counts.

To statistically assess the impact of these two factors on the pre- vs. post- evolution distinction, a logistic linear-mixed model was run with subject and item as random factors, and mora counts and the number of voiced obstruents, as well as their interaction, as fixed factors. The dependent variable was the pre-evolution vs. post-evolution distinction.[6] The results reveal that the effect of mora counts was highly significant ($\beta = 0.74, z = 14.69, p < .001$), which indicates that longer names, measured in terms of mora counts, are more likely to be associated with the post-evolution characters. The effect of voiced obstruents was also significant ($\beta = 1.56, z = 6.97, p < .001$), indicating that the more voiced obstruents a name contains, the more likely it was used for a post-evolution character.

The interaction term between the the number of voiced obstruents and mora counts was also significant ($\beta = -0.23, z = -4.50, p < .001$); the significance of this interaction term indicates that the degrees to which voiced obstruents are associated with post-evolution characters vary depending on how long the names are. To interpret this interaction in detail, as post-hoc multiple comparisons, we fit a logistic linear mixed model for each mora length, and examined the effects of voiced obstruents on the pre- vs. post- evolution distinction. The estimates of the coefficient indeed changed as a function of mora length: 2 mora ($\beta = 0.91, z = 2.54, p < .05$), 3 mora ($\beta = 1.02, z = 6.66, p < .001$), 4 mora ($\beta = 0.61, z = 7.84, p < .001$), 5 mora ($\beta = 0.57, z = 5.32, p < .001$), 6 mora ($\beta = 0.11, z = 0.56, n.s.$), 7 mora ($\beta = 0.20, z = 0.62, n.s.$), 8 mora ($\beta = 0.37, z = 0.63, n.s.$) and 9 mora ($\beta = -0.20, z = -0.29, n.s.$). These analyses show that names with voiced obstruents are more likely to be used for post-evolution characters, as long as the names are 5 moras or shorter; for names that are longer, we cannot conclude that names with voiced obstruents are more likely to be associated with post-evolution characters.

The analyses so far treated as if Pokémon characters related via evolution as if they are independent of one another. In order to compare related Pokémon characters more directly, we then compared the names of the two Pokémon character names within each pair. This is analogous to a "within-subject" analysis in more standard experimentation. To do so, for each pair, we coded whether mora counts and the number of voiced obstruents increased, decreased, or stayed constant. The skew was assessed by a χ^2-test against the null hypothesis that distributions in the three conditions are uniform (i.e. the expected values were $N/3$). Since a χ^2-test can only tell us whether there is skew somewhere in the whole table, the χ^2-test was followed by residual analyses, which

[6] An alternative analysis would be to treat the evolution status as the independent variable and examine how it impacts the distribution of voiced obstruents and mora counts. The virtue of the current analysis is that it allows us to analyze the effects of voiced obstruents and mora counts in the same statistical model, which is impossible in the alternative analysis.

test whether the observed value in each cell is statistically higher or lower than expected by chance. Table 1 illustrates the results of these statistical analyses.

Table 1: The breakdown of within-pair analyses with post-hoc residual analyses.

	# of vcd obs		mora counts	
increase	707 (38%)	$< .01(\uparrow)$	1,034 (56%)	$< .001(\uparrow)$
decrease	182 (10%)	$< .001(\downarrow)$	189 (10%)	$< .001(\downarrow)$
constant	966 (52%)	$< .001(\uparrow)$	632 (34%)	$n.s.$
total	1,855		1,855	

Overall, the skew in Table 1 is significant in terms of the number of voiced obstruents ($\chi^2(2) = 320.1, p < .001$), and mora counts ($\chi^2(2) = 333.0, p < .001$). These χ^2-tests show that the observed distributions significantly differ from what is expected by chance. Furthermore, the post-hoc residual analyses reveal that for both the number of voiced obstruents and the mora counts, "the increase category" is overrepresented, whereas "the decrease category" is underrepresented. These results show that the number of voiced obstruents and mora counts are more likely to increase—and less likely to decrease—than by chance, from the pre-evolution state to the post-evolution state. These results again confirm the psychological reality of the patterns identified by Anonymous (2016).

2.3 Discussion

In light of the hypotheses discussed in section 1.3, the results are first of all compatible with the prediction of the Frequency Code Hypothesis (Ohala, 1984, 1994), which suggests that sounds with low frequency energy should generally be perceived to be large. Recall that voiced obstruents are characterized by low frequency energy during their constriction, as well as low f0 and low F1 in surrounding vowels (Kingston and Diehl 1994; Stevens and Blumstein 1981—see Kawahara 2006 for the acoustic data in Japanese). The Frequency Code Hypothesis predicts, therefore, that voiced obstruents should imply large objects because of their low frequency components. As shown in Figure 3, in the Pokémon world, Pokémon characters generally become larger and heavier after evolution ($\rho = 0.51, p < .001$ and $\rho = 0.42, p < .001$). Therefore, it would not be too mysterious that the presence and the number of voiced obstruents can be significant factors in naming post-evolution Pokémon characters.

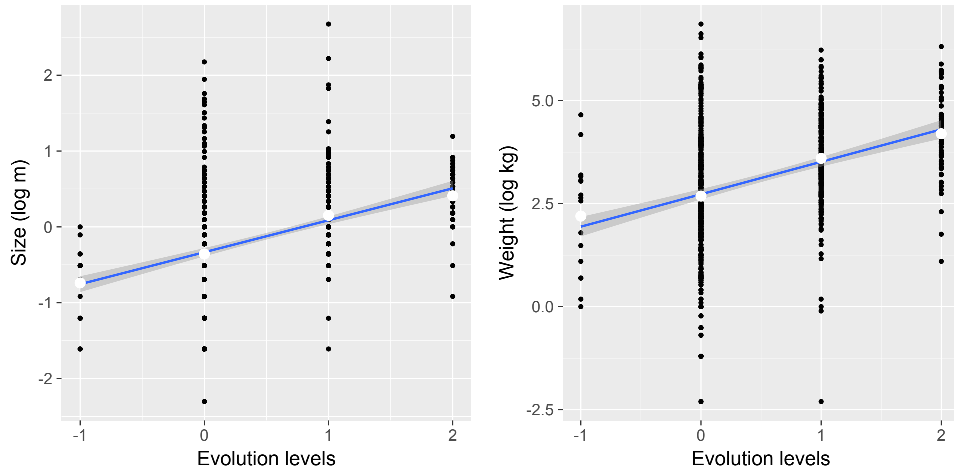

Figure 3: The correlations between evolution levels on the one hand, and size (left) and weight (right) on the other, in the existing Pokémon characters. Y-axis values are log-transformed, as the raw values are right-skewed (Anonymous, 2016). The white dots represent the average in each condition. The correlations in each panel are significant at $< .001$ level by a non-parametric Spearman test.

The results are also compatible with the "longer-is-stronger" principle (Anonymous, 2016), in that longer names are more likely to be associated with post-evolution Pokemon characters. The results, however, are also compatible with the hypothesis that evolved Pokèmons' names are longer, because in Japanese, male names tend to be longer than female names (Mutsukawa, 2016). We will tease apart these two hypotheses in Experiment 3. However, regardless of what the basis of the sound symbolic pattern is, the experiment confirms the productivity of the relationship between mora counts and the evolutionary status in Pokémon, found in Anonymous (2016).

3 Experiment 2

In order to further confirm the productivity of the sound symbolic patterns identified in Experiment 1 and Anonymous (2016), a forced-choice task experiment was run as Experiment 2. Although the forced-choice task format may potentially have a disadvantage of the experimenters selecting those stimuli that they already think would work before the experiment (Westbury, 2005), it also has the virtue of allowing experimenters to control parameters that are of interest. For example, we can use strictly mono-morphemic nonce words, which avoids the problem of affixation that came up during the analysis of Experiment 1 (and also in the analysis of Anonymous 2016). Another virtue is that we can vary the position of a voiced obstruent, thereby allowing us to address the issue of positional effects in sound symbolism, discussed in section 1.3. Also, this task is easier for the participants than the elicitation task—it is easier to choose from the options provided than to come up with new names from scratch. Hence, we were able to include more trials in this experiment than in Experiment 1. In order to address the potential concern of the stimuli being possibly biased by the experimenters, we used a random name generator.

3.1 Method

3.1.1 Stimuli

The experiment had four conditions: the first two conditions tested the effect of voiced obstruents, and the next two conditions tested the effect of mora counts. Each condition had 10 items. The list of the stimuli is provided in the Appendix. We avoided using minimal pairs—while minimal pairs would probably have shown clearer results, using minimal pairs would easily reveal the targets of the experiment to the participants.

In the first condition, the pairs of names contrasted in terms of the presence of a voiced obstruent, with both of the names being three mora long (e.g. *mureya* vs. *zuhemi*). The position of a voiced obstruent was varied across the first, second and third position, in order to examine the positional effect in sound symbolism, discussed in section 1.3. The second condition tested the number of voiced obstruents, in such a way that one item contained one voiced obstruent and the other contained two voiced obstruents (e.g. *bonechi* vs. *gudeyo*). In the third condition, one name was three moras long with all light syllables (e.g. *sa-ki-ro*) and the other name had a long vowel at the end, hence being four moras long (e.g. *ho-ki-ne-e*). The last condition compared four mora long names with five mora long names, all syllables being light syllables (e.g. *to-ku-su-hi* vs. *mo-no-he-hi-ta*). No voiced obstruents appeared in any of the stimuli for the last two conditions. All of the names were created by an online random name generator, which randomly combines Japanese (C)V-moras to create novel names (`http://bit.ly/2iGaKko`). Recall that this precaution was made in order to avoid the potential bias that we may have had in coming up with the stimuli. Since the name generator rarely produced a word-final long vowel, we created the stimuli with a long final vowel by lengthening the final vowels of CVCVCV output forms.

3.1.2 Procedure and Participants

Experiment 2 was also administered online using SurveyMonkey. As with Experiment 1, within each trial, the participants were presented with a pair of novel pre-evolution and post-evolution Pokémon characters (see Figure 2). They were asked which name should correspond to the pre-evolution version, and which name should correspond to the post-evolution version. The pictures used in this experiment were a superset of what was used in Experiment 1. There was a total of 40 questions. The order between the questions was randomized per participant. One participant was not a native speaker of Japanese. Another speaker reported that s/he studied sound symbolism before, and hence was excluded. The following analysis is based on the data from the remaining 80 speakers.

3.2 Results

Figure 4 shows the rates of expected responses averaged across all the participants, with the error bars representing 95% confidence intervals. Recall that the "expected responses" mean that the post-evolution Pokémon characters are associated with (1) a name with a voiced obstruent (leftmost bar), (2) a name with two voiced obstruents (2nd bar), (3) a name with a word-final long vowel (3rd bar) and (4) a name with 5 moras (the rightmost bar).

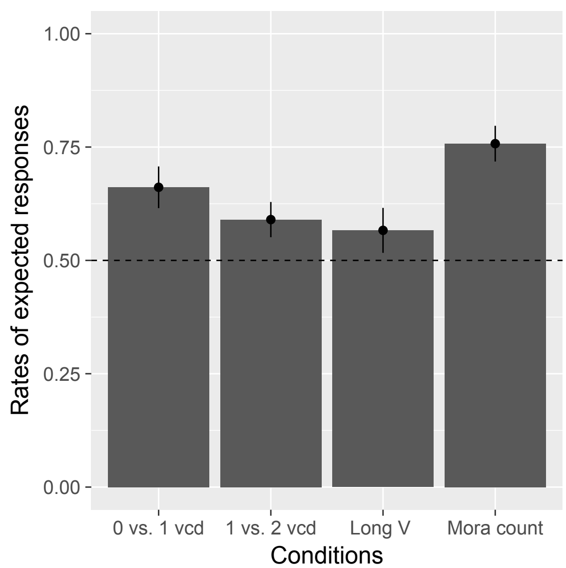

Figure 4: The rates of expected responses averaged across participants in Experiment 2. The error bars represent 95% confidence intervals.

For each condition, the averages are above the chance level (=0.5). A one-sample t-test compared the observed patterns against the null hypothesis that responses are random, which shows that all the bars are significantly higher than 0.5 (first bar: average=0.67, $t(79) = 7.42, p < .001$; second bar: average=0.60, $t(79) = 4.83, p < .001$; third bar: average=0.57, $t(79) = 2.55, p < .05$; fourth bar: average=0.76, $t(79) = 13.1, p < .001$).

These statistical tests show that Japanese speakers chose (1) names with a voiced obstruent, (2) names with more voiced obstruents, (3) names with a final long vowel, (4) names with an extra CV mora, for post-evolution Pokémon characters, and they do so above the level that is expected by chance. We note, however, that the effect sizes are not very large, the averages distributing around and above 0.6, except for the last condition which seems more robust (above 0.75). This observation may not be very surprising given that sound symbolic patterns are, after all, stochastic.

3.3 Discussion

3.3.1 The sound symbolic effects

The first two conditions in Figure 4 show that Japanese speakers are sensitive to both the presence and the number of voiced obstruents when choosing names of post-evolution Pokémon characters. These results further corroborate the conclusions of Experiment 1 and those of Anonymous (2016). The results are also compatible with the prediction of the Frequency Code Hypothesis—voiced obstruents, which are characterized with low frequency, should invoke large images. In the context of Pokèmon naming, names with voiced obstruents are better suited for post-evolution characters. The second bar shows that at least for Japanese speakers, the effects of voiced obstruents are cumulative in that two voiced obstruents are better suited for post-evolution Pokémon names than one voiced obstruent.

The last two conditions in Figure 4 show that Japanese speakers are sensitive to mora counts of names, when deciding which option is better for post-evolution Pokémon characters—longer names are better suited for post-evolution Pokémon names. These results are also compatible with the finding in Experiment 1 and Anonymous (2016), although again, this experiment, like Experiment 1, does not tell us about *why* this sound symbolic relationship holds. Overall, in terms of effect size, out of all the four conditions, the addition of a CV mora is the most robust (the fourth bar).

Since the effect sizes were otherwise not very large, we explored the data further in terms of inter-speaker variation, using a boxplot shown in Figure 5.

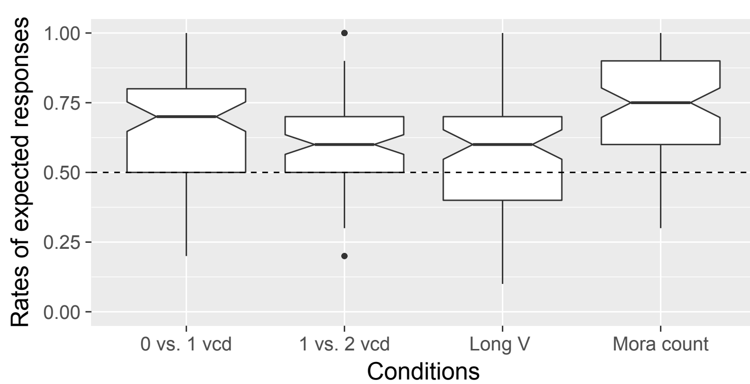

Figure 5: A boxplot showing the distribution of the rates of expected responses (Experiment 2). The chance level is shown with a dotted line.

Figure 5 shows that there are participants whose scores are below the chance level (the dotted line). The lower lines of the boxes (25% percentile) are placed near or below the 50% chance line, except for the last condition, which indicates that there was a non-negiligble amount of speakers who did not follow the expected sound symbolic patterns. Especially, there seems to be a large inter-speaker variability for the long vowel condition (the third plot).[7] The overall results thus suggest that not everybody chose Pokémon's names based on the specific sound symbolic patterns that we have been discussing (the presence/number of voiced obstruents and mora counts). It could be the case that, some other sound symbolic factors or analogies to some existing names, whose exact natures are yet to be found out, have blurred the results.[8]

3.3.2 Reanalysis with only those who do not know Pokémon

The general conclusion that we can draw from the results so far is that the sound symbolic relationships observed by Anonymous (2016) are not simply a matter of conventions used by the Pokémon designers. As anticipated in section 1.3, however, one may object to this conclusion because the participants may have been familiar with the existing Pokémon names: we know from extensive previous studies that speakers can learn much—if not all—about phonology from exposure to lexicon (Daland et al., 2011; Ernestus and Baayen, 2003; Hay et al., 2003; Hayes and Londe, 2006). To address this question, we made use of a post-experimental questionnaire which asked how familiar they were with Pokémon using a 1-to-7 Likert scale where '1' was labeled as "never touched it" and '7' was labeled "Pokémon is my life". There were 17 speakers who chose the two lowest points in answer to this question. Figure 6 shows the results of these participants, which is very similar to what we observe in Figure 4. Statistically, all the responses but the third condition are higher than the chance level (from left to right: $t(16) = 6.10, p < .001; t(16) = 3.12, p < 0.01; t(16) = 1.55, n.s.; t(16) = 10.3, p < .001$).

[7] With hindsight, the small effect size of this condition may not be very surprising, given that in actual Pokémon names, long vowels do not substantially impact size or weight: see Appendix of Anonymous (2016). The re-analysis of the data in Anonymous (2016) shows that the correlation between the number of long vowels and evolution level is positive but barely significant ($\rho = 0.7, p = .06$).

[8] An anonymous reviewer pointed out a potential way to overcome this problem deploying a between-subject design experiment. To quote, "[t]his problem could perhaps be avoided by taking two nonce names for each pair, neither of which has the property in question, and adding the property to one of the names for half the participants and the other name for the other half. For example, 'mureya' vs. 'sumehi' $\rightarrow$ 'bureya/suhemi' for half the participants and 'mureya/zuhemi' for the other half. This would help control for other properties that might be adding sound-symbolic effects, because those should favor the form with the voiced obstruent ('bureya') in half the cases and the form without the voiced obstruent ('mureya') in the other half."

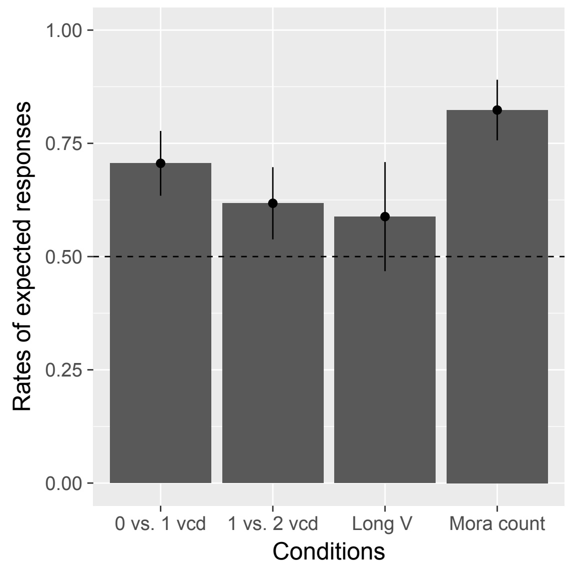

Figure 6: The results of Experiment 2 (those who are not familiar with Pokémon).

This analysis shows that at least for the first, second and fourth condition, the sound symbolic patterns hold without familiarity with Pokémon naming conventions. While we cannot exclude the possibility that these speakers learned these sound symbolic relationship from the entire Japanese lexicon (rather than "the Pokémon lexicon"), the results at least demonstrate that exposure to Pokémon is not necessary to exhibit the expected sound symbolic patterns.

3.3.3 Positional effects

In the first condition, the position of voiced obstruents was varied between C1, C2, and C3. As reviewed in section 1.3, a body of psycholinguistic work has demonstrated that word-initial positions are psychologically prominent (Browman, 1978; Brown and MacNeill, 1966; Cole, 1973; Kawahara and Shinohara, 2011; Marslen-Wilson, 1975; Mattys and Samuel, 2000; Nooteboom, 1981), and as such, privileged phonologically (Beckman, 1998; Becker et al., 2012; Hawkins and Cutler, 1988; Kawahara et al., 2002; Smith, 2002). Kawahara et al. (2008) investigated the positional effects in sound symbolism with Japanese listeners, and showed that voiced obstruents in word-initial position indeed cause stronger images than voiced obstruents in word-medial position. The current data from the first condition allows us to assess whether sound symbolism is more prominent in initial syllables than in non-initial syllables. To that end, Table 2 shows the results of each item of the first condition, broken down by item.

The results are not straightforward yet suggestive—two out of the three items in the C1 condition (*domana* and *zetemu*) show the highest expected responses, which is compatible with the prediction that voiced obstruents in word-initial position cause stronger sound symbolic effects

Table 2: The rates of expected responses, broken down by position of the voiced obstruent. Name 1=those names that include a voiced obstruent; Name 2=competitor; Name 1 Res. = the proportion of responses in which Name 1 was assigned to the evolved version of the Pokèmon.

position	C1	C1	C1	C2	C2	C2	C3	C3	C3	C3
name 1	domana	zuhemi	zetemu	negemu	mabiho	tazuri	furiba	tohoze	hafubi	ruyoga
name 2	hifuho	mureya	ritoha	matoha	mishimi	riyare	nehoma	tsurera	karuno	satora
name 1 res.	63	42	74	56	51	54	44	51	40	54

than word-internal ones (Kawahara et al., 2008). However, *zuhemi* behaves exceptionally in this regard—it showed one of the lowest expected response ratios. The data is thus not conclusive; new experiments with Pokémon, with further items, can shed new light on the issue of positional effects in sound symbolism.

4 Experiment 3

The final experiment targeted English speakers, with the same set of stimuli as Experiment 2. The purposes of this experiment were (i) to explore the question of the universality of sound-symbolic patterns observed so far, and (ii) to address the hypothesis that longer names are chosen for the post-evolution characters because Japanese male names are longer than female names. Recall that in English, if the length difference between male names and female names is responsible for the observed sound symbolic effect, the opposite pattern should hold, because male names are generally shorter than female names in English (Cutler et al., 1990; Wright et al., 2005).

4.1 Method

4.1.1 Stimuli

In order to make the cross-language comparison straightforward, the same set of stimuli as Experiment 2 was used, except that *koemuna* was replaced with *kosemuna*, because it was not clear whether an /oe/ sequence is phonotactically possible in English. In terms of stimulus presentation, word-final long vowels are expressed orthographically as “ar” for *aa*, “ey” for *ee*, “ie” for *ii*, “ow” for *oo*, and “ew” for *uu*. All other aspects of the experiment were identical to Experiment 2.

We admit at this point that we cannot be confident about how English speakers actually read the orthographic stimuli, which are psuedo-Japanese. An anonymous reviewer point out, for example, that a word-medial letter *e* can be read as “silent *e*”, which would coerce the preceding vowel to be a diphthong. Concretely, given *kosemuna*, English speakers may have read it as [kɔwz.mʊw.nə], which consists of three syllables rather than four. Whether "ar" was read as a long final vowel is also questionable, given that some dialects drop word-final "r" (e.g. McCarthy 1993).[9] Also, when English speakers count the "length" of names, it is more likely that they count syllables rather than moras. Given these limitations, it is necessary that we interpret the results of Experiment 3 with caution. Nevertheless, we believe that it is interesting to obtain the data from English speakers, using the (almost) same set of stimuli. A follow-up experiment with English speakers should be run, ideally after the corpus analysis of English Pokèmon names (for which see the conclusion section below). We hope to situate Experiment 3 as a stepping-stone for better Pokèmon experiments with English speakers in the future.

4.1.2 Participants

The call for participants was announced on the authors' SNS pages, which were shared by their colleagues. The instructions of the experiment were almost identical to that of Experiment 2, except that they were given in English. The participants were told that since the stimuli were "pseudo-Japanese," they were to imagine that they were working for a Japanese company for coming up with Pokémon names for the next generation. A surprisingly high number of participants (=33) reported that they had studied sound symbolism. The reason may be because the call for participants was advertised by a number of university professors and graduate students, and there may have been several student participants who learned about sound symbolism in their linguistics or psychology class. After removing these participants, 68 naive speakers remained for the analysis.

4.2 Results

Figure 7 shows the ratios of expected responses averaged across all the English-speaking participants. All but the second conditions show responses that are higher than the chance level (=0.5) to a statistically significant degree (from left to right: average=0.55, $t(67) = 2.35, p < .05$; average=0.48, $t(67) = -0.80, n.s.$; average=0.55, $t(67) = 2.24, p < .05$; average=0.79, $t(67) = 7.05, p < .001$).

[9] We unfortunately did not ask for dialects of the participants, so a by-dialect analysis is impossible.

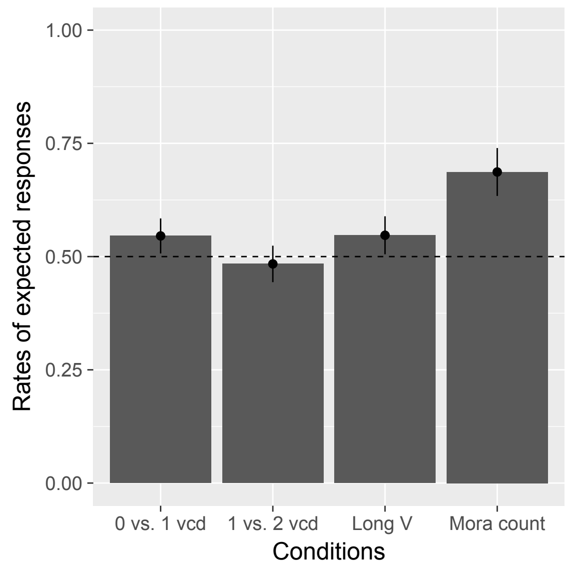

Figure 7: The ratios of expected responses averaged across the English-speaking participants (Experiment 3).

The first bar shows that English speakers, like Japanese speakers, are more likely to choose a name with a voiced obstruent for post-evolution Pokémon characters. The second bar shows, however, that English speakers did not choose names with two voiced obstruents to be more appropriate for post-evolution Pokémon characters than names with one voiced obstruent. The third condition shows that long vowels at the word-final positions—despite the fact that some of these may have not been strictly perceived as long—make the names more appropriate for post-evolution Pokémon characters. Finally, the fourth bar shows that English speakers, like Japanese speakers, tended to chose longer names for post-evolution Pokémon characters.

Though statistically significant, the responses—except for the last condition—are barely above chance. As the box plot in Figure 8 shows, the medians are on the chance level for the second and third conditions; 50% of the people showed less than the half of expected responses.

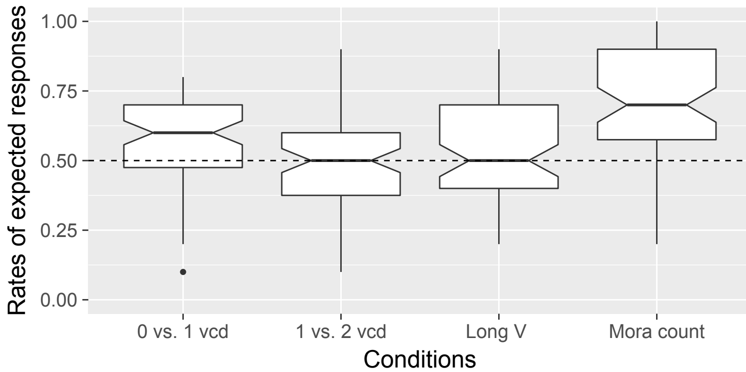

Figure 8: A boxplot of the results of Experiment 3.

4.3 Discussion

First, as observed in the rightmost bar in Figure 7, it seems safe to conclude that the addition of a CV mora in the stimuli robustly influences the judgment of the post-evolution Pokémon names even for English speakers, although we should bear in mind that what influenced the behavior of English speakers may be syllable counts—or segment counts—rather than mora counts. Be that as it may, we can still conclude that longer names tend to be associated with post-evolution Pokèmon characters. This result helps us to tease apart the two hypotheses about why longer names are associated with evolved Pokémon characters. The "longer is stronger" principle, which is arguably a specific case of quantitative iconicity (Haiman, 1985, 1980), is compatible with the results that are observed for the English speakers. On the other hand, we can reject the hypothesis that because in Japanese male names are longer than female names, longer names are favored for more evolved Pokèmon characters in the Japanese Pokèmon lexicon. This hypothesis predicts that English speakers should behave the opposite way, because in English male names are shorter (Cutler et al., 1990; Wright et al., 2005). The actual result shows that this prediction is false.

The effect of the presence of a voiced obstruent was significant (the first bar in Figure 7). Previous studies (Newman, 1933; Shinohara and Kawahara, 2016) showed that English speakers associate voiced obstruents with large images, like Japanese speakers, and therefore it is not too surprising that English speakers would also associate voiced obstruents with Pokémon characters after evolution, although the effect size is small. The results are also compatible with the Frequency Code Hypothesis (Ohala, 1984, 1994), as English voiced consonants too are characterized by low frequency (e.g. Lisker 1978, 1986), and hence should invoke the images of large size. However, no sensitivity to the difference between one vs. two voiced obstruents was observed, unlike Japanese speakers. On the one hand, it seems that the null hypothesis is that the Frequency Code Hypothesis should predict cumulative effects—"two low frequency sounds" should be larger than "one low frequency sound". On the other hand, there may have been some abstraction at work in such a way that only the presence/absence of voiced obstruents may matter (see the next section for some related discussion).

Overall, the effect sizes in Experiment 3 are very small (about 5% above chance for the first and third conditions). The boxplot shows that some speakers were not at all sensitive to the sound symbolic patterns under investigation. We used stimuli that are "psuedo-Japanese", as the original Pokémon names are in Japanese. Therefore, it would be interesting to follow up with an experiment with more English-like nonce words. As stated above, we hope that the current experiment will be used as a stepping-stone toward more Pokémon experimentation with English speakers.

5 Overall conclusion

The current experiments have found that (some) Japanese speakers associate voiced obstruents and higher mora counts to post-evolution Pokémon characters. Some English speakers too showed similar patterns, although the results were not as clear as those of Japanese speakers. These results confirm the previous corpus-based study (Anonymous, 2016), and further strengthen the existence of sound symbolic patterns in Pokèmon naming conventions. Experiment 2 further shows that those who are not very familiar with Pokémon also show the same sound symbolic effects. However, we also note that not every participant followed the sound symbolic rules we examined, which suggests a more nuanced view of sound symbolism. It probably suggests that the effects of voiced obstruents and mora lengths—not too surprisingly—do not entirely determine how Pokémon characters are named. There was also a large inter-speaker variability in terms of to what degrees they follow the sound-symbolic principles—the inter-speaker variation in sound symbolism is a topic that has been understudied, and needs more attention in future research.

More generally, we believe that what we found in this study, as well as in Anonymous (2016), is a tip of an iceberg. There are many more remaining tasks for this general project on the sound symbolic patterns of Pokémon names. The first one is the analysis of existing Pokémon names in English, which is on-going.[10] Whether Japanese and English show the same sound symbolic patterns in their respective Pokémon lexicon is an interesting question to pursue, given the different results we obtained between Experiments 2 and 3. Other sound symbolic factors may have been at work in Experiments 2 and 3, which could have resulted in the observed small effect sizes.

The overall results suggest the possibility that there may be sound symbolic patterns that are shared across languages (Blasi et al., 2016; Shinohara and Kawahara, 2016) as well as those that are language-specific (Diffloth, 1994; Garrigues, 1995; Saji et al., 2013). On the one hand, the

[10] Collaborative research with Drs. Sharon Inkelas, Darya Kavitskaya, Stephanie Shih, Alan Yu is on-going, as of 2017. Once we reveal the sound symbolic patterns of English Pokémon names, we can polish up Experiment 3 to test more specific hypotheses.

phonological length effects—the addition of a CV syllable—were very robust for both Japanese and English speakers. On the other hand, the difference between one vs. two voiced obstruents was observed only with Japanese speakers. We are looking forward to addressing the issue of universality and language specificity of sound symbolic patterns with speakers with different language background. Since Pokémon is translated into many different languages, and people from many different language backgrounds are familiar with Pokémon, the sound symbolic study of Pokémon names offers a forum to investigate the issue of the universality and language-specificity of sound symbolic patterns. In general, the current results raise interesting questions for future research in sound symbolism.

On this note, an anonymous reviewer raised an interesting—and as far as we know, new—hypothesis on sound symbolism, which is that evolution (in Pokémon names) is expressed via *phonological markedness*. Although the notion of markedness is sometimes taken to be too ambiguous and elusive (Haspelmath, 2006), we can, for the sake of discussion, take it to mean "a structure that is assigned a violation mark by a markedness constraint" within Optimality Theory (Prince and Smolensky, 2004) (see Alderete and Kochetov 2017 for an analysis of sound symbolism within Optimality Theory). A violation of a markedness constraint can coerce a phonological change to eliminate that structure. For example, a voiced obstruent is marked in the sense that there are languages that avoid voiced obstruents all together (e.g. Hawai'ian; Pukui and Elbert 1979, see also Hayes and Steriade 2004). In Japanese, the occurrence of two voiced obstruents within a morpheme is actively avoided, the effects known as Lyman's Law (Lyman, 1894; Vance, 2007). In some views, long words are marked because of a reason that is related to prosodification (McCarthy and Prince, 1994). In short, those structures that are associated with post-evolution Pokémon names can all be viewed as being marked in some sense.[11]

This theory has an extra virtue of explaining why in Experiment 3, English speakers did not show a difference between one vs. two voiced obstruents, whereas in Experiment 2, Japanese speakers did show this difference. The reason may be that Japanese, but not English, actively avoids two voiced obstruents within a morpheme; i.e. that configuration is marked specifically in Japanese. Kawahara (2008) indeed argues that the markedness constraint against two voiced obstruents is not innate or universal, but specific to Japanese. This hypothesis opens up new lines of research in sound symbolism, making very specific predictions. If Pokémon were to be borrowed in Khoisan languages, for example, it is predicted that clicks should be used for post-evolution Pokémon names, as clicks are generally considered to be marked. In English, final-stress is rare and marked (Gelbart, 2005), and it is predicted that final-stress can be used for post-evolution Pokémon names. Front rounded vowels are demonstrably marked cross-linguistically (Flemming, 1995), and thus this theory predicts that German speakers would use front rounded vowels for the

[11] Of course, a question remains as to why phonological markedness is associated with post-evolution state.

post-evolution Pokémon characters. In general, this is a new theory of sound symbolism, which is worth pursing more extensively in future studies.

We would like to close this paper with one final remark. In addition to the research values of the current project, we would like to highlight its potential contribution to education in phonetics (as well as general linguistics and psychology). Perhaps many of us have experienced difficulty in teaching phonetics in undergraduate education. The challenge is partly due to the nature of the subject matter. In order to understand phonetics, it is necessary to have some background in mathematics and physics, which could be overwhelming to some. However, teaching the Frequency Code Hypothesis with Pokémon would be useful in teaching why it matters to talk about "low frequency energy."

Although we have not tested this quantitatively, our experience is that using this project as an illustration of phonetic research lowers the psychological boundary of learning phonetics for some students. The number of participants we gathered for this paper (ca. 200 Japanese speakers and 100 English speakers) is indicative—many were willing to volunteer in the online experiments because they thought that an experiment on Pokémon would be fun. Another piece of anecdotal evidence is that students have been inspired to look at other similar materials in Japanese pop culture, including Yookai Watch, Takaraduka Actresses names, and AKB idol nicknames, although these studies are still on-going (Anonymous 2018). Yet another piece of evidence comes from the fact that the first author was asked to write an article about this research for a general business journal[12] and also that he was interviewed by the university newspaper at his university.[13]

Another virtue that we have noticed while using this material in teaching is that analyses in sound symbolism necessarily require skills in quantitative analyses, as sound symbolism is never deterministic, but stochastic, due to the thesis of arbitrariness (Hockett, 1959; Saussure, 1916). Those students who worked on their own projects on sound symbolism, building on this current project on Pokémon, were very motivated to learn statistical analyses.

We hope that as we further explore the sound symbolic nature of Pokémon names, we will identify more sound symbolic patterns which can be deployed to teach more phonetic concepts. And we are optimistic about this possibility. Another aspect in which we find Pokémon to be useful to use in education is the fact that Pokémon has many features that we have not yet explored. For example, one student pointed out to us that some Pokémon characters are "legendary Pokémon", and asked whether some special sound symbolic patterns are used to express them. Another student told us that Pokémon characters are categorized into classes, such as "Fire", "Ice", and "Ghost", and asked whether there is "type-specific" sound symbolism. We have encouraged them to investigate these questions themselves. Students know aspects of Pokémon that we do not know, which allows students to actively participate in the discussion.This feature of Pokémon al-

[12] `URL_TO_BE_PROVIDED`

[13] `URL_TO_BE_PROVIDED`

lows students to come up with new topics of exploration themselves, thereby allowing us to engage in student-oriented exploration of new hypotheses.

Appendix

Table 3: The stimuli for Experiments 2 and 3.

condition 1	No voiced obstruents	1 voiced obstruent
	hifuho	*domana*
	mureya	*zuhemi*
	ritoha	*zetemu*
	matoha	*negemu*
	mishimi	*mabiho*
	riyare	*tazuri*
	nehoma	*furiba*
	tsurera	*tohoze*
	karuno	*hafubi*
	satora	*ruyoga*
condition 2	1 voiced obstruent	2 voiced obstruents
	bamachi	*bedeme*
	gasoyu	*zazohi*
	bonechi	*gudeyo*
	genefu	*darobe*
	goyamu	*goruzu*
	dosora	*dokuba*
	zeyuri	*berada*
	sozafu	*yabude*
	najiyo	*kuguji*
	hodamo	*neguzu*
condition 3	All light syllables	Final long vowel
	sakiro	*hokinee*
	sukihi	*muhuraa*
	saheshi	*kishimaa*
	tsumohi	*kutonaa*
	wasehe	*momuruu*
	samimu	*tsunokee*
	wakeya	*korunii*
	rihepi	*mekiree*
	soromo	*semafuu*
	raneho	*myusaroo*
condition 4	4 light syllables	5 light syllables
	hukoyota	*norutehume*
	tokusuhi	*monohehita*
	henaroho	*noshiyohoya*
	manoyaki	*miyarifuchi*
	mumotoke	*yaserenama*
	nushikoya	*haretamonu*
	harochifu	*homiherori*
	sunemaro	*taharohore*
	fuchikeho	*hisahemetsu*
	ko(s)emuna	*takimekama*

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