Do sibilants fly?
Evidence from a sound symbolic pattern in Pokémon names*

Abstract

Ancient writers, including Socrates and the Upanishads, argued that sibilants are associated with the notions of wind, air and sky. From modern perspectives, these statements can be understood as an assertion about sound symbolism, systematic connections between sounds and meanings. Inspired by these writers, this paper reports on an experiment which tests a sound symbolic value of sibilants. The experiment is a case study situated within the Pokémonastics research paradigm, in which researchers explore the sound symbolic patterns in natural languages using Pokémon names. The current experiment shows that when presented with pairs of a flying type Pokémon character and a normal type Pokémon character, Japanese speakers are more likely to associate the flying type Pokémons with names that contain sibilants than those names that do not contain sibilants. As was pointed out by Socrates, the sound symbolic connection identified in the experiment is likely to be grounded in the articulatory properties of sibilants—the large amount of oral airflow that accompanies the production of sibilants. Various implications of the current experiment for the sound symbolism research are discussed throughout the paper.

*We are grateful to Kimi Akita, Ola Ćwiek, Donna Erickson, Susanne Fuchs and two anonymous reviewers for their comments on previous versions of this paper and/or helpful discussions on some of the issues that are addressed in the paper. This research is supported by the JSPS grant #17K13448. All remaining errors are ours.

1 Introduction

Socrates in *Cratylus* suggests that [s] (=σ) and [z] (=ζ) are suited for words that represent wind and vibration, because the production of these sounds accompanies strong breath (427). Likewise, the Upanishads, ancient Sanskrit texts, suggests that "[t]he mute consonants represent the earth, **the sibilants the sky**, the vowels heaven. The mute consonants represent fire, **the sibilants air**, the vowels the sun" (Aitareya Aranyaka III.2.6.2., emphasis ours).[1] These statements by the ancient writers concern what we now call "sound symbolism," in which certain sounds directly represent certain meanings. The commonly held dictum in modern linguistic theories in the twentieth century, which is often attributed to Saussure (1916), is that the relationships between sounds and meanings are fundamentally arbitrary. However, as these ancient writers had already noticed, systematic relationships between sounds and meanings occur in some environments. For instance, nonce words containing the low back vowel [a] are often judged to be larger than nonce words containing the high front vowel [i] by speakers of many languages (Berlin 2006; Jespersen 1922; Newman 1933; Sapir 1929; Shinohara & Kawahara 2016, among others). Another example is the *bouba-kiki* effect, in which sounds like [b] and [u] tend to be associated with round objects, whereas sounds like [k] and [i] tend to be associated with angular objects (D'Onofrio 2014; Ramachandran & Hubbard 2001). In recent years, the current fields of anthropology, linguistics, cognitive science and psychology have witnessed a dramatic rise of interests in sound symbolism (see e.g. Dingemanse et al. 2015, Kawahara 2020a, Lockwood & Dingemanse 2015 and Nuckolls 1999 for recent overviews).

This paper reports on an experiment which demonstrates that the intuitions expressed by Socrates and the Upanishads were correct, at least to some extent. We draw on a research paradigm now referred to as "Pokémonastics," in which researchers explore sound symbolic patterns using Pokémon names across different languages (Shih et al. 2019). Pokémon is a game series in which players collect fictional creatures called Pokémon (itself truncation of [poketto monsutaa] 'pocket monster'), and let them battle with other Pokémons. It was first released by Nintendo in 1996, and has now become a very popular game series in many parts of the world. Each Pokémon character has various attributes, including weight, height, strength parameters, evolution levels and types, the last of which is the main concern of the paper.

The Pokémonastics research paradigm was initiated by Kawahara et al. (2018), who first pointed out that some linguistic parameters in the Japanese Pokémon characters' names, including the number of voiced obstruents (=[b], [d], [g], [z]) and the number of moras (=the basic counting units in Japanese: Otake et al. 1993), are significantly correlated with some Pokémons' attributes, such as weight, height, strength parameters and evolution levels. A similar analysis has now been extended to the names of existing Pokémon characters in Can-

[1] https://en.wikipedia.org/wiki/Sound_symbolism#theUpanishads (last access, June 2020).

tonese, English, Korean, Mandarin, and Russian (Shih et al. 2018, 2019). In addition, there have been several experimental studies which used non-existing Pokémon characters to explore sound symbolic patterns; the target languages studied so far include Brazilian Portuguese (Godoy et al. 2019), English (Kawahara & Moore to appear) and Japanese (Kawahara & Kumagai 2019a; Kumagai & Kawahara 2019).

While studies within the Pokémonastics paradigm have been flourishing and revealing interesting sound symbolic patterns in natural languages, one aspect that remains under-explored is whether Pokémon *types* can be symbolically represented. Pokémon characters are classified into different types, such as dragon, electric, fairy, fire, ghost, grass, normal, water, etc. Hosokawa et al. (2018) was the first attempt to investigate this question, who found that in the existing Japanese Pokémon names, bilabial consonants, such [p] and [m], are overrepresented in the names of the fairy type Pokémons, whereas voiced obstruents, such as [d] and [z], are overrepresented in the names of the dark, poison and ghost type Pokémons (which Hosokawa et al. collectively refer to as the "villain" type Pokémons).[2] The productivity of these sound symbolic patterns was confirmed by an experimental study with nonce words by Kawahara & Kumagai (2019b).

This question—whether Pokémon types can be symbolically represented—is an interesting topic of exploration, not just because Pokémon is fun material to study but also because it bears upon an important question in the studies of sound symbolism in general; namely, what kinds of semantic dimensions can be cued by sound symbolic patterns. Two semantic dimensions that have been studied extensively in the literature on sound symbolism so far are size and shape (Sidhu & Pexman 2018), but currently, we barely understand what other semantic dimensions can be conveyed via sound symbolism in natural languages (Lockwood & Dingemanse 2015; Spence 2011; Westbury et al. 2018). For example, can *freedom* or *justice* be symbolically represented (Lupyan & Winter 2018)? The current study is a modest contribution to this general debate, inspired by the words of Socrates and the Upanishads.

To this end, we report on an experiment which examined whether sibilants (=coronal fricatives, including [s] and [ʃ] in English, for example) can represent the flying type in the Pokémon world. To the best of our knowledge, sound symbolic values of sibilants have been understudied in the literature on sound symbolism. Coulter & Coulter (2010) argue that fricatives—a superset of sibilants—may be associated with images of smallness in English, due to their high frequency energy. However, their experiment on price discount judgments targeting English speakers conflated the stop/fricative distinction with the vowel backness distinction, and as such, it is not clear if their results can be unambiguously attributed to the sound symbolic values of fricatives. Kawahara & Moore (to appear) did not find a substantial difference between stops and fricatives in terms of how likely they are associated with larger, post-evolution Pokémon characters. In Lahu,

[2]This initial observation by Hosokawa et al. (2018) is analyzed in further detail by Uno et al. (to appear).

there are many diminutive/affective words that contain sibilants followed by a certain type of diphthong (Matisoff 1994). In Japanese mimetic, onomatopoetic words, [s] can mean 'light touch' or 'friction' (Hamano 1998); e.g. *sara-sara* 'lightly touching/smooth.' Hamano (1998) also contends that [s] can mean 'absence of obstruction' or 'ease of movement,' as in *sorori* 'walking quietly' and *suku-suku* 'growing healthy.' In a study of sound symbolism in general Japanese grammar, Makino (2007) points out that the suffix [-ɕii] ([ɕ]=alveolo-palatal fricative) denotes emotive descriptions. None of these sound symbolic patterns, however, are directly related to the notion of flying (or sky or wind, for that matter), as the two aforementioned ancient writers noted.

Given that Socrates pointed out a possible sound symbolic association between sibilants and wind, and the Upanishads suggests a connection between sibilants on the one hand and sky and air on the other, perhaps we might see that Pokémon character names with sibilants are also associated with the notion of flying.

In addition to bearing on the general question of which semantic dimensions can be represented via sound symbolism, the current hypothesis is interesting to test for another reason, because it concerns the question of phonetic grounding of sound symbolism. Many if not all sound symbolic patterns are based on iconic mapping between the phonetic properties of the sounds at issue and their meanings (Kawahara 2020a). For example, [a] is often judged to be larger than [i], and this sound symbolic pattern may hold because the oral aperture is much wider for the production of [a] than for [i] (Jespersen 1922; Sapir 1929). The intuitions expressed by Socrates and the Upanishads may likewise be grounded in the fact that the production of sibilants involves a large amount of oral airflow compared to the other types of sounds, as Socrates noticed (see Mielke 2011 for actual measurement data of oral airflow using nasometer). If the productivity of the sound symbolism between sibilants and the notion of flying can be confirmed, we would have yet another plausible instance of an iconic mapping between meanings and phonetic properties of sounds.

2 Methods

2.1 Task

The current experiment followed the format of the previous Pokémonastics experiments, studies of sound symbolic effects using Pokémon names (e.g. Kawahara & Kumagai 2019a,b; Kumagai & Kawahara 2019). Within each trial, a pair of two non-existing Pokémon characters was presented, together with a pair of nonce names. In the current experiment, visual cues consisted of one flying type Pokémon and one normal type Pokémon (the latter of which do not have specific outstanding characteristics). An illustrative sample pair of these characters is shown in Figure 1. Given two name choices, the task for the participants was to choose which name is better for the flying type Pokémon character, and which name is better for the normal type Pokémon character. The pictures of Pokémon were those that were drawn by *toto-mame*, a digital artist who draws original Pokémon character.[3] The pictures were used with the permission of the artist. The Pokémon character pictures drawn by *toto-mame* are not a priori assigned to a particular type. Hence the third author, who is very familiar with the Pokémon game, chose those characters that look representative of the flying and normal type characters for this experiment. Most of the flying type characters were bird-like creatures, while some of them looked like a flying insect. All of them had wings to make it clear to the participants that they actually fly. In the current experiment, a flying type Pokémon appeared on the left, whereas a normal type Pokémon appeared on the right, as in Figure 1.

Figure 1: A sample pair of Pokémon pictures used in the experiment. Left = flying type; right = normal type. Sixteen such pairs were created and used in the experiment. Due to copy right issues, not all of them can be reproduced in the paper, but they can be made available upon request for the sake of replication, granted that the artist gives an approval to do so.

2.2 Stimuli

Table 1 lists all the pairs of names used in the experiment. All the names were non-existing words/names in Japanese. Two types of sibilants were tested in this experiment: [s] and [sh] (the latter of which is realized as an alveolo-palatal fricative in Japanese, written as [ɕ] in International Phonetic Alphabet: Vance 2008). We only tested voiceless sibilants, because voiced sibilants convey other sound symbolic meanings, such as heaviness and evilness, in the Japanese Pokémon universe and elsewhere in the language (Hosokawa et al. 2018; Kawahara et al. 2018; Kawahara & Kumagai 2019b; Uno et al. to appear).[4] The [s]-condition compared word-initial [s]

[3]For other pictures of non-existing Pokémons drawn by this artist, see `https://t0t0mo.jimdo.com` (last access, June 2020)

[4]An anonymous reviewer pointed out that it would have been better if we tested that voiced fricatives are indeed not associated with the notion of flying. We would like to leave this task for future research.

against word-initial [t], the latter of which is a consonant with the same place of articulation which minimally differs from [s] in terms of continuency. In this condition, the target words also contained word-medial [ɕ], whereas the comparison names contained word-medial [k]. In the [sh]-condition, word-initial [ɕ] was compared against either word-initial [k] or [t]. [k] was generally used as a comparative baseline with [ɕ], because it is a stop consonant that is produced at a point further back in the oral cavity (i.e. velar) than [s] or [t], and in this sense, [k] is more like [ɕ] than [t] is; i.e. [s] and [t] are "front" consonants, whereas [ɕ] and [k] are "back" consonants (Mann & Repp 1981). [t] was used, however, when the use of [k] would have resulted in a real word in Japanese. The [ɕ]-initial words also contained word-medial [s], which is allophonically produced as [ɕ] before [i] in Japanese (Vance 2008). To minimize the sound symbolic effects of other consonants possibly affecting the results, the only non-target consonants which appeared in the stimuli were limited to [ɾ] in the second syllable, and the vowel quality within each pair was controlled. Each condition had 8 items. The experiment therefore consisted of 16 trials in total (8 item pairs × 2 conditions).

Table 1: The list of stimuli used in the experiment. [ɾ] represents an alveolar flap. [ɕ] represents a voiceless alveolo-palatal fricative.

The [s]-condition	The [sh]-condition
[saroɕɕuu] vs. [tarokkuu]	[ɕarossee] vs. [karottee]
[suraɕɕoo] vs. [turakkoo]	[ɕurassoo] vs. [kurattoo]
[sureɕɕuu] vs. [turekkuu]	[ɕuressee] vs. [kurettee]
[seriɕɕaa] vs. [terikkaa]	[ɕiressaa] vs. [tirekkaa]
[sareɕɕaa] vs. [tarekkaa]	[ɕareɕɕii] vs. [karettii]
[seruɕɕaa] vs. [terukkaa]	[ɕirassaa] vs. [tirakkaa]
[soroɕɕaa] vs. [torokkaa]	[ɕorossaa] vs. [korottaa]
[soreɕɕuu] vs. [torekkuu]	[ɕoressee] vs. [korettee]

2.3 Procedure

The experiment was distributed online using SurveyMonkey. All the stimuli were written in the *katakana* orthography, the standard way to write nonce words in Japanese. Within each main trial, the participants were reminded that the pair consists of a flying type Pokémon and a normal type Pokémon, and they were asked to choose a better name for each type of character. Each trial used a different pair of characters; i.e. there were 16 pairs of visual stimuli as well. The order of trials was randomized per each participant. Before the experiment, they read through the consent form to participate in the web-based experiment. After the experiment, they provided some demographic information. One of the questions was about how familiar they are with the Pokémon game, and the participant responded to this question using a 7-point ordinal scale, in which higher values corresponded to more familiarity with Pokémon. In this scale, 1 was labeled "I have never played Pokémon", 7 was labelled "Pokémon is my life," and 4 was labelled "so so." The other numbers were not labelled. As post-hoc questions, they were asked whether they had studied sound symbolism before and whether they participated in an experiment in which they named new Pokémon names, as in the current experiment. The participation in this experiment was completely voluntary, and there were no particular compensations for participating in this experiment.

2.4 Participants

Initially, the call for participants was circulated on various Social Networking Services and via word of mouth, which resulted in 69 participants. We excluded those participants who either had studied sound symbolism before or had participated in a similar Pokémon naming experiment, and used the data from the remaining 63 participants for the subsequent analysis (26 male, 36 female, plus 1 who did not identify their gender—the distribution of the age groups is reported in the Appendix).

Someone later posted the link for the online survey on a website for Pokémon fans,[5] and it was subsequently made into an online blog article, and more than 700 people participated in the experiment over a single night. Since the latter set would be likely to yield a statistically significant result due to large N, we analyzed the two datasets separately (henceforth, "the small dataset" and "the large dataset"). The small dataset is comparable in size with the other previous Pokémonastics experiments. The large dataset was also analyzed in this paper to confirm the robustness of the target patterns with a much larger number of participants.

In the large dataset, a total of 791 speakers completed the online experiment. After excluding those who had studied sound symbolism before or had participated in a Pokémon naming experiment, data from 776 participants entered into the following analysis (573 male, 192 female, plus 11 who did not identify their gender). Again the Appendix reports the distribution of age groups of the large dataset, as well as the analysis of their possible effects on the sound symbolic effect under investigation.

2.5 Statistical analyses

The current experiment is, as described above, a two-alternative forced choice experiment. To statistically analyze the results obtained in this format, we followed the methodology proposed by Daland et al. (2011), which has advantages over other possible alternatives (see their footnote 5); concretely, each trial was split into two observations, each corresponding to one member of a

[5] `http://pokemon-matome.net` (last access, June 2020).

stimulus pair. Since each trial consisted of a pair of stimuli, this splitting was necessary to use a linear mixed effects model with items as a random effect. A logistic linear mixed effects model (Jaeger 2008) was fit with the sound symbolic principle (i.e. sibilant=flying type) as a fixed factor and participant and item as random factors. The fixed factor was coded as 0.5 vs. -0.5. A model with maximum random structure with both slopes and intercepts was fit first (Barr 2013; Barr et al. 2013). In case the model with the maximum random structure did not converge, a simpler model with only random intercepts was then fit and interpreted.

3 Results

Figure 2 shows boxplots illustrating the distributions of expected response ratios—in which names containing sibilants were associated with the flying type—in the small dataset, both by participant (left) and by item (right). The grand averages are shown as white dots. The grey bars around the grand averages show the 95% confidence intervals. The grand averages in this dataset are 0.80 and 0.69, respectively. The linear mixed effects logistic regression shows that the [s]-condition showed an average response that is significantly higher than the chance level ($\beta = 2.22, s.e. = 0.15, z = 15.21, p < .001$).[6] The [sh]-condition also showed an average response that is significantly higher than the chance level ($\beta = 2.72, s.e. = 0.42, z = 6.48, p < .001$).

[6]The model with random subject slopes did not converge, so we interpreted a model with random intercepts for subjects only, along with random intercepts and slopes for items.

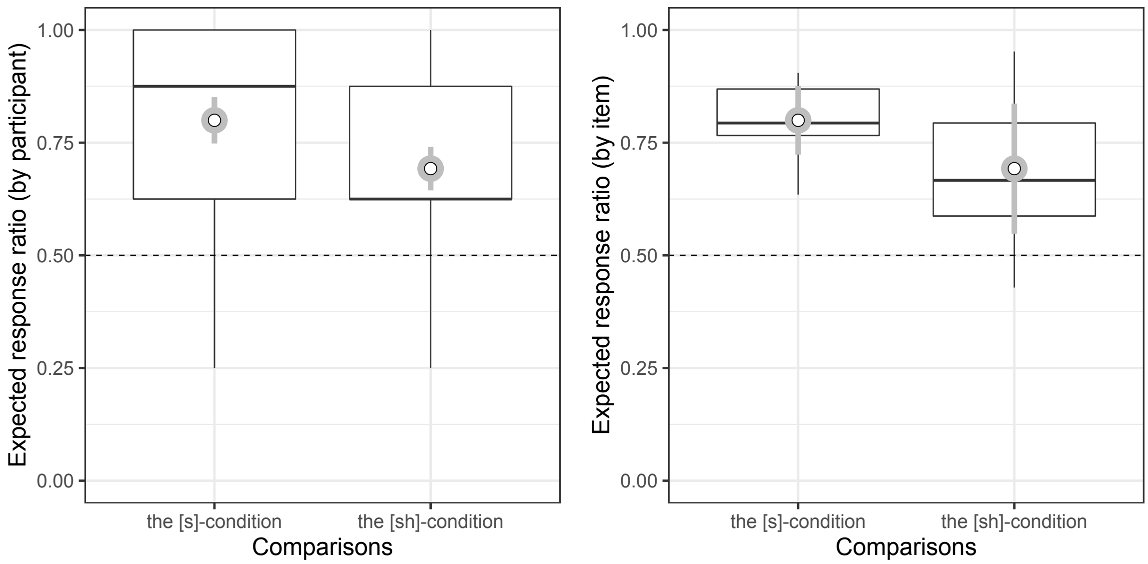

Figure 2: Boxplots illustrating the distributions of expected response ratios (the small dataset), by participant (left) and by item (right). The white circles represent the grand averages. The grey bars around the white circles represent the 95% confidence intervals around these averages.

Figure 3 shows boxplots illustrating the distribution of expected response ratios in the large dataset. The grand averages for the large group dataset are 0.75 and 0.59, respectively. The mixed effects logistic regression shows that both the [s]-condition and the [sh]-condition exhibit expected response ratios which are significantly above the chance level ($\beta = 1.86, s.e. = 0.142, z = 13.12, p < .001$ and $\beta = 1.79, s.e. = 0.115, z = 15.51, p < .001$, respectively).

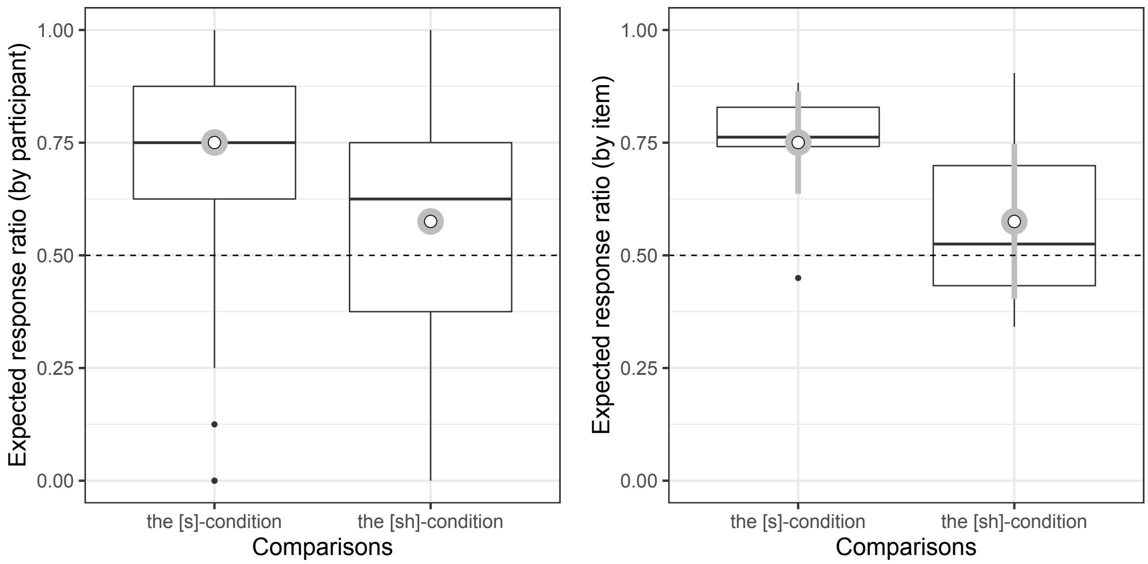

Figure 3: Boxplots illustrating the distributions of expected response ratios (the large dataset). Left = by participant; right = by item. The 95% confidence intervals of the left figure (the by-participant analysis) are tiny due to large N (=776).

A post-inspection of the boxplots in Figures 2 and 3 shows that names with initial [s] may have induced more flying responses than those with initial [ɕ]. To access this observation statistically, we included the interaction between the sound symbolic principle and the [s] vs. [ɕ] difference in our models. The results show that this interaction term is not significant in either data set (the small dataset: $\beta = 0.11, s.e. = 0.20, z = 0.61, n.s.$; the large dataset: $\beta = -0.004, s.e. = 0.05, z = -0.08, n.s.$, respectively), possibly due to fairly large variability across items in the [sh]-condition.

4 Discussion

The current experiment shows that Japanese speakers are more likely to associate the flying type Pokémon characters with names that contain sibilants than those names that do not contain sibilants.[7] This result is likely to be due to the sound symbolic association between sibilants and the

[7]As an anonymous reviewer reminded us, the current methodology (i.e. a two-alternative forced choice task), although it is widely used in studies on sound symbolism, has its limits in that there remain alternative possibilities which can explain the current results (e.g. those names without sibilants were associated with the normal type or they are negatively associated with the flying type) (see Westbury et al. 2018 for extensive discussion on this methodological issue). While we acknowledge that these alternative explanations are possible, we doubt that for the case at hand, they are likely to be what underlies the current results, because there are no plausible sound symbolic principles, for example, that would connect voiceless stops with the normal type Pokémon, which did not have outstanding characteristics in our experiment. A study with a different experimental format—e.g. presenting one stimulus per trial—would more directly address this potential concern, however. See Kawahara et al. (2020) for an experiment which found the

notion of flying, an association that is very similar to what Socrates and the Upanishads identified in their writings. The sound symbolic association is gradient rather than deterministic, as is usually the case for other sound symbolic connections (Dingemanse 2018; Kawahara et al. 2019), although inspection of the boxplots shows that there were participants who always chose names with sibilants for the flying type Pokémons.

One natural question that arises from this experimental result is whether sibilants are overrepresented in the flying type of Pokémon characters in the existing set of Japanese Pokémon names. To address this question, we counted the total numbers of consonants as well as the number of voiceless sibilants in the flying type Pokémons and normal type Pokémons. The results are shown in Table 2. There are not many voiceless sibilants in the first place, and no significant differences were found between the two types of Pokémon characters ($\chi^2(1) = 0.326, n.s$). We also counted the number of those characters whose names contain voiceless sibilants in both the flying type characters and normal type characters. The results appear in Table 3, which again shows that there are no substantial differences between the two types ($\chi^2(1) = 0.41, n.s$).

Table 2: The distributions of voiceless sibilants and other consonants in the names of the flying type characters and normal type characters in Japanese. The analysis is based on the data from Kawahara et al. (2018), which includes all the characters up to the 7th generation.

	Flying type	Normal type
sibilants	15 (3.8%)	13 (3.1%)
other consonants	377	407
total	392	420

Table 3: The numbers of names that contain sibilants and those that do not in the flying type characters and normal type characters.

	Flying type	Normal type
with sibilants	13 (19.4%)	13 (18.0%)
without sibilants	54	59
total	67	72

These analyses show that the sound symbolic connection that we identified above *emerged* in the experiment, without the distributional evidence in the existing Pokémon names. This result reminds us of cases in which phonetically natural phonological patterns emerge in nonce word

sound symbolic connection between sibilants and the flying Pokémon types using this format, although Kawahara et al. (2020) tested English speakers, not Japanese speakers.

experiments, without statistical evidence in the lexicon (e.g. Berent et al. 2007; Guilherme 2019; Jarosz 2017; Wilson 2006). There are comparable cases from studies of sound symbolism as well. For example, in the English Pokémon names, back vowels are not necessarily overrepresented for post-evolution characters (Shih et al. 2019). Nevertheless, when presented with a pair of nonce names, English speakers are more likely to associate names with [u] with post-evolution characters than names with [i] (Kawahara & Moore to appear). In Korean mimetic expressions, [ɑ] and [o] are smaller than [u] and [ʌ] in terms of their sound symbolic values (Garrigues 1995; Kim 1977), which goes counter to an otherwise cross-linguistically common observation that high vowels are generally judged to be smaller than non-high vowels (Sapir 1929 *et seq.*). However, Shinohara & Kawahara (2016) found that given nonce words, Korean speakers judge nonce words with high vowels to be smaller than those with low vowels, contrary to what we would expect from the lexical patterns. In short, as with these cases, the current experiment adds a new instance of sound symbolism that emerges in an experimental setting without overt evidence in the lexicon.

Another question that arises is whether showing the sound symbolic connection we identified in the current experiment requires exposure to existing Pokémon names (some of which are quite sound symbolic, as other Pokémonastic studies have shown), or whether the participants know the sound symbolic connection between sibilants and the notion flying, independently of the exposure to Pokémon. If the former, those who are not familiar with Pokémon should show low expected response ratios, whereas those who are very familiar with Pokémon should show high expected response ratios. To address this question, Figure 4 plots the correlation between familiarity with Pokémon and expected response ratios for the [s]-condition and [sh]-condition separately, both in the small dataset and the large dataset.

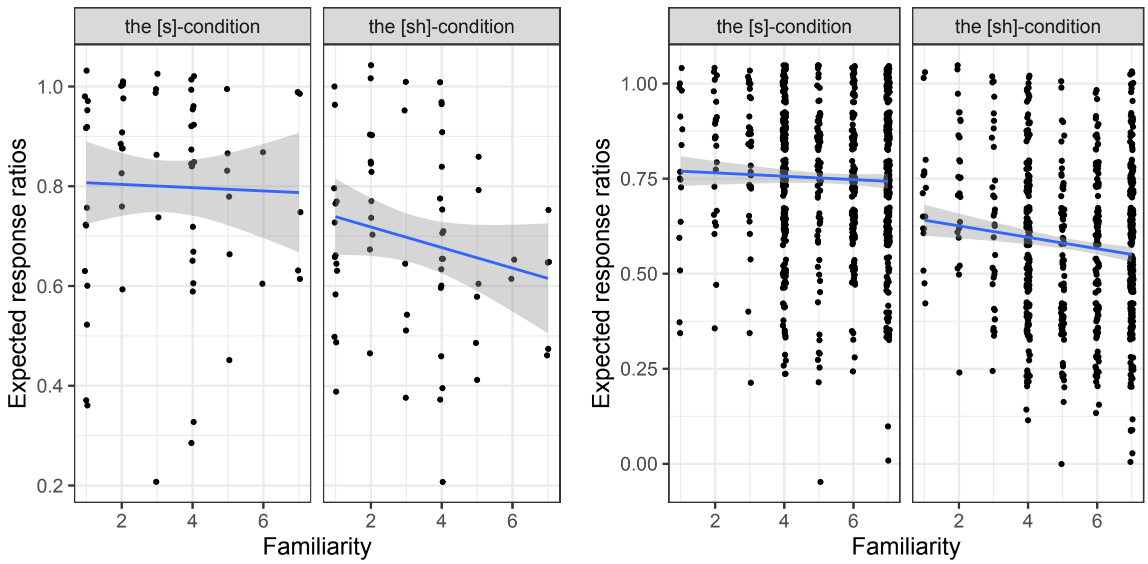

Figure 4: Correlation between familiarity with Pokémon and expected response ratios. Left = the small dataset; right = the large dataset. The solid lines are linear regression lines. The grey areas represent the 95% confidence intervals.

Significance of the correlation between the two measures was assessed using a Spearman test (a non-parametric correlation test, because the familiarity scale was ordinal). Neither correlation was significant for the small dataset (the [s]-condition: $\rho = 0.05$ and the [sh]-condition: $\rho = -0.18$). The large dataset also showed similar patterns. Due to the large N, the [sh]-condition showed a significant correlation (the [s]-condition: $\rho = -0.04, n.s.$ and the [sh]-condition: $\rho = -0.08, p < .05$). However, the effect size (-0.08) is quite small. Overall, exposure to existing Pokémon names does not seem to have affected the results, not positively at least. This result is in line with the results of other Pokémonastics experiments in that familiarity with Pokémon plays very little, if any, role for the judgment of sound symbolic patterns in new Pokémon names (e.g. Godoy et al. 2019; Kawahara & Kumagai 2019a,b; Kawahara & Moore to appear).

From the analyses above, we conclude that Japanese speakers associate names containing sibilants with the flying type of Pokémon, and this association holds regardless of whether the participants are familiar with Pokémon or not. As anticipated in the introduction, this sound symbolic association is likely to have its roots in the fact that the production of sibilants involves a large amount of oral airflow to create frication noise, compared to the other types of sounds (Mielke 2011)—we can "hear" the air blowing/moving in a sibilant sound, and if you are close enough to the speaker, you can even feel the air moving (cf. Derrick & Gick 2013; Gick & Derrick 2009).[8] This result provides a new piece of support for the idea that at least a subset of sound symbolic

[8] We assume that airflow and the notion of flying are closely related concepts.

patterns are grounded in their phonetic properties (Kawahara 2020a).[9]

Furthermore, it may bear on an interesting question of how articulatory and/or acoustic features of sounds are iconically mapped onto their sound symbolic meanings. Jespersen (1922) and Sapir (1929), two pioneering studies of modern studies of sound symbolism, already entertained two hypotheses regarding why [a] tends to be judged to be larger than [i]. One is the articulation-based explanation—it is because the oral aperture is much wider for the production of [a] than for [i]. The other explanation is based on the acoustics—it is because the acoustic properties of [a] (more specifically, f0 and F2 in modern acoustic parlance) are lower than those for [i]. Ohala (1994) proposed a general theory of sound symbolism based on acoustic properties of sounds at issue, now known as the Frequency Code Hypothesis; those sounds with low frequency energy tend to be judged to be large, because that is what physics tells us. If the sound symbolic nature of sibilants is grounded in the amount of oral airflow, as Socrates suggests, it implies that the sound symbolic association identified in the current experiment has its roots in the articulation of sibilants.

We note, however, that it is not impossible to imagine that since sibilants have energy concentration in high frequency region because of their very small resonance cavities (Johnson 2003), this "highness" is iconically mapped onto the notion of sky, and by extension, to the notion of flying. See Paraise et al. (2014) and references cited therein for the possible iconic connections between high frequency sounds and the notion of elevation, which may also be relevant for the sound symbolic pattern that is identified in the current experiment. As both Jespersen (1922) and Sapir (1929) anticipated, the phonetic grounding of sound symbolism may be based on both articulation and acoustics.

Finally, we would like to point out one general virtue of using the Pokémon universe to explore sound symbolic patterns. As mentioned in the method section, the link to our online experiment was shared on a website for Pokémon fans, and it was made into an online blog article, advertising that a linguistics professor was conducting an experiment on Pokémon. Consequently, we were able to obtain data from more than 700 participants over a single night. This fact in and of itself instantiates a research advantage, because it is rare to be able to obtain data from such a large number of participants during such a short period of time. Another related point that we would like to highlight is that a large number of people who are not in academia were interested in this project, so much so that they participated in the experiment without any compensation. Many participants reported in a free commentary section at the end of the experiment that they were curious about what the experiment was about and/or that they would like to know the results. Thus, this constitutes evidence that Pokémonastics—studies of sound symbolism using Pokémon

[9] There are sound symbolic patterns which do not have such apparent phonetic grounding—for example, the fact that the English *sn-* sequence is often used to represent words related to "nose" or "mouth" (e.g. *snarl*, *sneeze*, *snore*, *snack*, *snicker*, etc) (Bergen 2004) is unlikely to be grounded in how [s] and [n] are produced, or in their acoustic properties.

names—can be an effective means to popularize linguistic and psychology studies, which can also potentially be applied to teaching (see Kawahara 2019, Kawahara 2020b and MacKenzie 2018 for related discussion).

5 Conclusion

The current experiment has demonstrated that Japanese speakers are more likely to associate the flying type Pokémon characters with names containing sibilants than those names that do not contain sibilants, despite the fact that this connection between sibilants and the notion of flying does not hold among the existing Pokémon names in Japanese. This sound symbolic association seems to hold regardless of whether the participants are familiar with the Pokémon game or not.

At the most general level, the issue that we addressed relates to the question of what kinds of semantic dimension can be represented via sound symbolism in natural languages. While the scope of our study is admittedly limited because it tested only one semantic dimension, the current study, building upon some previous observations (Hosokawa et al. 2018; Kawahara & Kumagai 2019b; Uno et al. to appear), found that a notion that is as complex as Pokémon type can be symbolically represented. The sound symbolic pattern that we identified is, as anticipated long ago by Socrates and the Upanishads, the connection between sibilants and flying. It is likely that this connection is grounded in the articulatory properties of sibilants, a large amount of oral airflow that accompanies the production of these sounds to cause frication noise.

The current finding accords well with what Shih et al. (2019) conclude based on an extensive cross-linguistic comparison of Pokémon names. They observe that while in the real world we observe various types of sound symbolic effects to signal gender differences (see Sidhu & Pexman 2019 for a recent review), we do not observe robust sound symbolic effects to signal gender differences in the Pokémon world. Shih et al. (2019) argue that this difference arises because finding a mate is crucial for survival and reproduction in the real world, but this is not so much the case in the Pokémon world. This claim by Shih et al. is further supported by the fact that Pokémon strength status is actively signaled by way of sound symbolism across languages, and this is so because Pokémon characters routinely fight with each other. They conclude that sound symbolism is actively deployed to signal those attributes that are important for their lives in the given world ("survival of the fittest") (see also Uno et al. to appear). Types play a crucial role in Pokémon battles (e.g. flying types have advantages over grass types), and therefore, types do constitute an attribute that can or should be signaled by sound symbolism. In short, for humans, masculine and feminine sound symbolic names are important for pro-creation and survival; for Pokémon, sound symbolic names to represent types are important for survival. Taken together with the previous studies, this result thus invites new research questions; can other Pokémon types be symbolically represented, and if so, how and in what languages?

Appendix

The participants for the current experiment had to be 18 years old or older. One of the demographic information questions asked their age using a scale with nine categories, largely divided by a five year increment. The distributions of the age groups in the small and large datasets are shown in Table 4.

Table 4: The distribution of age groups in the small dataset and the large dataset.

age group label	1	2	3	4	5	6	7	8	9
age group	18-19	20-24	25-29	30-34	35-39	40-44	45-49	50-59	above 60
small dataset	9	25	2	11	1	3	3	6	3
large dataset	149	308	189	98	10	7	5	7	3

While examining the effects of gender and age on sound symbolic effects was not something that was planned when we designed the experiment, since we obtained an unexpectedly high number of participants, we explored these effects using the large dataset, as a post-hoc data exploration. Figure 5 illustrates the effects of gender difference on expected response ratios, which does not show any substantial differences between the two genders. A simple regression analysis confirmed that the gender difference is not a significant factor in predicting expected response ratios ($\beta = -0.001, s.e. = 0.14, t = -0.067, n.s.$).

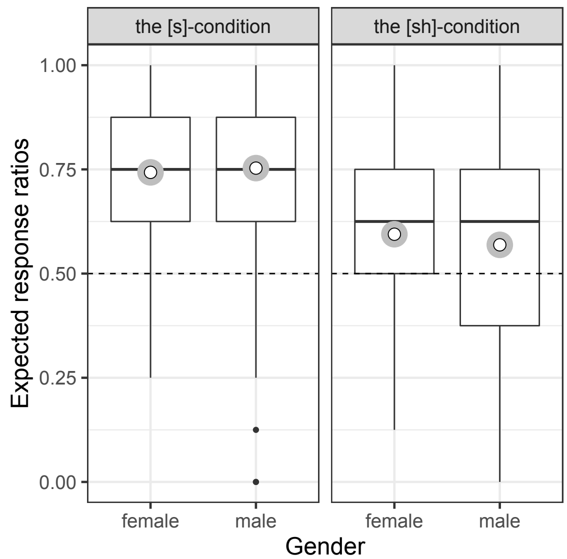

Figure 5: The effects of gender on expected response ratios in the large dataset.

Figure 6 shows the effects of age groups on the expected response ratios. While Groups 7 (45-49) and 9 (above 60) show higher expected response ratios compared to the other groups, there do not seem to be systematic trends between age groups and expected response ratios. Table 4 shows that the numbers of the participants in these two age groups were not very high, and indeed, a Spearman correlation test reveals no significant correlation between age groups and expected response ratios ($\rho = 0.04, n.s.$).

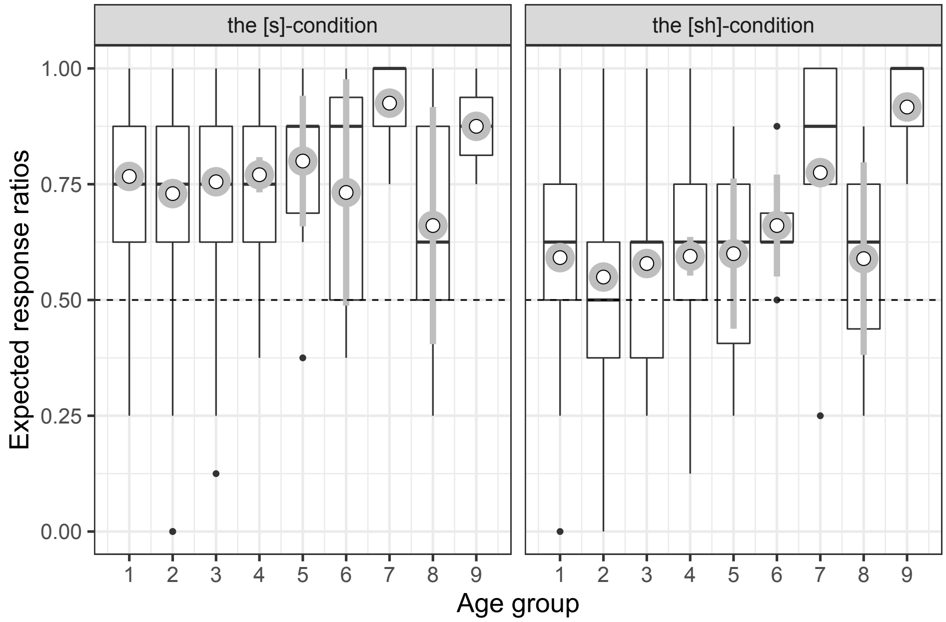

Figure 6: The effects of age groups on expected response ratios in the large dataset. See Table 4 for which age group label corresponds to which age range.

Since our experiment did not carefully control the number of participants in each age group, we certainly do not intend to claim that age does not generally affect sensitivities to sound symbolism. We simply note that in the current dataset, we did not find positive evidence for the effects of age or gender on sound symbolism. With this said, this topic (the effects of gender and age on sound symbollism) is one understudied area in the sound symbolism research (cf. Bankieris & Simner 2015; Klink 2009; Kraus 2015)—since Pokémonastics experiments have a distinct advantage of being able to collect many data points, as the current experiment has shown, it can turn out to be a useful tool in addressing this understudied topic in future exploration.

References

Bankieris, Kaitlyn & Julia Simner. 2015. What is the link between synaesthesia and sound symbolism? *Cognition* 136. 186–195.

Barr, Dale J. 2013. Random effects structure for testing interactions in linear mixed-effects models. *Frontiers in Psychology* 4. 328.

Barr, Dale J., Roger Levy, Christoph Scheepers & Harry J. Tily. 2013. Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language* 68. 255–278.

Berent, Iris, Donca Steriade, Tracy Lennertz & Vered Vaknin. 2007. What we know about what we have never heard: Evidence from perceptual illusions. *Cognition* 104. 591–630.

Bergen, Benjamin K. 2004. The psychological reality of phonaesthemes. *Language* 80. 290–311.

Berlin, Brent. 2006. The first congress of ethonozoological nomenclature. *Journal of Royal Anthropological Institution* 12. 23–44.

Coulter, S. Keith & Robin A. Coulter. 2010. Small sounds, big deals: Phonetic symbolism effects in pricing. *Journal of Consumer Research* 37(2). 315–328.

Daland, Robert, Bruce Hayes, James White, Marc Garellek, Andrea Davis & Ingrid Norrmann. 2011. Explaining sonority projection effects. *Phonology* 28(2). 197–234.

Derrick, Donald & Bryan Gick. 2013. Aerotactile integration from distal skin stimuli. *Multisensory Research* 26. 405–416.

Dingemanse, Mark. 2018. Redrawing the margins of language: Lessons from research on ideophones. *Glossa* 3(1). 4, doi:org/10.5334/gjgl.444.

Dingemanse, Mark, Damián E. Blasi, Gary Lupyan, Morten H. Christiansen & Padraic Monaghan. 2015. Arbitrariness, iconicity and systematicity in language. *Trends in Cognitive Sciences* 19(10). 603–615.

D'Onofrio, Annette. 2014. Phonetic detail and dimensionality in sound-shape correspondences: Refining the *bouba-kiki* paradigm. *Language and Speech* 57(3). 367–393.

Garrigues, Stephen L. 1995. Mimetic parallels in Korean and Japanese. *Studies in Language* 19. 359–398.

Gick, Bryan & Donald Derrick. 2009. Aero-tactile integration in speech perception. *Nature* 462. 502–504.

Godoy, Mahayana C., Neemias Silva de Souza Filho, Juliana G. Marques de Souza, Hális Alves & Shigeto Kawahara. 2019. Gotta name'em all: An experimental study on the sound symbolism of Pokémon names in Brazilian Portuguese. *Journal of Psycholinguistic Research* .

Guilherme, Duarte Garcia. 2019. When lexical statistics and the grammar conflict: Learning and repairing weight effects on stress. *Language* 95(4). 612–641.

Hamano, Shoko. 1998. *The sound-symbolic system of Japanese*. Stanford: CSLI Publications.

Hosokawa, Yuta, Naho Atsumi, Ryoko Uno & Kazuko Shinohara. 2018. Evil or not? Sound symbolism in Pokémon and Disney character names. Talk presented at the 1st international conference on Pokémonastics.

Jaeger, Florian T. 2008. Categorical data analysis: Away from ANOVAs (transformation or not) and towards logit mixed models. *Journal of Memory and Language* 59. 434–446.

Jarosz, Gaja. 2017. Defying the stimulus: Acquisition of complex onsets in Polish. *Phonology* 34(2). 269–298.

Jespersen, Otto. 1922. Symbolic value of the vowel *i*. In *Linguistica: Selected papers in English, French and German*, vol. 1, 283–303. Copenhagen: Levin and Munksgaard.

Johnson, Keith. 2003. *Acoustic and auditory phonetics: 2nd edition*. Malden and Oxford: Blackwell.

Kawahara, Shigeto. 2019. Teaching phonetics through sound symbolism. *Proceedings of ISAPh* .

Kawahara, Shigeto. 2020a. Sound symbolism and theoretical phonology. *Language and Linguistic Compass* .

Kawahara, Shigeto. 2020b. Teaching and learning guide for "Sound symbolism and theoretical linguistics". *Language and Linguistic Compass* .

Kawahara, Shigeto, Hironori Katsuda & Gakuji Kumagai. 2019. Accounting for the stochastic nature of sound symbolism using Maximum Entropy model. *Open Linguistics* 5. 109–120.

Kawahara, Shigeto & Gakuji Kumagai. 2019a. Expressing evolution in Pokémon names: Experimental explorations. *Journal of Japanese Linguistics* 35(1). 3–38.

Kawahara, Shigeto & Gakuji Kumagai. 2019b. Inferring Pokémon types using sound symbolism: The effects of voicing and labiality. *Journal of the Phonetic Society of Japan* 23(2). 111–116.

Kawahara, Shigeto, Gakuji Kumagai & Mahayana C. Godoy. 2020. English speakers can infer Pokémon types based on sound symbolism. Ms. Keio University, Meikai University and Federal University of Rio Grande do Norte.

Kawahara, Shigeto & Jeff Moore. to appear. How to express evolution in English Pokémon names. *Linguistics* .

Kawahara, Shigeto, Atsushi Noto & Gakuji Kumagai. 2018. Sound symbolic patterns in Pokémon names. *Phonetica* 75(3). 219–244.

Kim, Kong-On. 1977. Sound symbolism in Korean. *Journal of Linguistics* 13. 67–75.

Klink, Richard R. 2009. Gender differences in new brand name response. *Marketing Letters* 20. 313–326.

Kraus, Timothy Allen. 2015. *Sound effects: Age, gender, and sound symbolism in American English*: Portland State University Master's thesis.

Kumagai, Gakuji & Shigeto Kawahara. 2019. Effects of vowels and voiced obstruents on Pokémon names: Experimental and theoretical approaches [in Japanese]. *Journal of the Linguistic Society of Japan* 155. 65–99.

Lockwood, Gwilym & Mark Dingemanse. 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.

Lupyan, Gary & Bodo Winter. 2018. Language is more abstract than you think, or, why aren't languages more iconic? *Proceedings of Royal Society B.* 373. 20170137.

MacKenzie, Laurel. 2018. What's in a name? Teaching linguistics using onomastic data. *Language [Teaching Linguistics]* 94. e1–e18.

Makino, Seiichi. 2007. An argument for non-arbitrary relationship between sound and meaning in Japanese grammar. In Yoshihiko Ikegami, Viktoria Eschbach-Szabo & André Wlodarczyk (eds.), *Japanese lingusitics: European chapter*, 239–250. Tokyo: Kuroshio.

Mann, Virginia & Bruno Repp. 1981. Influence of preceding fricative on stop consonant perception. *Journal of the Acoustical Society of America* 69. 548–558.

Matisoff, James. 1994. Tone, intonation, and sound symbolism in Lahu: Loading the syllable canon. In Leane Hinton, Johanna Nichols & John Ohala (eds.), *Sound symbolism*, Cambrdige University Press.

Mielke, Jeff. 2011. A phonetically based metric of sound similarity. *Lingua* 122(2). 145–163.

Newman, Stanley. 1933. Further experiments on phonetic symbolism. *American Journal of Psychology* 45. 53–75.

Nuckolls, Janis B. 1999. The case for sound symbolism. *Annual Review of Anthropology* 28. 225–252.

Ohala, John. 1994. The frequency code underlies the sound symbolic use of voice pitch. In Leane Hinton, Johanna Nichols & John Ohala (eds.), *Sound symbolism*, 325–347. Cambridge: Cambridge University Press.

Otake, Takashi, Giyoo Hatano, Anne Cutler & Jacques Mehler. 1993. Mora or syllable? Speech segmentation in Japanese. *Journal of Memory and Language* 32. 258–278.

Paraise, Cesare V., Katharina Knorre & Marc O. Ernst. 2014. Natural auditory scene statistics shapes human spatial hearing. *Proceedings of National Academy of Sciences* 111(16). 6104–6108.

Ramachandran, Vilayanur S. & Edward M. Hubbard. 2001. Synesthesia–a window into perception, thought, and language. *Journal of Consciousness Studies* 8(12). 3–34.

Sapir, Edward. 1929. A study in phonetic symbolism. *Journal of Experimental Psychology* 12. 225–239.

Saussure, Ferdinand de. 1916. *Cours de linguistique générale*. Paris: Payot.

Shih, Stephanie S, Jordan Ackerman, Noah Hermalin, Sharon Inkelas, Hayeun Jang, Jessica Johnson, Darya Kavitskaya, Shigeto Kawahara, Miran Oh, Rebecca L Starr & Alan Yu. 2019. Cross-linguistic and language-specific sound symbolism: Pokémonastics. Ms. University of Southern California, University of California, Merced, University of California, Berkeley, Keio University, National University of Singapore and University of Chicago.

Shih, Stephanie S, Jordan Ackerman, Noah Hermalin, Sharon Inkelas & Darya Kavitskaya. 2018. Pokémonikers: A study of sound symbolism and Pokémon names. *Proceedings of LSA* 2018.

Shinohara, Kazuko & Shigeto Kawahara. 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.*, 396–410. Berkeley: Berkeley Linguistics Society.

Sidhu, David & Penny M. Pexman. 2018. Five mechanisms of sound symbolic association. *Psychonomic Bulletin & Review* 25(5). 1619–1643.

Sidhu, David & Penny M. Pexman. 2019. The sound symbolism of names. *Current Directions in Psychological Science* 1–5.

Spence, Charles. 2011. Crossmodal correspondences: A tutorial review. *Attention, Perception & Psychophysics* 73(4). 971–995.

Uno, Ryoko, Kazuko Shinohara, Yuta Hosokawa, Naho Ataumi, Gakuji Kumagai & Shigeto Kawahara. to appear. What's in a villain's name? Sound symbolic values of voiced obstruents and bilabial consonants. *Annual Review of Cognitive Linguistics* .

Vance, Timothy. 2008. *The sounds of Japanese*. Cambridge: Cambridge University Press.

Westbury, Chris, Geoff Hollis, David M. Sidhu & Penny M. Pexman. 2018. Weighting up the evidence for sound symbolism: Distributional properties predict cue strength. *Journal of Memory and Language* 99. 122–150.

Wilson, Colin. 2006. Learning phonology with substantive bias: An experimental and computational study of velar palatalization. *Cognitive Science* 30(5). 945–982.