Sound symbolic patterns in Pokémon names*

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Abstract

This paper presents a case study of sound symbolism, cases in which certain sounds tend to be associated with particular meanings. We use the corpus of all Pokémon names available as of October 2016.

We tested the effects of voiced obstruents, mora counts, and vowel quality on Pokémon characters' size, weight, strength parameters, and evolution levels. We found that the number of voiced obstruents in Pokémon names correlates positively with size, weight, evolution levels, and general strength parameters, except for speed. We argue that this result is compatible with the Frequency Code Hypothesis (Ohala, 1984, 1994). The number of moras in Pokémon names correlates positively with size, weight, evolution levels and all strength parameters.

Vowel height is also shown to have an influence on size and weight—Pokémon characters with initial high vowels tend to be smaller and lighter, although the effect size is not very large.

Not only does this paper offer a new case study of sound symbolism, it provides evidence that sound symbolism is at work when naming proper nouns. In general, the materials provided in this paper are useful for undergraduate education in linguistics, phonetics and psychology to attract students' interests, as Pokémon is very popular among current students.

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1 Introduction

This paper offers a new case study of sound symbolic patterns, in which particular sounds tend to be associated with particular meanings or images (e.g. Blasi et al. 2016; Dingemanse et al. 2015; Hamano 1986; Hinton et al. 1994, 2006; Lockwood and Dingemanse 2015; Perniss et al. 2010; Sapir 1929; Sidhu and Pexman 2017 among many others). Although language is a system which can in principle combine any phonotactically permissible sound sequences to any meanings (the thesis of arbitrariness: Hockett 1959; Saussure 1916), there are some systematic exceptions. The claim that there can be connections between sounds and meanings goes back to Socrates, who argues in the dialogue *Cratylus* that Greek ρ (="r") is used in many words that express movement, that α (="a") means "large", and that o means "round", etc (Plato, *Cratylus*, 423B, 426-427). Modern research on sound symbolism was inspired by experimental work by Sapir (1929), who showed that English speakers feel /a/ to be larger than /i/. Since then, research has revealed many sound-meaning connections, which demonstrably hold across many languages (Blasi et al., 2016). For example, voiced obstruents (/b/, /d/, /g/, /z/) are often associated with "heaviness" and "largeness", and these associations have been shown to hold for English speakers (Newman, 1933) as well as for Japanese speakers (Hamano, 1986; Kawahara and Shinohara, 2012; Shinohara and Kawahara, 2016; Sidhu and Pexman, 2015) and for Chinese speakers (Shinohara and Kawahara, 2016).

It has also been demonstrated that sound symbolism can affect naming patterns (Berlin, 2006; Kawahara and Shinohara, 2012; Köhler, 1947; Perfors, 2004; Ramachandran and Hubbard, 2001; Sapir, 1929; Shinohara and Kawahara, 2013; Shinohara et al., 2016). For example, Köhler's classic study (1947) shows that, given a pair of a round object and an angular object, as in Figure 1, people tend to associate *maluma* with the former and *takete* with the latter (see Hollard and Wertheimer 1964; Kawahara et al. 2015; Koppensteiner et al. 2016; Lindauer 1990; Nielsen and Rendall 2013; Shinohara et al. 2016 for follow-up studies of this effect). It seems to be the case that in general, sonorants tend to be associated with round objects, whereas obstruents tend to be associated with angular objects (Shinohara et al., 2016). In a similar situation, a round object is more likely to be associated with *bouba* than with *kiki* (D'Onofrio, 2014; Fort et al., 2015; Maurer et al., 2006; Ramachandran and Hubbard, 2001; Sidhu and Pexman, 2015).

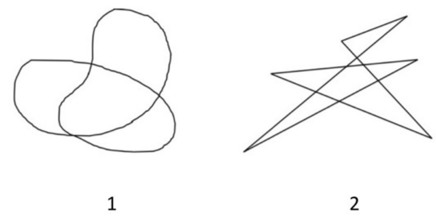

Figure 1: Schematic illustration of *maluma* and *takete* figures. A pair of a round object and an angular object; the former is more likely to be named *maluma/bouba* and the latter is more likely to be named *takete/kiki*. The figures are taken from Kawahara and Shinohara (2012), itself inspired by Köhler (1947).

Likewise, Berlin (2006) argues that sound symbolism is operative when naming animals and insects in many languages—for example, animals that move slowly tend to be named with sounds with low frequency energy, such as labial consonants and nasal consonants. For example, Berlin (2006) compares names of two kinds of birds—rail and tinamou, the latter of which moves slower—in 17 different languages. He found that both nasals and labials are more likely to be used for slow-moving tinamou (e.g. *mami* in Cuiba and *aawaa* in Bora) than for rail. The experiment reported in Perfors (2004) reveals that English male names with stressed front vowels are judged to be more attractive than those with back vowels, but English female names with stressed back vowels are judged to be more attractive than those with front vowels. A number of studies show that female and male names in English are (stochastically) distinguished by many phonological features (Brown and Ford, 1961; Cassidy et al., 1999; Cutler et al., 1990; Slater and Feinman, 1985; Wright and Hay, 2002; Wright et al., 2005), some of which are grounded in sound symbolic principles; for example, female names are more likely to contain sonorants than male names, an observation that may be related to why the round figure in Figure 1 is more likely to be called *maluma* than *takete*. All of these studies indicate that the choice of sounds in naming patterns is not entirely random, but rather governed, at least partially, by some sound symbolic principles. In addition, a growing body of work has also examined the impact of sound symbolism in brand names, and has shown that sound symbolism may affect the attractiveness of the products as well as the perception of their priciness (Abels and Glinert, 2008; Bolts et al., 2016; Coulter and Coulter, 2010; Klink, 2000; Peterson and Ross, 1972; Yorkston and Menon, 2004).

Building on this research tradition, we ask whether there are any sound symbolic effects in Japanese Pokémon names (cf. Miura et al. 2012 and Ohyama 2016 for previous linguistic analyses of Pokémon names). Japanese has a large class of mimetic words, which are sound symbolic (Hamano, 1986), and some Pokémon names are based on such mimetic words. For example, *gabu* represents an action of a “big bite”, and there is a Pokémon character named *gaburiasu*; likewise, *goron* is a mimetic word representing rolling movement, and a rock-like character Pokémon is named *goroon*. Therefore, Japanese offers an interesting test case to address whether Pokémon names show sound symbolic patterns (although we do not want to imply at this point that studying Pokémon names in other languages is uninteresting, which is contrary to what we hope; see the conclusion section).

Pokémon, whose name is etymologically a truncated compound of *poketto* 'pocket' and *monsutaa* 'monster', started as a video game in 1995 by Nintendo, and has been very popular in Japan and many other countries (see Tobin 2004 and the Wikipedia article[1] for details). Pokémon features fictional creatures, themselves called "Pokémon", who trainers can collect, train, and battle. One feature of the Pokémon game is that Pokémon characters evolve into different, related forms with new names. Although for copy-right reasons, we are unable to produce actual Pokémon pictures, Figure 2 presents a pair of pre- and post-evolution of (non-official) Pokémon characters, drawn by a digital artist.[2] (These pictures were judged by many Pokémon players to look authentic, and have been used for an experiment related to this study (Kawahara and Kumagai, to appear).) Each Pokémon character officially has size, height, and strength parameters, the last of which includes HP (for "Hit Point" = stamina), attack, defense, special attack, special defense, and speed.

Figure 2: A sample of pre- and post-evolution pair of Pokémon. Drawn by a digital artist, *totomame*.

As of 2016, there are more than 700 Pokémon characters in total, which is the target of the current study. The current corpus-based study suggests that there are indeed some systematic patterns in Pokémon characters' names, which can be considered to be sound symbolic. More specifically, we show that the number of voiced obstruents in Pokémon names positively correlates with a Pokémon character's size, weight, evolution levels, and general strength parameters, except for speed. The number of moras in Pokémon names positively correlates with size, weight, evolution levels and all strength parameters. Finally, Pokémon characters with high vowels in the initial syllables tend to be smaller and lighter, although its effect size is small; no apparent effects of vowel

[1] `https://en.wikipedia.org/wiki/pokemon`

[2] Her website can be found at: `https://t0t0mo.jimdo.com`.

quality on evolution levels or strength parameters are observed.

There are several reasons for using the corpus of Pokémon characters in order to explore sound symbolic patterns in naming patterns of proper names. First, there are more than 700 Pokémon characters, as of October 2016, guaranteeing enough data points for a quantitative analysis. Although there is an impressionistic observation in Japanese phonology that voiced obstruents are associated with heavy images (Hamano, 1986; Kawahara, 2015; Kubozono, 1999*b*), for example, there has not been a quantitative study on the sound symbolic pattern using a natural corpus.[3] Second, each Pokémon character has many numeric parameters, such as size, weight, and various strength parameters, which allow us to examine which parameters correlate with which sound properties. Third, most if not all current university students in Japan and other countries are familiar with Pokémon, so this is a very catchy topic to use in introductory linguistics, phonetics, and psychology classes. In the discussion section, we report evidence that this material indeed attracts interests from the general public, including university students.

This paper targets the effects of voiced obstruents, mora lengths, and vowel quality in initial syllables, but we by no means claim that these are the only sound symbolic patterns lurking behind the Pokémon naming systems in Japanese—interested students and researchers are welcome to follow up on our case study.

One final important caveat is in order. Pokémon names do sometimes include real, existing words in Japanese. For example, *hushigidane* consists of *hushigi* 'mysterious' and *tane* 'seed' (the first consonant of the second word becomes voiced by a morphophonological process called *rendaku*: Vance 2015; Vance and Irwin 2016). Since real words do not often follow sound symbolic relationships (the thesis of arbitrariness: Hockett 1959; Saussure 1916), we expected that the effects of sound symbolism would not be perfect. Nevertheless, as with other cases of sound symbolism, there could be stochastic tendencies. Principles of sound symbolism may even possibly affect the choice of real words in Pokémon naming in such a way that their names represent their characteristics, although this influence too would be stochastic, if present at all. To illustrate this point, let us take an actual Pokémon pre- and post-evolution pair, *goosuto* and *gengaa*, the second of which is the evolved version of the first. The first name is based on the English word *ghost*, and the second name is based on the German word *Gänger*. Why was it that the *gengaa*, rather than *goosuto*, was chosen as the name for the more evolved version of the character? One answer is that since *gengaa* contains more voiced obstruents than *goosuto*, it was chosen as a more suitable name for the evolved version of the Pokémon character. In this way, a sound symbolic principle may affect the choice of real words, but this principle too would be stochastic. For this reason, in order to examine sound symbolic patterns in Pokémon names, we take a statistical approach using

[3]There is some experimental work that supports this sound symbolic relationship in a quantitative fashion (Kawahara et al., 2008; Shinohara and Kawahara, 2016). Miura et al. (2012) also offers an analysis of Pokémon names using machine learning, who point out that voicing can be a relevant factor in determining strength parameters.

the large corpus.

2 Method

2.1 Hypotheses tested

This paper analyzes three types of sound symbolic effects: those of voiced obstruents, prosodic (mora) length, and vowel quality. Voiced obstruents include a set of sounds (/b/, /d/, /g/, /z/), which are produced with strong constriction or complete closure in the oral cavity—strong enough to result in aperiodic noise, frication or burst—accompanied with vocal fold vibration (see Kawahara 2006 for a detailed acoustic description of voiced obstruents in Japanese). Moras are basic prosodic units in Japanese (much like syllables in English), which include a vowel (optionally preceded by a consonant), a coda nasal, and the first half of a geminate (Ito, 1989; Kawahara, 2016; Kubozono, 1999*a*; Labrune, 2012; Vance, 1987). For example, [to-o-kyo-o] 'Tokyo' contains four moras, [ho-n-da] 'Honda' contains three moras, and [po-k-ki-i] 'Pocky' contains four moras (here and throughout, "-" represents a mora boundary). Moras, rather than segments or syllables, are used in the current analysis, as moras are psycholinguistically prominent prosodic units for Japanese speakers (Inagaki et al. 2000; Kureta et al. 2006; Otake et al. 1993, though cf. Cutler and Otake 2002; Kawahara 2016). Most importantly in this context, moras are units that are used by Japanese speakers when counting the number of sounds.

One reason to study the effects of voiced obstruents is that sound symbolic meanings of voiced obstruents are prevalent in Japanese (Hamano, 1986; Kawahara et al., 2008; Kawahara, 2015; Kubozono, 1999*b*; Shinohara and Kawahara, 2016). For example, there is a minimal pair in Japanese mimetic (or ideophonic) words, *goro-goro* and *koro-koro*—both of these words represent the state of a rock rolling; however, the former implies that the rolling rock is big and heavy (Hamano, 1986). Likewise, Kawahara (2015) observes that *gandamu*, a giant robot (about 15 m and 7500 kilograms) in a science fiction series anime, would sound very funny if we turn the voiced obstruents into voiceless obstruents, i.e. *kantamu*. In fact, *kantamu* is used as a name for a parody character in the anime *Kureyon Shinchan*, which looks very light. These examples illustrate that there is a clear sense in which voiced obstruents are associated with large and heavy images in Japanese.

These associations may have a phonetic basis, which makes sense under the Frequency Code Hypothesis, proposed and developed by Bauer (1987) and Ohala (1984, 1994) (see also Berlin 2006, Gussenhoven 2004, Gussenhoven 2016 and others, who extended this hypothesis). In this theory, sounds with high fundamental frequency (f0) imply small objects, whereas those with low f0, imply large objects, thus reflecting physical laws of sound vibration. Acoustically, voiced obstruents are characterized by low frequency during their constriction (Lisker, 1978, 1986; Raphael, 1981; Stevens and Blumstein, 1981), as well as in their surrounding vowels, especially in their low f0 and low F1 (Diehl and Molis, 1995; Kingston and Diehl, 1994, 1995; Lisker, 1986). The low frequency components of voiced obstruents would lead to large images, according to the Frequency Code Hypothesis, and everything else being equal, heavy ones.[4]

The effects of mora length came out during our data-mining stage. We noticed that those Pokémon characters with higher mora counts tend to have strong parameters, heavy and large. For example, *go-o-su-to* (four moras) is stronger than *go-o-su* (three moras); likewise, *nyo-ro-bo-n* (four moras) is stronger than *nyo-ro-zo* (three moras). Also, the pair, *pi-chu-u* and *pi-ka-chu-u*, is very telling. In the first generation, there existed only *pikachuu*; in the second generation, *pichuu* was added as a pre-evolved state of *pikachuu*. In this pair, the "weakness" of the pre-evolution state was expressed by the truncation of the second mora, *ka*. Therefore, there seems to be a "longer-is-stronger" principle in Pokémon naming conventions. In order to test this hypothesis more rigorously, we statistically examined the effects of mora counts in the corpus of Pokémon names. As far as we know, no previous studies have proposed sound symbolic relationships between word length on the one hand, and notions such as size and weight on the other (although see some examples of "quantitative iconicity" in natural languages discussed in section 3.2). Therefore, this is a new and interesting hypothesis to test in a quantitative fashion.

The final target of the analysis was vowel quality. The effects of vowel quality are arguably the most well-studied topic in the studies of sound symbolism. Sapir (1929), who inspired much of modern research on sound symbolism, showed that English speakers feel *mal* to be larger than *mil*. Jespersen (1922) discussed the sound symbolic nature of the vowel /i/, pointing out, among others, that it can imply images that are "small, slight, insignificant, or weak" (p. 557). An extensive body of work has revealed that cross-linguistically, high vowels tend to be judged to be smaller than non-high vowels, and front vowels, smaller than back vowels (e.g. Berlin 2006; Coulter and Coulter 2010; Jakobson 1978; Jespersen 1922; Newman 1933; Sapir 1929; Shinohara and Kawahara 2016; Ultan 1978 among many others). It may be that degrees of oral aperture and the size of the oral cavity in front of the constriction are projected onto the images of size. We thus explored the effects of vowel quality in Pokémon names. Since different Pokémon characters have different numbers of vowels, we analyzed the initial vowels, which are prominent psycholinguistically (Browman, 1978; Brown and MacNeill, 1966; Cole, 1973; Marslen-Wilson, 1975; Mattys and Samuel, 2000; Nooteboom, 1981).

[4]Some other work (Kawahara, 2015; Shinohara and Kawahara, 2016; Shinohara et al., 2016) proposes an articulatory explanation of why voiced obstruents may be considered to be large. The proposal capitalizes on the oral cavity expansion due to the aerodynamic complication involved in the production of voiced obstruents (Ohala, 1983; Proctor et al., 2010).

2.2 Analyses

For our analysis, we started with the corpus of the names of all the Pokémon characters available as of October, 2016.[5] To be conservative, we excluded those Pokémon names that are prefixed with *mega* ‘mega’. These Pokémon characters tend to be larger and heavier, and this prefix contains a voiced obstruent. Some Pokémon characters are distinguished only in terms of having a suffix *mesu* ‘female’ or *osu* ‘male’, and these are also excluded to avoid counting the same characters twice. There is one Pokémon character with four voiced obstruents (*jiguzaguma*), which was excluded. This is because we cannot get a reliable estimate for this condition with just a single item. After excluding these characters, 715 Pokémon names remained for the following analysis.

Each Pokémon character has its size (m) and weight (kg) specified. However, some Pokémon characters are outstandingly large and/or heavy. For example, *guraadon* is 3.5 m and 950 kg, while *pikachuu* is only 0.4 m and 6 kg. Since the distributions of these measures are heavily right-skewed, we took the natural log of these measures, which made the distributions less skewed, as illustrated in Figure 3.

[5] A matrix that includes all Pokémon names and their characteristics was first created based on the chart that was made available at the following website: `http://blog.game-de.com/pokedata/pokemon-data/` (last access, June 2017).

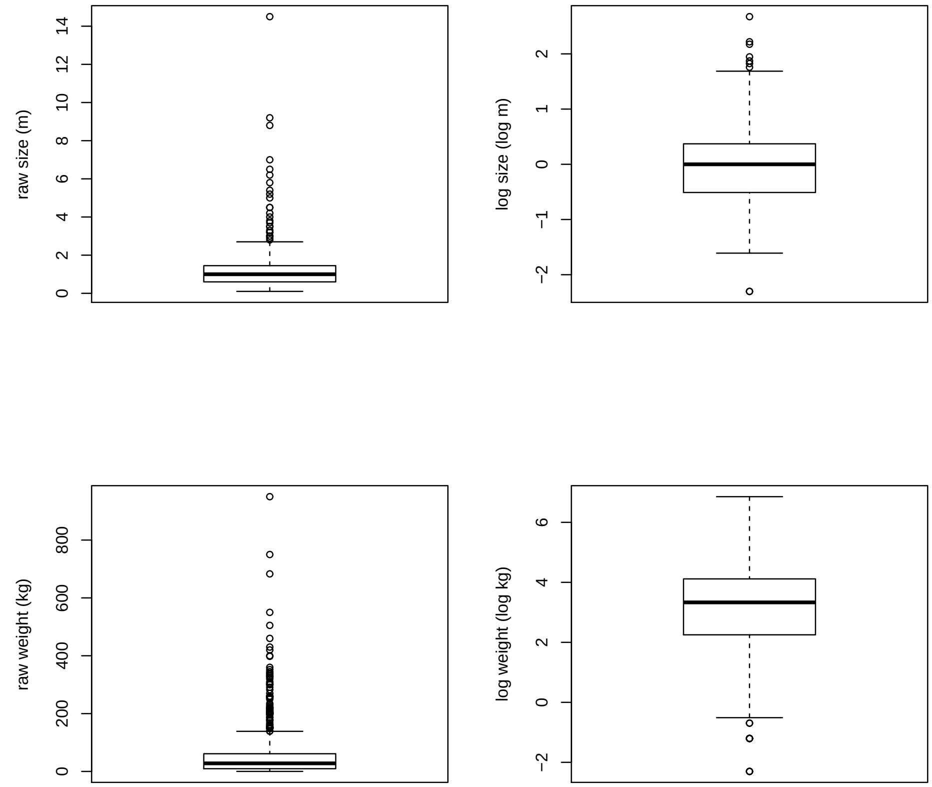

Figure 3: Boxplots illustrating the distribution of size (top) and weight (bottom) values. Raw values are shown in the left panels; log-transformed values are shown in the right panels. The distributions are less skewed and have fewer outliers after log-transformation.

Most Pokémon characters undergo "evolution" (see Figure 2), and when they do, they are called by a different name. For example, *nyoromo* becomes *nyorozo* and then *nyorobon*. We coded these evolution levels as 0, 1, 2, respectively. Pokémon came out in different series in different years, and 16 Pokémon characters were introduced as "pre-evolution" versions of an already-existing character—they are referred to as "baby Pokémon". For example, *pichuu* was added as the baby Pokémon of *pikachuu*, whose evolved version is *raichuu*. In such cases, their evolution levels are coded as -1, 0, 1, where the baby Pokémon is coded as -1. Some Pokémon characters do not undergo any evolution, in which case they are coded as 0. Finally, each Pokémon is specified for its strength parameters, including HP, attack, defense, special attack, special defense, and speed. These measures were also used as dependent variables.

To summarize, in our analysis, the independent variables are (1) the number of voiced obstruents, (2) the number of moras, and (3) the vowel quality (in initial syllables) in each Pokémon's name. The dependent variables are (1) size and weight, (2) evolution levels and (3) their strength parameters. Unless otherwise stated, since the number of voiced obstruents and the number of moras are non-continuous variables, we use non-parametric Spearman rank-sum correlation analyses (ρ) to examine the potential correlations between the dependent variables and the independent variables. When necessary, post-hoc comparisons are made using non-parametric Wilcoxon signed-rank tests. Since vowel quality is a categorical variable, its effects was accessed via regression analyses and ANOVA. All statistical calculations are computed using R (R Development Core Team, 1993–).

3 Results and discussion

3.1 Voiced obstruents

Figure 4 illustrates the effects of voiced obstruents on (log-transformed) size and weight values. The linear regression lines show that the correlations are positive. The positive correlations are significant for both size and weight, as revealed by non-parametric Spearman correlation analyses ($\rho = 0.25, p < .001$ and $\rho = 0.28, p < .001$). These results support the hypothesis that in Japanese Pokémon names, voiced obstruents imply largeness and heaviness. This conclusion is consistent with previous studies of the images of voiced obstruents in Japanese (Hamano, 1986; Kawahara and Shinohara, 2012; Shinohara and Kawahara, 2016; Shinohara et al., 2016; Sidhu and Pexman, 2015), but offer the very first quantitative support for this intuition using a large natural corpus of existing names. The results are also consistent with the Frequency Code Hypothesis (Ohala, 1984, 1994), in which sounds with low frequency should be perceived as large: since voiced obstruents are characterized by low frequencies in Japanese—closure voicing, low f0 and F1 (Kawahara, 2006)—they should invoke "large" images.[6]

[6] An anonymous reviewer pointed out an interesting alternative hypothesis. In the Japanese orthographic system, voiced obstruents are represented as the combination of the signs for corresponding voiceless obstruents and an orthographic diacritic, which are two dots placed at the right top corner (た=/ta/ vs. だ=/da/; か=/ka/ vs. が=/ga/). In this sense, the reviewer suggests that "voiced stops and fricatives are essentially "evolved" versions of basic kana, as (in most cases) they are the voiceless kana plus the voicing marker." In this view, voiced obstruents are literally bigger than voiceless obstruents in the Japanese orthographic system. Teasing apart this hypothesis from the Frequency Code Hypothesis would be relatively simple: to explore languages that do not have this diacritic system, such as English. The Frequency Code Hypothesis, which is essentially based on psychoacoustics, predicts that the association between voiced obstruents and largeness should hold universally; the orthography-based explanation predicts that it only holds in languages that have an orthographic system like Japanese. On this note, see Newman (1933) and Shinohara and Kawahara (2016) who have shown that English and Mandarin speakers, respectively, associate voiced obstruents with the image of largeness. Testing the effects of voiced obstruents in Pokémon names in other languages would help us address these two alternatives as well.

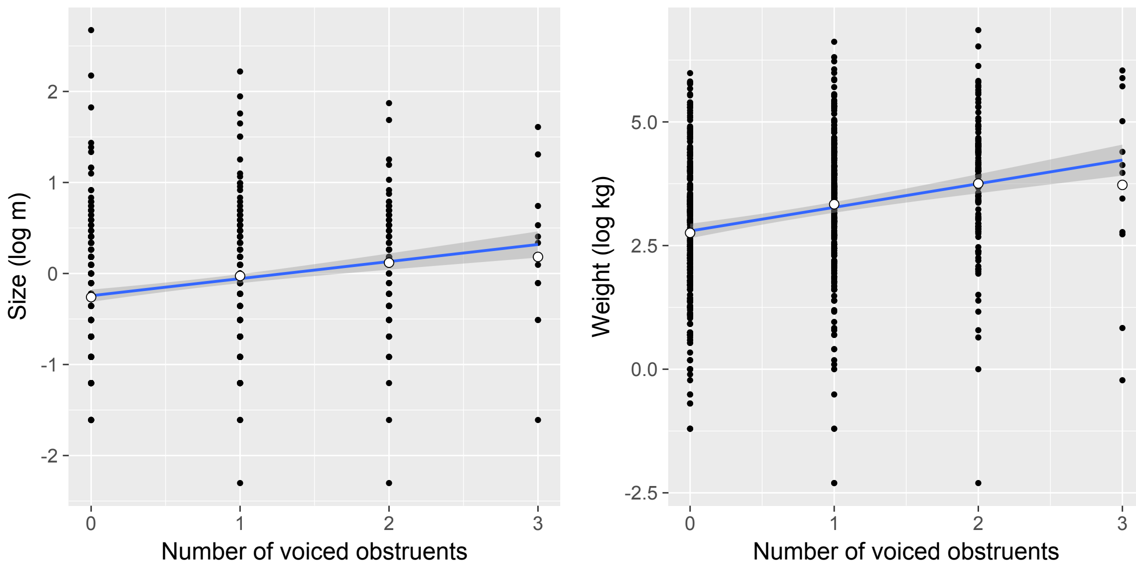

Figure 4: The effects of voiced obstruents on the size and weight. The size and weight values are log-transformed (the base = e). The linear regression line is superimposed, with the shaded area representing the 95% confidence intervals. The means in each condition are shown as white dots. The strengths and significance of the linear correlation are tested by a non-parametric Spearman rank-based correlation test.

Figure 5 illustrates the average number of voiced obstruents in Pokémon names for each evolution level, with the error bars representing 95% confidence intervals. We observe that the more evolved a Pokémon character is, the more voiced obstruents its name contains on average. The Spearman correlation coefficient between the evolution level and the number of voiced obstruents is 0.22, which is significant at the $p < 0.01$ level. Post-hoc comparisons using non-parametric Wilcoxon signed-rank test shows that all the differences between the adjacent evolution levels are significant at $p < .001$ level as well. Indeed then, the more voiced obstruents a Pokémon name contains, the more likely that it is used for a more evolved Pokémon.

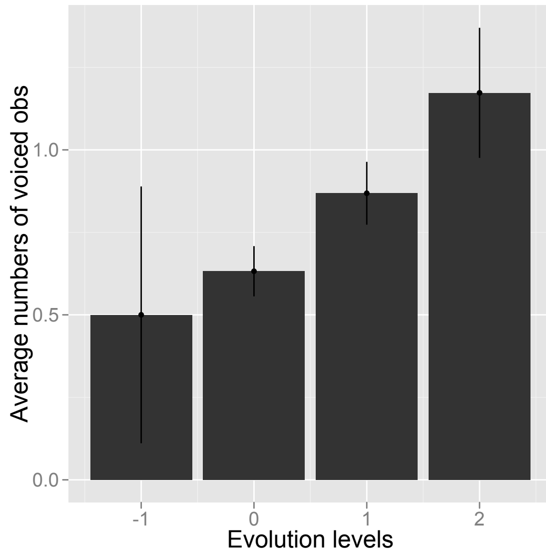

Figure 5: The average numbers of voiced obstruents contained in Pokémon names for each evolution level. The error bars represent 95% confidence intervals. Ns = 16, 368, 251, 81. N is small for the "-1" category, because it represents baby Pokémon characters, which are not very common.

We further explored the effects of voiced obstruents on evolution by comparing each Pokémon character pair before and after its evolution; e.g. *goosu* (evolution level = 0) vs. *goosuto* (evolution level = 1) and *goosuto* (evolution level = 1) vs. *gengaa* (evolution level = 2). For each pair, we coded whether the number of voiced obstruents increased, decreased, or stayed constant after the evolution. The observed distributions were compared to a null hypothesis in which the three changes occur with equal probability (= 33.3%) using a χ^2-test, followed by residual analyses. The results appear in Table 1.

Table 1: Comparison between pairs of pre-evolution Pokémon characters and post-evolution Pokémon characters. An illustrative example for each category; "increase": *karakara* (0) $\rightarrow$ *garagara* (2); "decrease": *kibago* (2) $\rightarrow$ *onondo* (1); "constant": *riguree* (1) $\rightarrow$ *oobemu* (1).

	numbers	skew
increase	120 (35%)	$n.s.$
decrease	48 (14%)	$\downarrow$ ($<$ .001)
constant	177 (51%)	$\uparrow$ ($<$ .001)
Total	345	

The number of voiced obstruents stayed constant about half of the time. More importantly, we observed that decreasing the number of voiced obstruents between pre- and post-evolution Pokémon pairs is less likely than expected by chance. This analysis provides further support to the conclusion that voiced obstruents tend to be associated with Pokémon characters with a higher evolution level.

Table 2 shows a correlation vector between the number of voiced obstruents on the one hand, and various strength parameters on the other. It demonstrates that the number of voiced obstruents exhibit a significant correlation with HP, attack, defense, special attack, special defense, but not with speed. The lack of significant correlation with speed is particularly interesting—in the actual world, objects that are large and heavy tend to move slowly, and therefore voiced obstruents in names may represent something that moves slowly (see also Saji et al. 2013 for a related observation in Japanese); this effect may have cancelled out the general effects of voiced obstruents indicating strengths, as observed in the other parameters. This lack of correlation between the number of voiced obstruents and speed indicates that the sound symbolic patterns which we are observing in Pokémon names is not random, but something that makes sense given the natural observation that those animals that are large and heavy generally do not move fast. Except for speed, however, the presence (and its number) of voiced obstruents make Pokémon characters stronger.

Table 2: A correlation vector between the number of voiced obstruents and various strength parameters. The first row represents Spearman rank-based coefficients ρ. The second row shows their p-values.

	HP	attack	defense	special attack	special defense	speed
ρ	0.12	0.21	0.15	0.10	0.11	0.05
p-value	$< .01$	$< .001$	$< .001$	$< .01$	$< .01$	= 0.18

3.2 Mora counts

Figure 6 shows the correlation between the mora counts on the one hand, and size and weight values on the other. It demonstrates that the higher the mora counts (i.e. the longer the name), the larger and heavier the Pokémon character is. The positive correlations are both significant ($\rho = 0.36, p < .001$ and $\rho = 0.34, p < .001$). There are only 2 data points for 2 moras and 6 mora conditions; even excluding these two conditions, the correlations remain significant ($\rho = 0.35, p < .001$ and $\rho = 0.34, p < .001$). These results confirm our impressionistic observation during the data mining stage that Pokémon characters with longer names are heavier and larger.

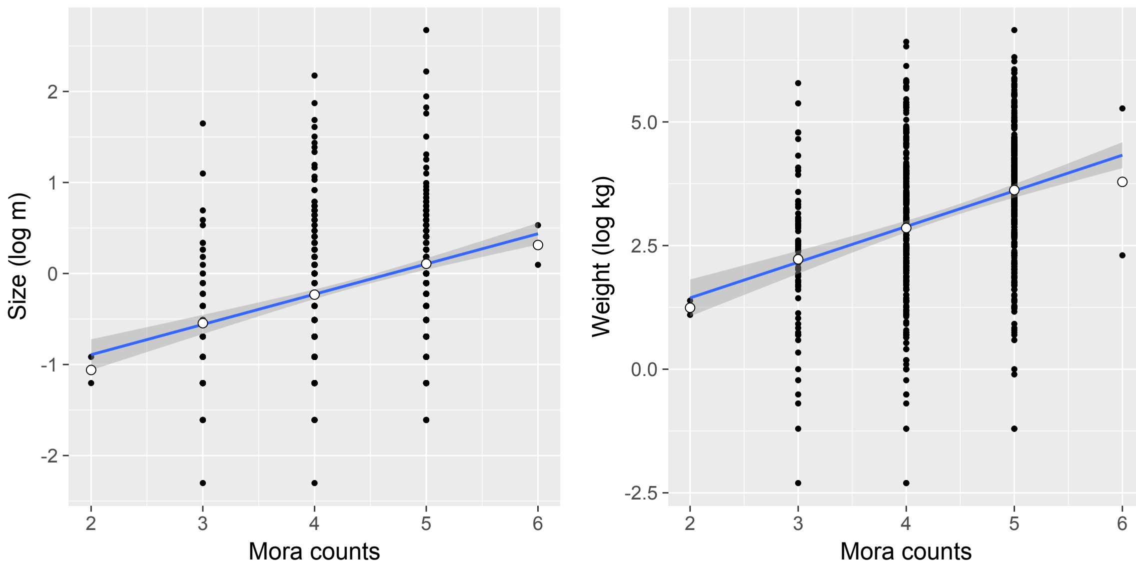

Figure 6: The effects of mora counts on the size and weight values. The white dots represent the means in each condition. The positive correlations are significant at the $p < .001$ level, even excluding the 2-mora and 6-mora conditions.

Figure 7 illustrates the average number of moras in the Pokémon names for each evolution level. We observed that the more evolved a Pokémon character is, the more moras its name contains. The Spearman correlation coefficient is 0.38, which is significant at the $p < .001$ level. Post-hoc comparisons with non-parametric Wilcoxon test show that all adjacent evolution levels are significantly different in terms of their mora counts at the $p < .001$ level.

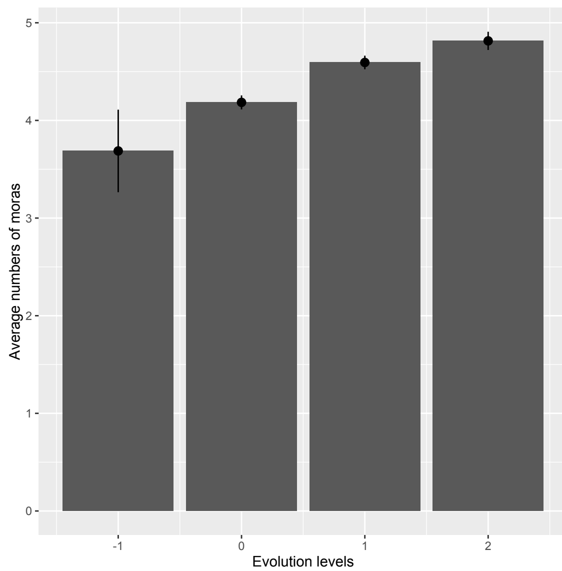

Figure 7: The average number of mora counts for each evolution level.

Table 3 shows a within-Pokémon comparison before and after evolution in terms of mora counts. Just like voiced obstruents, the probability of decreasing mora counts after evolution is lower than expected by chance. We observe that about half of the time, the mora counts increase after evolution. The likelihood of the mora counts staying constant is also higher than chance level. These are due to the fact that "the decrease category" is significantly underrepresented.

Table 3: A within-Pokémon comparison between pre-evolution Pokémon and post-evolution Pokémon in terms of mora counts. An illustrative example for each category; "increase": *hi-m-ba-su* (4) $\rightarrow$ *mi-ru-ka-ro-su* (5); decrease: *ku-nu-gi-da-ma* (5) $\rightarrow$ *fo-re-to-su* (4): constant: *ra-ru-to-su* (4) $\rightarrow$ *ki-ru-ri-a* (4).

	numbers	skew
increase	166 (48%)	$\uparrow$ (< .001)
decrease	20 (6%)	$\downarrow$ (< .001)
constant	159 (46%)	$\uparrow$ (< .001)
Total	345	

Overall, the analyses so far have shown that evolved Pokémon names are generally longer. One objection that may be raised against this conclusion is that this result may not have to do with phonological length, but instead with morphological complexity. In some Pokémon pairs, the post-evolution characters are expressed via quasi-affixation: *ri-za-a-do* $\rightarrow$ *ri-za-a-do-n*, in which the final /n/ could be considered as a Pokémon-specific suffix (it is not an existing suffix in Japanese). In order to address this morphological complexity hypothesis, we eliminated all pairs that could be considered as morphologically related, even when the observed "affixes" do not actually exist in Japanese. The results appear in Figure 9—the pattern remained the same, the more evolved Pokémon characters tend to have longer names, although the Spearman correlation coefficient became slightly lower in this analysis ($\rho = 0.32, p < .001$).[7]

[7]The relationship between mora counts on the one hand and size and weight on the other remained stable, after excluding (quasi)-morphologically related pairs, as shown in Figure 8. The Spearman correlations are 0.24 for size and 0.34 for weight, both significant at the $p < .001$ level.

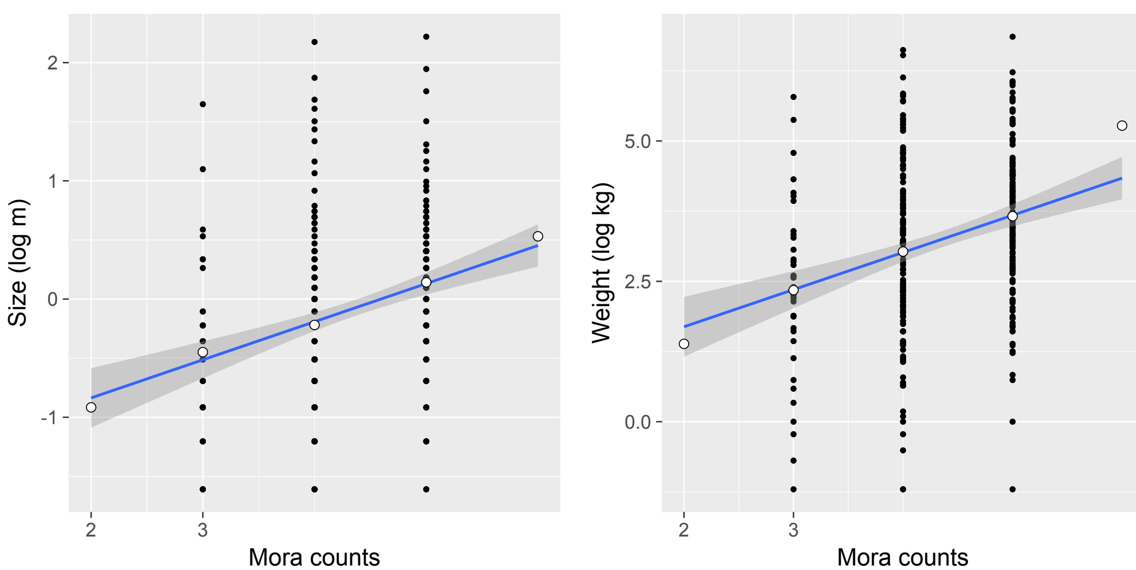

Figure 8: The correlations between mora counts and size (left) and weight (right). Pairs that are potentially related by (quasi)-morphological derivation are eliminated.

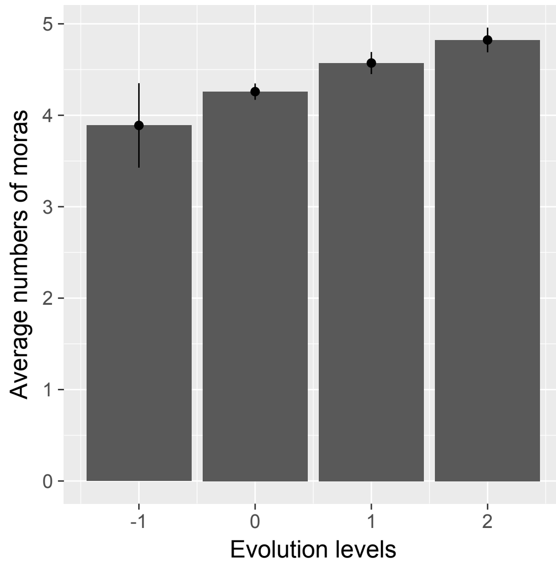

Figure 9: The average number of mora counts for each evolution level. Pairs that are potentially related by (quasi)-morphological derivation are eliminated. The total N is 322.

Another reason to consider that phonological length, rather than—or at least, in addition to—morphological complexity, plays a role in influencing naming of pre- and post-evolution Pokémon names comes from a nonce word experiment reported in Kawahara and Kumagai (to appear). In that study, within each trial, the participants were presented with a pair of Pokémon characters (like the one in Figure 2), and were provided with unrelated two nonce words like *he-na-ro-ho* (four moras) and *no-shi-yo-ho-ya* (five moras). The results showed that the participants were more likely to associate the longer nonce word names with the post-evolution Pokémon characters. Since the stimuli were all nonce words and the stimulus pairs were not related by morphological derivation in any sense, this result cannot be explained in terms of morphological complexity.

Turning to the relationship between mora counts and strength, Table 4 shows the correlation vector between the number of moras on the one hand and the strength parameters on the other. It shows that all the correlations are significant at the $p < .001$ level. The results show that the longer the name, the stronger the Pokémon character is in every parameter.

Table 4: A correlation vector between the number of moras and strength parameters.

	HP	attack	defense	special attack	special defense	speed
ρ	0.26	0.27	0.29	0.20	0.25	0.15
p-value	$< .001$	$< .001$	$< .001$	$< .001$	$< .001$	$< .001$

One remaining question is how general this sound symbolic[8] "longer-is-stronger" relationship is—is it specific to Pokémon names, or specific to proper names, or more generally operative in natural languages? One relevant observation comes from the spell names in the Dragon Quest series—a nationally renowned Role Playing Game,[9]which follow the same "longer-is-stronger" principle as the Pokémon naming: in a series of four spells related to fire, *me-ra* (two moras) is the weakest, *me-ra-mi* (three moras) next, *me-ra-zo-o-ma* (five moras) next, and *me-ra- ga-i-ya-a* (6 moras) is the strongest; similarly, *gi-ra* (two moras) becomes *be-gi-ra-ma* (four moras) when it gets stronger, and then *be-gi-ra-go-n* (five moras), and then *gi-ra-gu-re-i-do* (six moras) when it is strongest. The same can be said for *i-o* (two moras), *i-o-ra* (three moras), *i-o-na-zu-n* (five moras) and *i-o-gu-ra-n-de* (six moras), although there are exceptions to this "longer-is-stronger principle" too; e.g. *be-ho-ma* (three moras) is stronger than *be-ho-i-mi* (four moras) and *ma-hya-do* (three moras) is stronger than *hya-da-i-n* (four moras). Kawahara (2017) systematically studied this correlation between the levels of each spell and the length of their names in the Dragon Quest series, and found a positive correlation ($\rho = 0.67, p < .001$), as shown in Figure 10.[10]

[8]It has been asked whether "sound symbolic" is the right term to refer to this association, as "sound symbolism" most often refers to meanings associated with individual segments, rather than prosodic shapes or lengths. While we agree that this association may not be a prototypical example of what has been discussed under the rubric of "sound symbolism," it is nevertheless a quantitative "iconic" relationship between sound shapes and meanings. We could potentially use the term "Phonasethetics" or "quantitative iconic sound-meaning relationships". However, since the term "sound symbolism" is well-known in the literature now, we keep using this term in this paper.

[9]See the Wikipedia article `https://en.wikipedia.org/wiki/Dragon_Quest` and the official website (in Japanese) at `http://www.jp.square-enix.com/archive/dq/` for details.

[10]Unlike Pokémon evolution, most if not all cases of Dragon Quest spell names involve quasi-morphological derivation. However, we still observe that the morphological complexity is not all there is to it. For example, the level 2 fire spell is *mera#mi* (# = a morphological boundary), whereas the level 3 spell is *mera#zo-o-ma*, in which the latter "suffix" is longer (one mora vs. three moras). The level 4 "suffix" is *ga-i-ya-a*, which is longer than the level 3 suffix *zo-o-ma*. The same pattern holds for the comparison among *begira#ma* (level 2) vs. *begira#go-n* (level 3) vs. *gira#gu-re-e-do* (level 4), and *io#ra* (level 2) vs. *io#na-zu-n* (level 3) vs. *io#gu-ra-n-de* (level 4). We suspect that the sound symbolic "longer-is-stronger" principle is at work, even when spell name levels are expressed via morphological complexity as well.

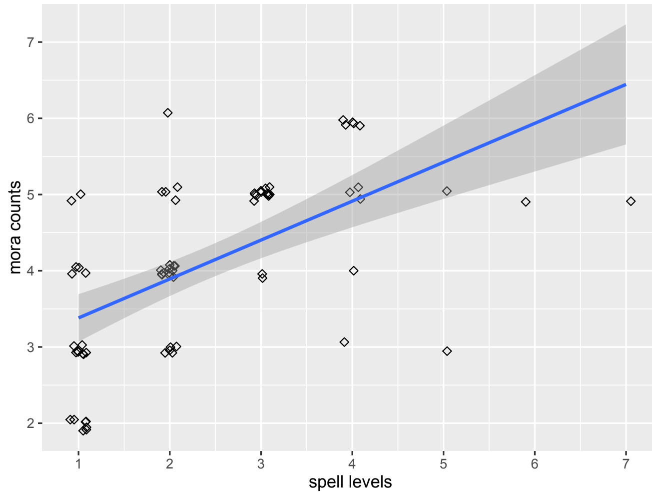

Figure 10: The relationship between the levels of the spells and the mora counts of their names in Dragon Quest series. Based on Kawahara (2017).

An anonymous reviewer pointed out that this "longer-is-stronger" principle may be a specific case of what is more generally known as "iconicity of quantity" in the literature on the role of iconicity in grammar (Haiman, 1980, 1985). An example of quantitative iconicity includes comparatives and superlatives in Latin (e.g., long(-us) 'long' $<$ long-ior 'long-er' $<$ long-issim(-us) 'long-est'). More generally, Haiman (1980: 528) suggests that "generally speaking, the positive, comparative, and superlative degrees of adjectives show a gradual increase in the number of phonemes." Many languages, including Japanese, express plurality, repetition and intensification using reduplication (a Japanese example: *yama* 'mountain' and *yama-yama* 'mountains'), which would also be an example of quantitative iconicity (Haiman, 1980). Dingemanse et al. (2015) cite an example from Japanese and Siwu in which vowel lengthening expresses "long-ness". In short, there may be some cases in natural languages in which the "longer-is–stronger" principle is at work. Exploring the relationship between the current finding in Pokémon naming and the general quantitative iconicity patterns in natural languages offers an interesting line for future research.

3.3 Multiple regression analyses

Having established the effects of voiced obstruents and those of mora counts, we need to address an important question. Given that the effects of both voiced obstruents and mora counts are present, could it be the case that we obtained significant results of both factors, because a longer word is more likely to contain voiced obstruents? In other words, are the effects of voiced obstruents and mora counts independent of one another? In order to address this question, multiple regression analyses were run. The independent variables were log-transformed weight, log-transformed size, evolution level, and total strength (the sum of all strength parameters except for speed). The dependent variables were the number of voiced obstruents and mora counts, and their interaction. Table 5 summarizes the results.

Table 5: The results of multiple regression analyses. The effects of voiced obstruents and mora counts are significant, but their interaction terms are not.

WEIGHT	Df	F	p-value
voiced obs	$1, 712$	53.2	$< .001$
mora counts	$1, 712$	71.7	$< .001$
interaction	$1, 712$	< 1	$= .82$

SIZE	Df	F	p-value
voiced obs	$1, 712$	36.7	$< .001$
mora counts	$1, 712$	75.1	$< .001$
interaction	$1, 712$	< 1	$= .69$

EVOL	Df	F	p-value
voiced obs	$1, 712$	42.3	$< .001$
mora counts	$1, 712$	99.3	$< .001$
interaction	$1, 712$	2.7	$= .10$

STRENGTH	Df	F	p-value
voiced obs	$1, 712$	23.7	$< .001$
mora counts	$1, 712$	69.9	$< .001$
interaction	$1, 712$	1.9	$= .16$

In all the regression models, the effects of voiced obstruents and those of mora counts are highly significant, but none of the interaction effects are. These results show that the effects of voiced obstruents and those of mora counts independently hold. In other words, the effects of voiced obstruents are present, regardless of the number of moras that a particular Pokémon name contains.

3.4 Vowel quality

We now turn to the analysis of vowels. Since Pokémon names differ substantially in their length (recall section 3.2.), we analyzed the effects of vowels in initial syllables. We know from the previous psycholinguistic research that initial segments and/or syllables play an important role in speech perception and processing (Browman, 1978; Brown and MacNeill, 1966; Cole, 1973; Marslen-Wilson, 1975; Mattys and Samuel, 2000; Nooteboom, 1981), and that psycholinguistic prominence may play a significant role in shaping the phonology of human languages (Beckman, 1998; Becker et al., 2012; Hawkins and Cutler, 1988; Smith, 2002).

Figure 11 presents the distribution of log-transformed size (left) and weight (right), broken down by initial vowels.[11] We observe in the left figure that there are no large differences among the five vowels (the means: /a/ = -0.05; /o/ = -0.11; /e/ = -0.02; /u/ = -0.14; /i/ = -0.21), although two high vowels (/u/ and /i/) show the two smallest values. Two non-high back vowels (/a/ and /o/) show the two largest values. To assess the significance of height and backness on size, since vowel quality is not a numerical variable, a regression analysis was run with log-transformed size as the dependent variable and height (high vs. non-high) and backness (back vs. front), as well as their interaction, as independent variables. The results were that height was significant ($t(713) = -2.06, p < .05$), but not backness ($t(712) = -0.74, n.s.$) or the interaction ($t(711) = 1.07, n.s.$).

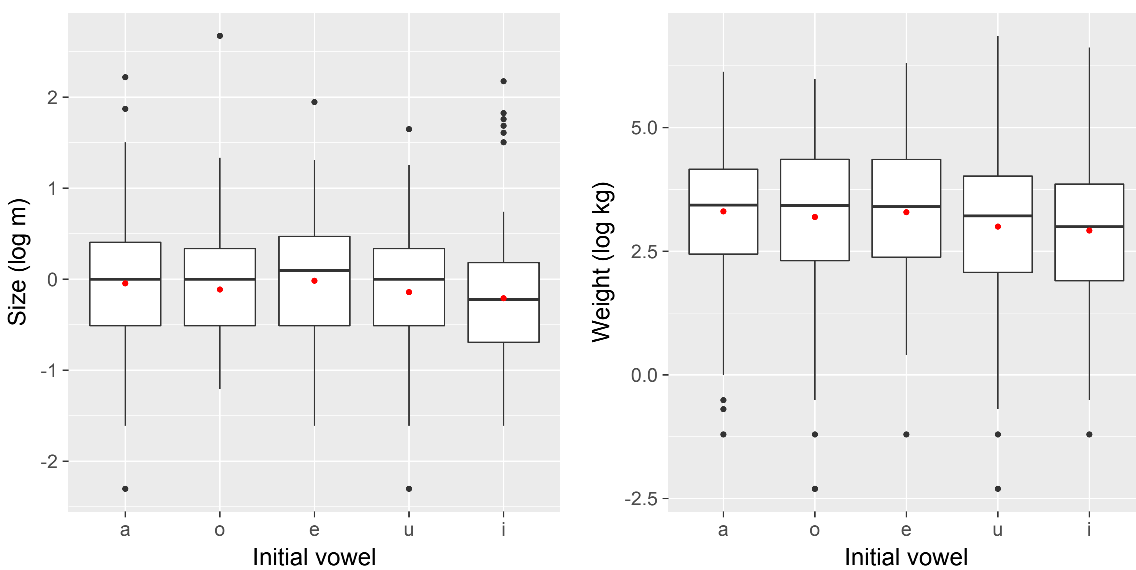

Figure 11: The distribution of size and weight (log-transformed), broken down by initial vowels. Red dots represent the means.

A similar tendency is observed in terms of weight (the right figure of Figure 11). The differences are not substantial, but high vowels tend to be associated with smaller weights (the means: /a/ = 3.31; /o/ = 3.19; /e/ = 3.29; /u/ = 3.00; /i/ = 2.92). A regression analysis shows that height was nearly significant ($t(713) = -1.80, p = .07$), but not backness ($t(712) = -0.17, n.s.$) or the

[11] Japanese has a short vs. long contrast in vowels (as well as consonants). It seems natural to hypothesize that long vowels imply something heavier and larger. See Appendix for analyses of long vowels and long consonants.

interaction ($t(711) = 0.43, n.s.$). A model without the interaction term shows a significant effect of height ($t(713) = -2.49, p < .05$), which shows that some variability of height was soaked up by the interaction term.[12] All in all, it seems justified to conclude that vowel height has a sound symbolic effect in such a way that high vowels represent something smaller and lighter, although its effect size is not very substantial in the Pokémon naming patterns.

Figure 12 shows the average evolution levels for each type of initial vowel. It shows the /a/ and /o/ tend to represent more evolved characters, whereas /u/ and /i/—particularly /i/—represent less evolved characters, and /e/ represents those in-between. However, the effect sizes are very small (note that the y-axis scale ranges from 0 to 0.6), and indeed no significant differences were found in terms of height ($t(713) = -0.55, n.s.$), backness ($t(712) = 0.72, n.s.$) or their interaction ($t(711) = -0.24, n.s.$).

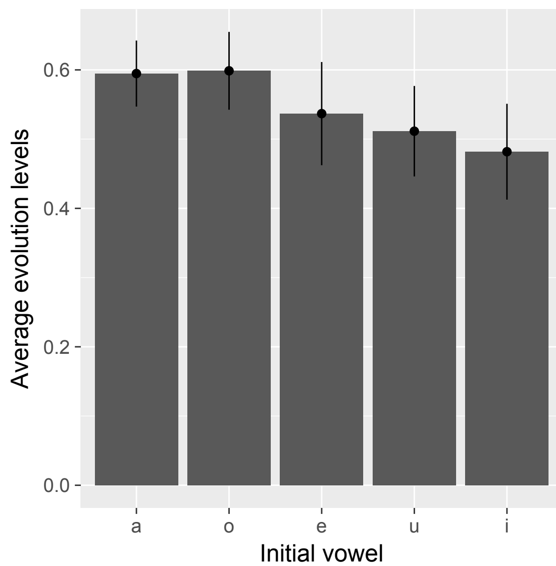

Figure 12: The average evolution levels for each vowel quality in initial syllables.

Finally, Figure 13 shows the effects of initial vowels on each strength parameter. No consistent patterns appear, except that /e/-initial names show slightly high values in special attack, special defense, and speed. /u/ shows values that are higher than /a/, /o/, and /i/ in terms of special defense. One-way ANOVA was run with strength parameters as independent variables and vowel type as dependent variables; HP: $F(4, 711) = 1.72, n.s.$; attack: $F(4, 711) = 1.75, n.s.$; defense: $F(4, 711) = 0.47, n.s.$; special attack: $F(4, 711) = 4.38, p < .01.$; special defense: $F(4, 711) = 5.30, p < .001.$; speed: $F(4, 711) = 6.64, p < .001$. A post-hoc test with /a/ as

[12]A model comparison between the two models, one with the interaction term and one without, does not show the improvement of fit for the more complex model ($\chi^2(1) = 0.39, n.s.$); therefore, we may be justified to interpret the simpler model, i.e., the one without interaction. Either way, the effect size of vowel height is not very large.

the baseline shows that /e/ is higher than /a/ in terms of special attack ($t(711) = 2.78, p < .01$), special defense ($t(711) = 2.28, p < .05$) and speed ($t(711) = 4.15, p < .001$). /u/ is higher than /a/ in terms of special defense ($t(711) = 2.13, p < .05$). We unfortunately do not have a clear explanation of these patterns.

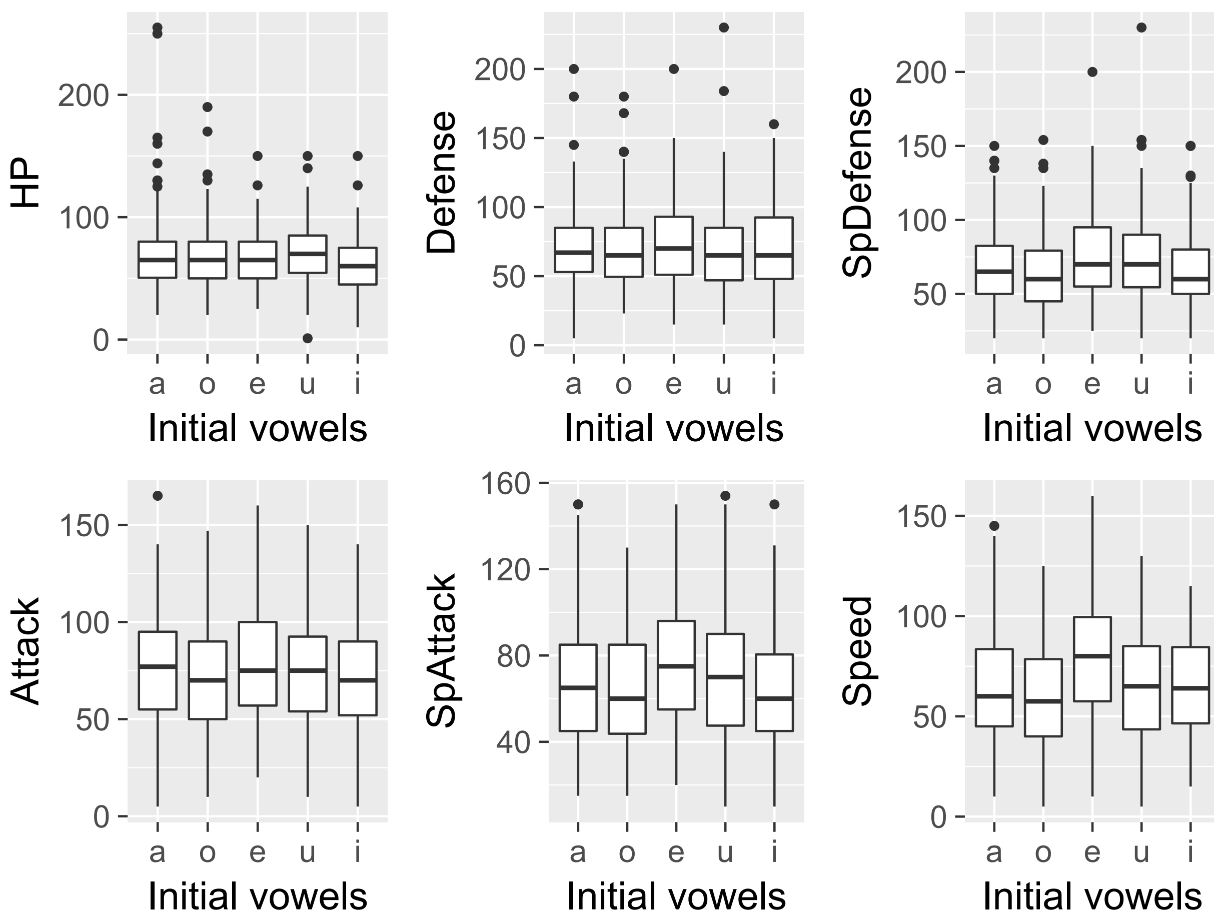

Figure 13: The effects of initial vowels on each strength parameter.

4 Conclusion

In natural languages, sound symbolic relationships hold between sounds and meanings, although these relationships are only stochastic and not deterministic (i.e. the sound-meaning relationships can be arbitrary: Saussure 1916; Hockett 1959). Previous studies have shown that sound symbolic patterns are operative in naming patterns of proper names as well (Berlin, 2006; Köhler, 1947; Kawahara and Shinohara, 2012; Ramachandran and Hubbard, 2001; Shinohara and Kawahara, 2013; Perfors, 2004; Shinohara et al., 2016; Sidhu and Pexman, 2015; Wright and Hay, 2002; Wright et al., 2005). The current study adds to this body of the literature on the existence of sound symbolic relationships in proper names, using a new corpus of data.

One advantage of the analysis presented in this paper is the fact that we were able to conduct statistical and quantitative analyses of sound symbolic patterns, using Pokémon names as a natural corpus. Japanese speakers do have an impressionistic intuition that “voiced obstruents are heavy”, for example, and this intuition has been reported in some linguistic work (Hamano, 1986; Kawahara, 2015; Kubozono, 1999*b*). However, we believe that we are the first to quantitatively test this sound symbolic connection using a natural corpus.

This study on the sound symbolic nature of Pokémon names did not cover all aspects of Pokémon; for example, all Pokémon characters belong to some “class” (e.g. water, grass, poison, fire, etc). Some Pokémon characters are also specified for their gender (either male or female). Whether the classes and/or gender are expressed via particular sound symbolic patterns is an interesting topic for future investigation in the analysis of Pokémon names. Nor has the current study tested all possible sound symbolic relationships that may be lurking behind Pokémon naming conventions. For example, place of articulation is something to look at, given a recent observation that Japanese speakers very often use labial consonants for names for baby diapers (Kumagai and Kawahara, 2017). Our hope is that future research will uncover other sound symbolic patterns in Pokémon names.

Another dimension in which this project can be extended is the analysis of Pokémon names in languages other than Japanese. Since Pokémon names are translated into many languages, including Chinese, English, French, and Spanish, the sound-symbolic study of Pokémon names provides a forum for cross-linguistic comparisons. We thus invite interested readers to follow-up on the current study.

Another task is to address whether the patterns identified in this paper are merely facts about the “Pokémon lexicon”, or whether these patterns are internalized by native speakers of Japanese. Testing this issue requires experimentation using new Pokémon characters (see Kawahara and Kumagai to appear, for the initial attempt). This experiment has shown that when given a pair of complete nonce words and a pair of pre- and post-evolution versions of Pokémon as in Figure 2, Japanese speakers tend to associate those names with voiced obstruents and those names that are longer with the post-evolution Pokémon. We also invite other researchers to test the same issue with speakers with different language backgrounds.

Finally, probably the most attractive aspect of this research is that it is very useful in teaching. Pokémon is a favorite game series for current undergraduate students in and outside of Japan. Concepts like log transformation and regression analyses are sometimes hard to understand—or even off-putting—to some undergraduate students who take introductory phonetics or psychology classes. However, since Pokémon is a catchy topic, our experience is that it helps lower the psychological boundary to learn these concepts. Evidence that this project appeals to a general audience, including college students, comes from the fact that the first author was invited to write an online article for a general business journal, which received 618 likes on Facebook as of June 2017,[13] and also that he was interviewed by the university newspaper at Keio University.[14] Moreover, through this project, we have inspired some graduate students to conduct their own corpus-based work, including an analysis of diaper names, Youkai Watch monsters, Takaraduka players, and Japanese idol girls (the AKB groups) (Kawahara and Monou, 2018). These new projects by students show that this work attracts students' interests in quantitative analyses of linguistic patterns. Since a corpus-based analysis on sound symbolism requires handling statistical analyses, it encourages graduate students to familiarize themselves with quantitative analyses in linguistics in general.

To this end, we invite other researchers to use this material in phonetics and psychology classes.

Appendix: Long vowels and geminates

It has been asked multiple times whether long vowels and long consonants (a.k.a. geminates) would affect size and weight of Pokémon characters. Figure 14 represents the effects of long vowels on size and weight. There is a slight positive correlation between the number of long vowels and size (left, $\rho = 0.09, p < .05$), but not between the number of long vowels and weight (right, $\rho = 0.05, n.s.$).

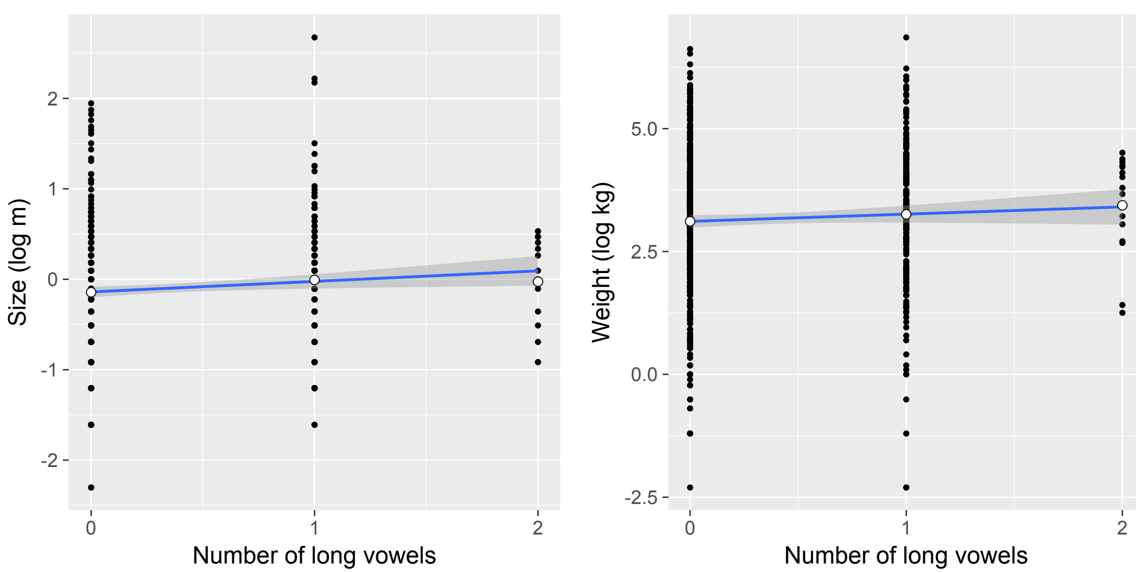

Figure 14: The effects of long vowels on size and weight.

[13] http://wired.jp/2017/03/02/pokemon-sound/
[14] http://www.jukushin.com/archives/28130

Figure 15 illustrates the effects of the presence of geminates on size and weight (there were no names in which there is more than one geminate). Both in terms of size and weight, the correlation is negative, and the correlation between the presence of geminates and weight is significant ($\rho = -0.06, n.s.$ for size; $\rho = -0.09, p < .05$ for weight). We do not have a clear explanation of why the presence of geminates would lead to lower weight.

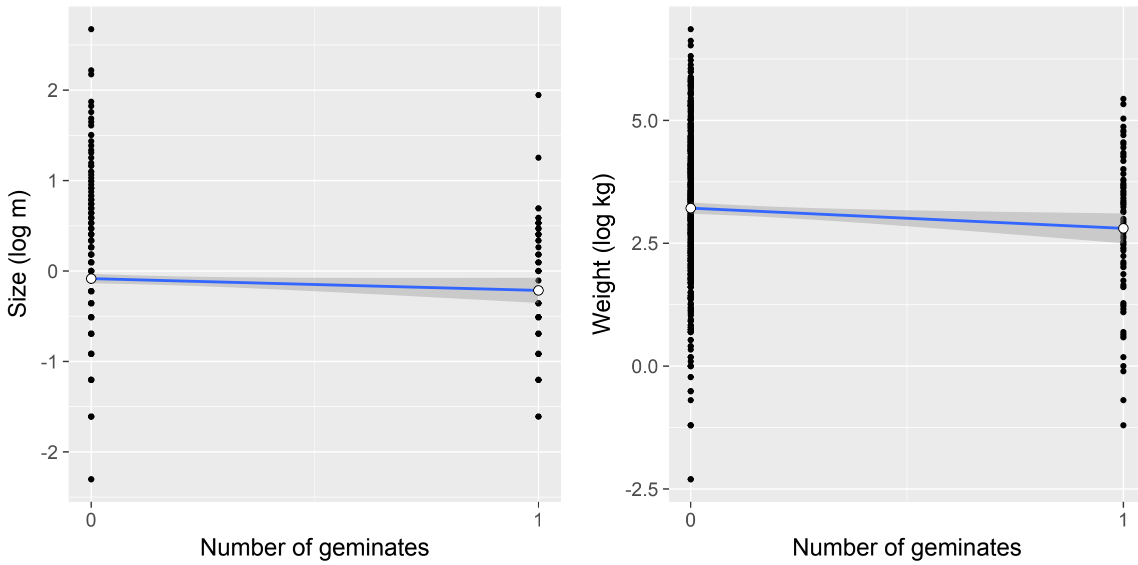

Figure 15: The effects of geminates on size and weight.

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