Sound (symbolic) patterns in Pokémon names: Focusing on voiced obstruents and mora counts

Shigeto Kawahara[1], Atsushi Noto[2], Gakuji Kumagai[3]
Keio University[1], Tokyo Metropolitan University[2], NINJAL[3]
kawahara@icl.keio.ac.jp

Abstract

This paper presents a case study of sound symbolism, cases in which certain sounds tend to be associated with particular meanings. The current study uses the corpus of all Pokémon names available as of October 2016. This paper explores the effects of voiced obstruents and mora counts in Japanese Pokémon names, and demonstrates that both of them impact Pokémon characters' size, weight, strength parameters, and evolution levels. In particular, the number of voiced obstruents in Pokémon names positively correlates with size, weight, evolution levels, and general strength parameters, except for speed. We argue that this result is compatible with the Frequency Code Hypothesis proposed by Ohala (1984, 1994). The number of moras in Pokémon names positively correlates with size, weight, evolution levels and all strength parameters. Multiple regression analyses show that the effects of voiced obstruents and those of mora counts hold independently of one another. 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 and psychology to attract students' interests, as Pokémon is very popular among current students.

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 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 as old as Socrates, who argues in the dialogue *Cratylus* that Greek ρ (="r") is used in many words that express movement, that α (="a") means "large", that o means "round", etc (Plato, nd). 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. 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 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). 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).

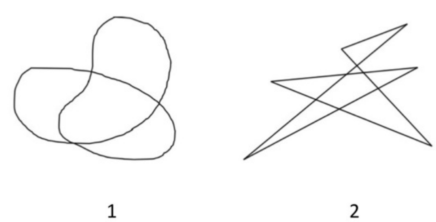

Figure 1: Schematic illustration of *maluma* and *takete* figures. A pair of a round object and an angular object; the former is more likely to be named *maluma*/*bouba* and the latter is more likely to be named *takete*/*kiki*. Taken from Kawahara and Shinohara (2012), inspired by Köhler (1947).

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. 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. Wright and Hay (2002) and

Wright et al. (2005) show that female and male names in English are (stochastically) distinguished by many phonological features, 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.

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). Pokémon started as a video game in 1995 by Nintendo, and has been very popular in Japan and many other countries (see the Wikipedia article for details).[1] As of 2016, there are more than 700 Pokémon characters in total, and this 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 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.

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 number of data points for a quantitative analysis. Although there had been 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 this sound symbolic pattern using a natural corpus.[2] Second, each Pokémon character has many numeric parameters, such as size (= height), weight, and various strength parameters, which allows us to examine which parameters correlate with what kinds of sound properties. Third, most if not all current university students, in Japan and other countries, are familiar with Pokémon, and this is a very catchy topic to use in introductory linguistics, phonetics, and psychology classes. In the discussion section, we report some evidence that this material indeed attracts interests from general public, including university students.

This paper focuses on the effects of voiced obstruents and mora lengths, 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 very welcome to follow up on our case study. The coded dataset will be made available once the paper is accepted for publication.

One final important caveat. Pokémon names do sometimes include real, existing words in

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

[2] There are some experimental work that supports this sound symbolic relationship in a quantitative fashion (Kawahara et al., 2008; Shinohara and Kawahara, 2016).

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 well, although this influence too would be stochastic, if present at all. To illustrate this point, let us take an actual Pokémon pair, *goosuto* and *gengaa*, the second of which is the evolved version of the first (evolving generally implies "becoming stronger"; see below for more details). 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* was chosen as the name for the more evolved version of the character? One answer is that since *gengaa* contains more voiced obstruents, it is 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 (or borrowed) 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 the large corpus.

2 Method

2.1 Hypotheses tested

This paper focuses on two types of effects: the effects of voiced obstruents and those of mora length. Voiced obstruents include a set of sounds (/b/, /d/, /g/, /z/), which are produced with fairly strong constriction in the oral cavity—strong enough to result in aperiodic noise, frication or burst—accompanied with vocal fold vibration (see Kawahara 2006 for detailed acoustic description of voiced obstruents in Japanese). Moras are basic counting 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 the moras are arguably the most psycholinguistically prominent counting units for Japanese speakers (Inagaki et al. 2000; Kureta et al. 2006; Otake et al. 1993, though cf. Cutler and Otake 2002; Kawahara 2016).

One reason to study the effects of voiced obstruents is that sound symbolic meanings of voiced obstruents are well-known 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 onomatopoetic words, *goro-goro* and *koro-koro*—both of these words represent the state of a rock rolling; however, the former implies that the rock is big and heavy (Hamano, 1986). 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, high frequency sounds imply small objects, whereas low frequency sounds imply large objects, which reflects the physical law of sound vibration. Acoustically, voiced obstruents are characterized by low frequency energy during their constriction (Lisker, 1978, 1986; Raphael, 1981; Stevens and Blumstein, 1981) (known as "closure voicing" or "a voice bar"), 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 images.[3]

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 status parameters, heavy, and large. For example, *go-o-su-to* (5 moras) is stronger than *go-o-su* (4 moras). Also, the pair of *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*. Note that in this pair, the "weakness" of the pre-evolution state was expressed by the truncation of the second mora, *ka*. Therefore, there seems to have been a "longer-is-stronger" principle in Pokémon naming conventions. In order to test this hypothesis more rigourously, we statistically examined the effects of mora counts 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. Therefore, this is a new and interesting hypothesis to test.

[3]See also Kawahara 2015; Shinohara and Kawahara 2016; Shinohara et al. 2016 for an articulatory explanation of why voiced obstruents may be considered to be large, which is based on the oral cavity expansion due to the aerodynamics 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 in October, 2016.[4] 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; to be conservative, we excluded those Pokémon characters. Some of the same Pokémon can have a suffix *mesu* ‘female’ or *osu* ‘male’, and these are excluded to avoid counting the same characters twice. There is one Pokémon character with four voiced obstruents (*jiguzaguma*), which was excluded, because this was the only character that contained four voiced obstruents in its name. After excluding these characters, 715 Pokémon monster names remained for the following analysis.

Each Pokémon character has their 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 2.

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

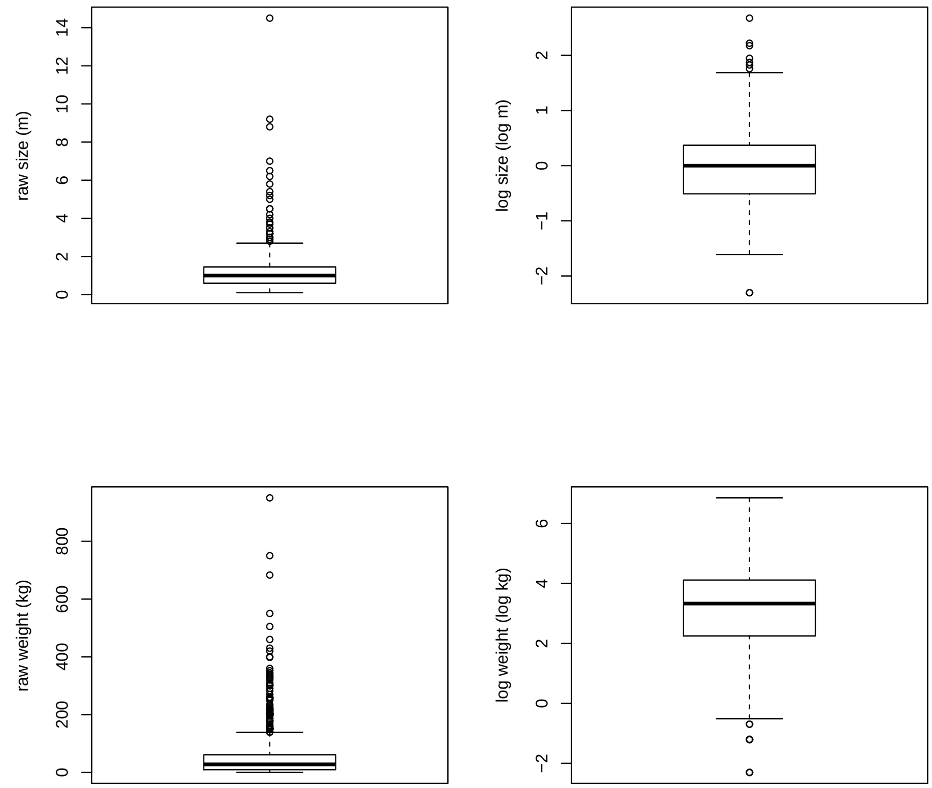

Figure 2: The distributions of the size and weight values. Boxplots illustrating the distribution of size (top) and weight (bottom) values. Raw values are shown in the left panels; log-transformed values are shown in the right panels. The distributions are less skewed and have less outliers after log-transformation

Most Pokémon characters undergo "evolution". For example, *njoromo* becomes *njorozo* and then *njorobon*. 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" version 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, they are coded as -1, 0, 1, where the baby Pokémon is coded as -1. Some Pokémon characters do not simply undergo any evoluation, 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, the independent variables were (1) the number of voiced obstruents and (2) the number of moras in each Pokémon's name. The dependent variables were (1) size and weight, (2) evolution levels and (3) their strength parameters. Since both of the independent variables were non-continuous variables, we used 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 were made using non-parametric Wilcoxon signed-rank tests. All statistical calculations were computed using R (R Development Core Team, 1993–).

3 Results and discussion

3.1 Voiced obstruents

Figure 3 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 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 the previous studies of the images of voiced obstruents in Japanese (Hamano, 1986; Kawahara and Shinohara, 2012; Shinohara and Kawahara, 2016; Sidhu and Pexman, 2015; Shinohara et al., 2016), but offer the very first quantitative support for this intuition using a large natural corpus of existing names. The results are also consistent with Frequency Code Hypothesis (Ohala, 1984, 1994), in which sounds with low frequency energy should be perceived as large: since voiced obstruents are characterized by low frequency energies in Japanese—closure voicing, low f0 and F1 (Kawahara, 2006)—they should invoke "large" images.

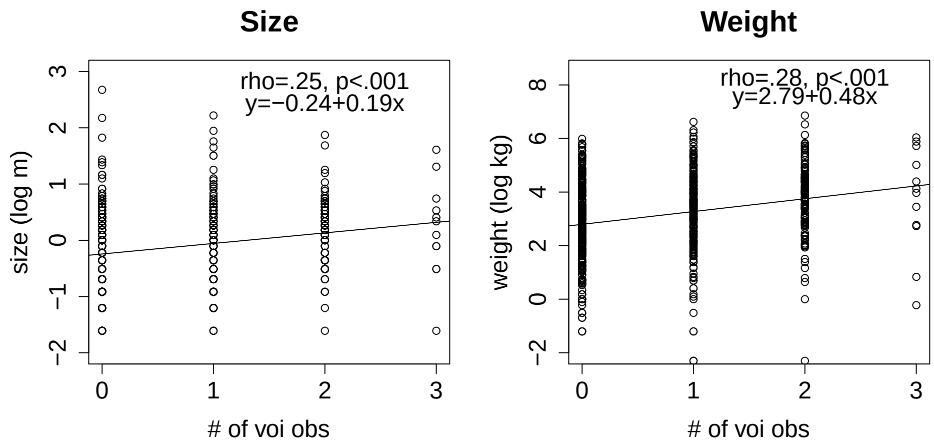

Figure 3: The effects of voiced obstruents on the size and weight. The size and weight values are log-transformed (the base = *e*). The linear regression line is superimposed. The strengths and significance of the linear correlation are tested by a non-parametric Spearman rank-based correlation test.

Figure 4 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 obstruent 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.

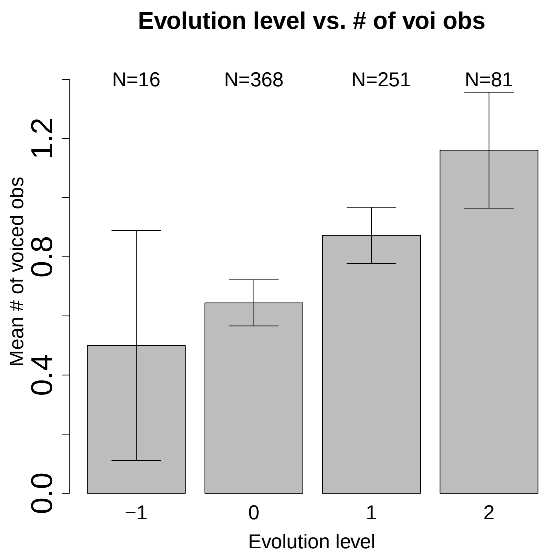

Figure 4: The average number of voiced obstruents contained in Pokémon names for each evolution level. The error bars represent 95% confidence intervals. Ns are given at the top of each bar. N is small for the "-1" category, because it represents baby Pokémon characters, which are not very common.

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 stage = 0) vs. *goosuto* (evolution stage = 1) and *goosuto* (evolution stage = 1) vs. *gengaa* (evolution stage = 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 these three changes occur with equal probability (= 33 %) using a χ^2-test, followed by residual analyses. The results appear in Table 1.

Table 1: Comparison between pairs of pre-evolution Pokémon character and post-evolution Pokémon character. An illustrative example for each category; "increase": *karakara* → *garagara*; "decrease": *kibago* → *onondo*; "constant": *riguree* → *oobemu*.

	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 observe 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 characters that are "more evolved".

Table 2 shows a correlation vector between the number of voice 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; therefore, the presence of voiced obstruents may not result in higher speed. This lack of correlation 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 character stronger.

Table 2: A correlation vector with 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 5 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 2 data points for 2 moras and 6 moras; 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.

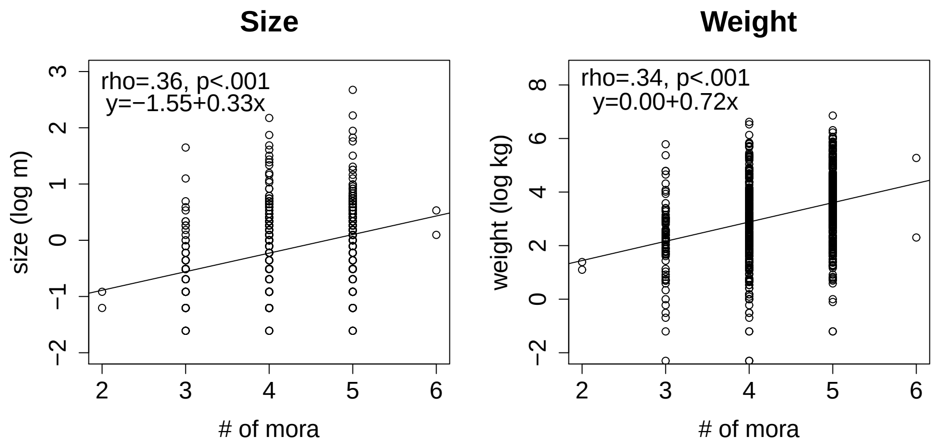

Figure 5: The effects of mora counts on the size and weight values. The positive correlations are significant at the $p < .001$ level, even excluding the 2-mora and 6-mora conditions.

Figure 6 illustrates the average number of moras in the Pokémon names for each evolution level. We observe that the more evolved a Pokémon character is, the more moras its name contains. The Spearman correlation co-efficient is 0.38, which is significant at the $p < .001$ level. Post-hoc comparisons with non-parametric Wilcoxon test shows that all adjacent evolution levels are significantly different in terms of their mora counts at the $p < .001$ level.

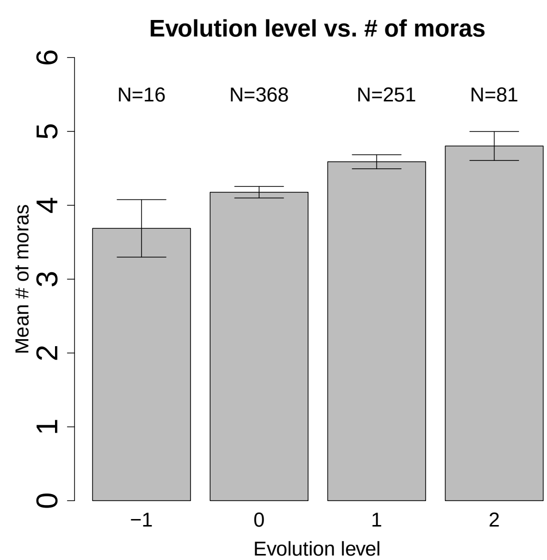

Figure 6: The average number of mora counts for each evolution level. The error bars represent 95% confidence intervals.

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 increases after evolution. The likelihood of the mora counts staying constant is also higher than the 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* → *mi-ru-ka-ro-su*; decrease: *ku-nu-gi-da-ma* → *fo-re-to-su*: constant: *ra-ru-to-su* → *ki-ru-ri-a*.

	Numbers	skew
Increase	166 (48%)	↑ ($< .001$)
Decrease	20 (6%)	↓ ($< .001$)
Constant	159 (46%)	↑ ($< .001$)

Table 4 shows the correlation vector with 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 respect.

Table 4: A correlation vector with 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 about this observation is how general this sound symbolic "longer-is-stronger" relationship is—is it specific to Pokémon names, or specific to proper names, or more generally operative in natural languages? We do not know of any studies which point out the correlation between word length and strengths, which may be a hint that it does not hold generally in natural languages. However, the spell names in Dragon Quest series—a nationally renowned Role Playing Game[5]—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*

[5]See the wikipedia article `https://en.wikipedia.org/wiki/Dragon_Quest` for details

(five moras), and then *gi-ra-gu-re-i-do* (6 moras) when it is strongest. Ditto 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 Dragon Quest series, and found a positive correlation ($\rho = 0.67, p < .001$), as shown in Figure 7.

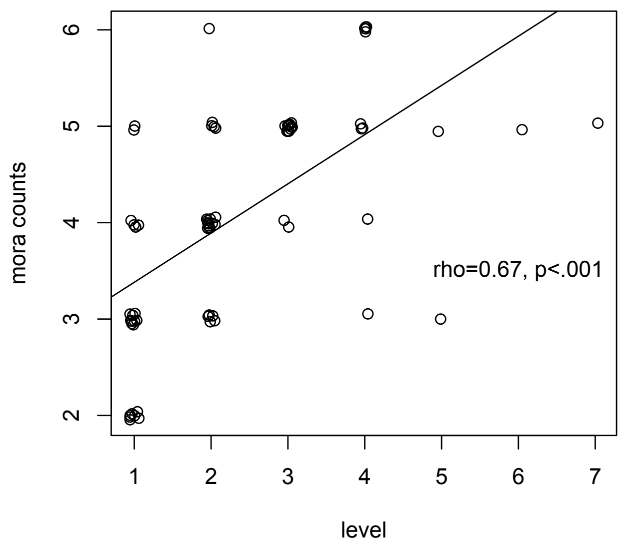

Figure 7: The relationship between the levels of the spells and the mora counts of their names in Dragon Quest series.

This sort of stochastic sound symbolic relationships may hold in the domain of naming proper nouns, although this hypothesis needs further quantitative verification. Most if not all studies of sound symbolism assume that sound symbolic relationships are not limited to particular vocabulary domains (though cf. Dingemanse et al. 2015; Monaghan et al. 2014; Wichman et al. 2010 for claims that they may), so it would be interesting if there can be a sound symbolic relationship specific to Pokémon names or proper names. Whether there can be a domain restriction on where sound symbolic relations can hold is an interesting and important question that needs to be addressed in future studies. Also whether this "longer-is-stronger" tendency is found in languages other than Japanese is also an interesting question that can be addressed in future research.

3.3 Multiple regression analyses

Having established the effects of voiced obstruents and those of mora counts, we need to address one 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 the 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 weight, 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.

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's names as a natural corpus. Japanese people 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 one to quantitatively test this sound symbolic connection using a natural corpus.

This study on the sound symbolic nature of Pokémon names is in no way comprehensive, and there are probably other sound symbolic factors that are present in Pokémon names. We chose to analyze the effects of voiced obstruents and mora counts, as they seem to be very clearly present. But there are other factors that seem to be operative, such as vowel quality and the presence of long vowels. For example, it is cross-linguistically known that back and low vowels tend to be judged to be larger than front and high vowels (Berlin, 2006; Haynie et al., 2014; Jespersen, 1922; Sapir, 1929; Shinohara and Kawahara, 2016; Ultan, 1978). It would be interesting to examine whether these sound symbolic effects of vowels are operative 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 (Kawahara and Kumagai, 2017). Although we are currently testing this issue with Japanese speakers, 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 classes. However, since Pokémon is a catchy topic, our experience is that it helps lower the psychological boundary of these students. Evidence that this project appeals to 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,[6] as well as from the fact that the first author was interviewed by the university newspaper at Keio University.[7]

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

Acknowledgments

This paper grew out of a seminar that the first author gave at Tokyo Metropolitan University in September 2016. We thank the students who participated in that seminar. Some of the analyses in this paper were used in introductory phonetics class at International Christian University, Keio University, Kwansei Gakuin University, and Tokyo Metropolitan University; this paper was also presented as invited lectures at Keio University, Meio University, Seoul International Phonology Conference, and Tokyo Gengo Kenkyuujyo (TEC), where we received interesting feedback.

References

Bauer, H. R. (1987), "Frequency code: Orofacial correlates of fundamental frequency," *Phonetica*, 44, 173–191.

Berlin, B. (2006), "The first congress of ethonozoological nomenclature," *Journal of Royal Anthropological Institution*, 12, 23–44.

Blasi, D., Wichman, S., Hammarström, H., Stadler, P. F., and Christianson, M. H. (2016), "Sound-meaning association biases evidenced across thousands of languages," *PNAS*, .

Cutler, A., and Otake, T. (2002), "Rhythmic categories in spoken-word recognition," *Journal of Memory and Language*, 46(2), 296–322.

Diehl, R., and Molis, M. (1995), "Effects of fundamental frequency on medial [voice] judgments," *Phonetica*, 52, 188–195.

Dingemanse, M., Blasi, D. E., Lupyan, G., Christiansen, M. H., and Monaghan, P. (2015), "Arbitrariness, iconicity and systematicity in language," *Trends in Cognitive Sciences*, 19(10), 603–615.

[6] http://wired.jp/2017/03/02/pokemon-sound/

[7] http://www.jukushin.com/archives/28130

D'Onofrio, A. (2014), "Phonetic detail and dimensionality in sound-shape correspondences: Refining the bouba-kiki paradigm," *Language and Speech*, 57(3), 367–393.
Fort, M., Martin, A., and Peperkamp, S. (2015), "Consonants are more important than vowels in the bouba-kiki effect," *Language and Speech*, 58, 247–266.
Gussenhoven, C. (2004), *The phonology of tone and intonation*, Cambridge: Cambrdige University Pressri.
Gussenhoven, C. (2016), "Foundations of intonational menaing: Anatomical and physiological factors," *Topics in Cognitive Science*, 8, 425–434.
Hamano, S. (1986), The Sound-Symbolic System of Japanese, Doctoral dissertation, University of Florida.
Haynie, H., Bowern, C., and LaPalombara, H. (2014), "Sound symbolism in the languages of Australia," *PLoS ONE*, doi:10.1371/journal.pone.0092852.
Hinton, L., Nichols, J., and Ohala, J. (1994), *Sound Symbolism*, Cambridge: Cambridge University Press.
Hinton, L., Nichols, J., and Ohala, J. (2006), *Sound Symbolism, 2nd Edition*, Cambridge: Cambridge University Press.
Hockett, C. (1959), "Animal "languages" and human language," *Human Biology*, 31, 32–39.
Hollard, M., and Wertheimer, M. (1964), "Some physiognomic aspects of naming, or maluma and takete revisited," *Perceptual and Motor Skills*, 19, 111–117.
Inagaki, K., Hatano, G., and Otake, T. (2000), "The effect of kana literacy acquisition on the speech segmentation unit used by Japanese young children," *Journal of Experimental Child Psychology*, 75, 70–91.
Ito, J. (1989), "A prosodic theory of epenthesis," *Natural Language and Linguistic Theory*, 7, 217–259.
Jespersen, O. (1922), "Symbolic value of the vowel i," in *Phonologica. Selected Papers in English, French and German*, Vol. 1, Copenhagen: Levin and Munksgaard, pp. 283–30.
Kawahara, S. (2006), "A faithfulness ranking projected from a perceptibility scale: The case of [+voice] in Japanese," *Language*, 82(3), 536–574.
Kawahara, S. (2015), *Oto-to Kotoba-no Hushigi-na Sekai*, Tokyo: Iwanami.
Kawahara, S. (2016), "Japanese has syllables: A reply to Labrune (2012)," *Phonology*, 33, 169–194.
Kawahara, S. (2017), "Sound symbolism in spell names in Dragon Quest series," *Journal of the Phonetic Society of Japan*, 21(2).
Kawahara, S., and Kumagai, G. (2017), "Expressing evolution in pokemon names: Experimental explorations,", Ms. Keio University and NINJAL.
Kawahara, S., and Shinohara, K. (2012), "A tripartite trans-modal relationship between sounds, shapes and emotions: A case of abrupt modulation," *Procedings of CogSci 2012*, pp. 569–574.
Kawahara, S., Shinohara, K., and Grady, J. (2015), "Iconic inferences about personality: From sounds and shapes," in *Iconicity: East meets west*, eds. M. Hiraga, W. Herlofsky, K. Shinohara, and K. Akita, Amsterdam: John Benjamins, pp. 57–69.
Kawahara, S., Shinohara, K., and Uchimoto, Y. (2008), "A positional effect in sound symbolism: An experimental study," in *Proceedings of the Japan Cognitive Linguistics Association 8*, Tokyo: JCLA, pp. 417–427.
Kingston, J., and Diehl, R. (1994), "Phonetic knowledge," *Language*, 70, 419–454.
Kingston, J., and Diehl, R. (1995), "Intermediate properties in the perception of distinctive feature

values," in *Papers in laboratory phonology IV: Phonology and phonetic evidence*, eds. B. Connell, and A. Arvaniti, Cambridge: Cambridge University Press, pp. 7–27.

Köhler, W. (1947), *Gestalt Psychology: An Introduction to New Concepts in Modern Psychology*, New York: Liveright.

Koppensteiner, M., Stephan, P., and Jäschke, J. P. M. (2016), "Shaking *takete* and flowing *maluma*. Non-sense words are associated with motion patterns," *PLOS ONE*, doi:10.1371/journal.pone.0150610.

Kubozono, H. (1999*a*), "Mora and syllable," in *The Handbook of Japanese Linguistics*, ed. N. Tsujimura, Oxford: Blackwell, pp. 31–61.

Kubozono, H. (1999*b*), *Nihongo-no Onsei: Gendai Gengogaku Nyuumon 2 [Japanese Phonetics: An Introduction to Modern Linguisitcs 2]*, Tokyo: Iwanami.

Kureta, Y., Fushimi, T., and Tatsumi, I. (2006), "The functional unit of phonological encoding: evidence for moraic representation in native Japanese speakers.," *Journal of Experimental Psychology: Learning, Memory and Cognition*, 32, 1102–1119.

Labrune, L. (2012), *The phonology of Japanese*, Oxford: Oxford University Press.

Lindauer, S. M. (1990), "The meanings of the physiognomic stimuli *taketa* and *maluma*," *Bulletin of Psychonomic Society*, 28(1), 47–50.

Lisker, L. (1978), "On buzzing the English /b/," *Haskins Laboratories Status Report on Speech Research*, SR-55/56, 251–259.

Lisker, L. (1986), ""Voicing" in English: A catalog of acoustic features signaling /b/ versus /p/ in trochees," *Language and Speech*, 29, 3–11.

Lockwood, G., and Dingemanse, M. (2015), "Iconicity in the lab: A review of behavioral, developmental, and neuroimaging research into sound-symbolism," *Frontiers in Psychology*, doi: 10.3389/fpsyg.2015.01246.

Maurer, D., Pathman, T., and Mondloch, C. J. (2006), "The shape of boubas: Sound-shape correspondences in toddlers and adults," *Developmental science*, 9, 316–322.

Miura, S., Murata, M., Hoda, S., Miyabe, M., and Aramaki, E. (2012), "Otoshoochoo-no kikaigakushuu-niyoru saigen: saikyoo-no pokemon-no seisei," *Gengoshori Gakkai Happyou Ronbunshuu*, pp. 65–68.

Monaghan, P., Shillcock, R., Christiansen, M., and Kirby, S. (2014), "How arbitrary is language?," *Phil. Trans. R. Soc. B.*, doi:10.1098/rstb.2013.0299.

Newman, S. (1933), "Further experiments on phonetic symbolism," *American Journal of Psychology*, 45, 53–75.

Nielsen, A. K. S., and Rendall, D. (2013), "Parsing the role of consonants versus vowels in the classic Takete-Maluma phenomenon," *Canadian Journal of Experimental Psychology*, 67(2), 153–63.

Ohala, J. J. (1983), "The origin of sound patterns in vocal tract constraints," in *The Production of Speech*, ed. P. MacNeilage, New York: Springer-Verlag, pp. 189–216.

Ohala, J. J. (1984), "An ethological perspective on common cross-language utilization of F0 of voice," *Phonetica*, 41, 1–16.

Ohala, J. J. (1994), "The frequency code underlies the sound symbolic use of voice pitch," in *Sound Symbolism*, eds. L. Hinton, J. Nichols, and J. J. Ohala, Cambridge: Cambrdige University Press, pp. 325–347.

Ohyama, Y. (2016), What can Pokémon names tell us about Japanese and English morphology and phonology,, Master's thesis, University of College London.

Otake, T., Hatano, G., Cutler, A., and Mehler, J. (1993), "Mora or syllable? Speech Segmentation in Japanese," *Journal of Memory and Language*, 32, 258–278.

Perfors, A. (2004), "What's in a name?: The effect of sound symbolism on perception of facial attractiveness," *Proceedings of CogSci 2004*, .

Perniss, P., Thompson, R. L., and Vigiliocco, G. (2010), "Iconicity as a general property of language: Evidence from spoken and signed languages," *Frontiers in Psychology*, doi:10.3389/fpsyg.2010.00227.

Plato (nd), *Cratylus* [translated by B. Jowett].

Proctor, M. I., Shadle, C. H., and Iskarous, K. (2010), "Pharyngeal articulation differences in voiced and voiceless fricatives," *Journal of the Acoustical Society of America*, 127(3), 1507–1518.

R Development Core Team (1993–), *R: A language and environment for statistical computing*, R Foundation for Statistical Computing, Vienna, Austria.

Ramachandran, V., and Hubbard, E. M. (2001), "Synesthesia–A window into perception, thought, and language," *Journal of Consciousness Studies*, 8(12), 3–34.

Raphael, L. (1981), "Duration and contexts as cues to word-final cognate opposition in English," *Phonetica*, 38, 126–47.

Sapir, E. (1929), "A study in phonetic symbolism," *Journal of Experimental Psychology*, 12, 225–239.

Saussure, F. d. (1916), *Cours de linguistique générale* Payot.

Shinohara, K., and Kawahara, S. (2013), "The sound symbolic nature of Japanese maid names," *Proceedings of the 13th Annual Meeting of the Japanese Cognitive Linguistics Association*, 13, 183–193.

Shinohara, K., and Kawahara, S. (2016), "A cross-linguistic study of sound symbolism: The images of size," in *Proceedings of the Thirty Sixth Annual Meeting of the Berkeley Linguistics Society.*, Berkeley: Berkeley Linguistics Society, pp. 396–410.

Shinohara, K., Yamauchi, N., Kawahara, S., and Tanaka, H. (2016), "*Takete* and *maluma* in action: A cross-modal relationship between gestures and sounds," *PLOS ONE*, doi:10.1371/journal.pone.0163525.

Sidhu, D., and Pexman, P. M. (2015), "What's in a name? Sound symbolism and gender in first names," *PLoS ONE*, doi:10.1371/journal.pone.0126809.

Stevens, K., and Blumstein, S. (1981), "The search for invariant acoustic correlates of phonetic features," in *Perspectives on the study of speech*, eds. P. Eimas, and J. D. Miller, New Jersey: Earlbaum, pp. 1–38.

Ultan, R. (1978), "Size-sound symbolism," in *Universals of Human Language II: Phonology*, ed. J. Greenberg, Stanford: Stanford University Press, pp. 525–568.

Vance, T. (1987), *An Introduction to Japanese Phonology*, New York: SUNY Press.

Vance, T. (2015), "Rendaku," in *The Handbook of Japanese Language and Linguistics: Phonetics and Phonology*, ed. H. Kubozono, Berlin: Mouton de Gruyter, pp. 397–441.

Vance, T., and Irwin, M., eds (2016), *Sequential voicing in Japanese compounds: Papers from the NINJAL Rendaku Project*, Amsterdam: John Benjamins.

Wichman, S., Holman, E. W., and Brown, C. H. (2010), "Sound symbolism in basic vocabulary," *Entropy*, 12(4), 844–858.

Wright, S., and Hay, J. (2002), "Fred and Trema: A phonological conspiracy," in *Gendered Practices in Language*, eds. S. Benor, M. Rose, D. Sharma, J. Sweetland, and Q. Zhang CSLI Publi-

cations, pp. 175–191.
Wright, S., Hay, J., and Tessa, B. (2005), “Ladies first? Phonology, frequency, and the naming conspiracy,” *Linguistics*, 43(3), 531–561.