

# Sound symbolism can count three segments (whereas phonological constraints presumably cannot)

## Abstract

Some researchers have recently argued that sound symbolic requirements can cause phonological alternations, suggesting that sound symbolic patterns and phonological patterns may be governed by similar mechanisms. Against this theoretical development, this paper further addresses the question regarding how similar phonological systems and sound symbolic systems are, by focusing on their counting capacity. It has been known that phonological constraints can count only up to two segments. To examine whether a similar sort of restriction holds in sound symbolic patterns, we experimentally addressed the question of whether three segments of the same sort can cause stronger sound symbolic images than two segments. The results of three experiments using Pokémon names demonstrate that three segments can cause stronger sound symbolic meanings than two segments. The overall results suggest that there is a non-negligible difference between the nature of phonological constraints and sound symbolic effects.

**Keywords:** sound symbolism, counting, voiced obstruents, [p], Pokémon, Japanese

**Approximate word count:** 5,000

## 1 Introduction

### 1.1 The issue addressed

Sound symbolism refers to systematic connections between sounds and meanings (e.g. Akita 2015; Dingemanse et al. 2015; Hinton et al. 2006; Perniss et al. 2010; Sidhu & Pexman 2018). For example, in many languages, low vowels like /a/ tend to be associated with images larger than high vowels like /i/ (Newman 1933; Sapir 1929; Thompson & Estes 2011). However, in modern linguistic theories, sound symbolic patterns had usually been considered to lie outside the realm of linguistic

8 inquiry, perhaps due to the influence of the Saussurian theorem of arbitrariness that the con-  
9 nections between sounds and meanings in natural languages are in principle arbitrary (Saussure  
10 1916) (see also Hockett 1959 for another influential paper on arbitrariness). However, the field  
11 has recently witnessed a rapidly increasing rise of interest on sound symbolic patterns and re-  
12 lated phenomena (see in particular Nielsen & Dingemanse 2021 for some quantitative evidence),  
13 and some scholars explicitly now argue that exploration of sound symbolic patterns can—and  
14 should—be a part of phonological research (see Kawahara 2020a for a review of the arguments).

15 Alderete & Kochetov (2017) for instance point out that expressive palatalization—e.g. patterns  
16 of palatalization observed in child-directed speech—is caused by a formal requirement to use  
17 particular types of sounds (e.g. palatal consonants and high front vowels) to express particular  
18 types of meanings, such as smallness. They propose a family of Optimality Theoretic constraints  
19 (Prince & Smolensky 1993/2004)—EXPRESS(X)—and argue that this family of constraints interacts  
20 with other phonological constraints within a single grammatical system. See also Akinbo (2021),  
21 Akinbo & Bulkaam (2024), Akita (2020), Klamer (2002), Dingemanse & Thompson (2020), Kumagai  
22 (2019, to appear) and Jang (2021) for other possible cases in which sound symbolic requirements  
23 affect—or at least, interact with—phonological patterns; see also Mithun (1982) and Monaghan &  
24 Roberts (2021) for possible effects of iconic sound symbolic effects on diachronic changes.

25 Approaching this issue from a slightly different perspective, Kawahara (2020b) compared  
26 particular quantitative signatures of patterns of sound symbolic judgments and those found in  
27 stochastic phonological patterns, and argued that there appears to exist an interesting paral-  
28 lel between the two patterns. More concretely, he argues that both sound symbolic patterns  
29 and stochastic phonological patterns exhibit what Hayes (2020, 2022) refers to as “wug-shaped  
30 curves,” a quantitative signature that is predicted by Maximum Entropy Harmonic Grammar,  
31 a framework that is now widely deployed to model a wide range of phonological—and other  
32 linguistic—patterns (Goldwater & Johnson 2003; Hayes 2022; Hayes & Wilson 2008; McPherson  
33 & Hayes 2016; Shih 2017; Smolensky 1986; Zuraw & Hayes 2017).

34 Building on these recent proposals to consider sound symbolic patterns on a par with phono-  
35 logical patterns, the current experiments examine the similarity—or dissimilarity—between the  
36 two, by focusing on the counting capability (or lack thereof) of the two systems. The focus of the  
37 topic that we explore in depth in the current experiments is the classic observation that phonolog-  
38 ical systems may count up to two but no more (e.g. Goldsmith 1976; Hayes 1995; Hewitt & Prince  
39 1989; Ito & Mester 2003; McCarthy & Prince 1986; Myers 1997; Nelson & Toivonen 2000; Prince  
40 & Smolensky 1993/2004; Walker 2001 among many others).<sup>1</sup> The following quote from McCarthy  
41 & Prince (1986: 1) succinctly summarizes this now-classic observation, which the current project  
42 built upon:

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<sup>1</sup>The same thesis is likely to hold in syntax. See e.g. Chomsky (1965) and Haspelmath (2014).

43 Consider first the role of counting in grammar. How long may a count run? Gen-  
44 eral considerations of locality, now the common currency in all areas of linguistic  
45 thought, suggest that the answer is probably ‘up to two’: a rule may fix on one spec-  
46 ified element and examine a structurally adjacent element and no other.

47 For example, there are many languages that prohibit two occurrences of the same segments or  
48 features (i.e. dissimilation patterns: see Bennett 2015, Hansson 2001 and Suzuki 1998 for extensive  
49 typological surveys), but no known languages prohibit three occurrences while allowing for two  
50 (Ito & Mester 2003: 265). For instance, the native phonology of Japanese prohibits morphemes  
51 with two voiced obstruents, but no known languages prohibit morphemes with three voiced  
52 obstruents. Further, an experimental investigation by Kawahara & Kumagai (2023a) using nonce  
53 words shows that Japanese speakers do not distinguish between forms with two voiced obstruents  
54 and those with three voiced obstruents—forms with three voiced obstruents were treated on a par  
55 with forms with two voiced obstruents.

56 Prince & Smolensky (1993/2004), as they proposed Optimality Theory (OT), spend some good  
57 portions of their book discussing why their proposed system does not involve counting. Mc-  
58 Carthy (2003) also argues that OT constraints should not count or assess “degrees of violations”,  
59 stating that “no language requires the presence of at least three round vowels to initiate rounding  
60 harmony, nor do we ever find that complementisers may be doubly but not trebly filled” (p. 80).

61 Paster (2019) recently challenged the thesis that phonology can only count up to two, demon-  
62 strating that there are cases that apparently involve counting. She, for example, proposes a tonal  
63 association rule for Kuria, by which the H-tone is associated with the *fourth* mora from the left  
64 edge of a stem. However, Paster also points out that all those patterns that apparently count are  
65 limited to suprasegmental patterns, and none involves segmental patterns (see §3 of Paster 2019).

66 Another challenge to the classic no-counting thesis recently came from Kim (2022), who ar-  
67 gues that Japanese disprefers a configuration in which a voiced obstruent is followed by two  
68 nasal consonants, implying the presence of a constraint that apparently involves counting three  
69 segments (i.e. \*[D...N...N]). However, a later examination demonstrates that evidence for this  
70 claim in the existing words is very weak at best; neither can the productivity of this alleged re-  
71 striction be identified in a nonce word experiment (Kawahara & Kumagai 2023b). Finally, some  
72 studies have demonstrated that multiple reduplications can induce more intensified meanings,  
73 for instance in Fungwa (Akinbo 2023; Gil 1990). These patterns may mean that morphological  
74 operations (i.e. reduplication) can apply multiple times, and that each operation has a semantic  
75 impact. However, these patterns do not necessarily imply that phonological constraints should  
76 have a capability to count beyond two segments.

77 In short, to the best of our knowledge, it is still safe to assume, *a la* McCarthy & Prince (1986),  
78 that phonological constraints—as we formulate them in OT analyses (McCarthy 2003; Prince &

79 Smolensky 1993/2004)—related to segmental phonology can count up to two segments, but not  
80 three or more in their structural description.<sup>2</sup>

## 81 **1.2 The background: Pokémonastics**

82 In the experiments reported below, we examined whether the same restriction holds or not in  
83 sound symbolic patterns, by specifically testing whether three segments can invoke stronger  
84 sound symbolic images than two segments. We took advantage of the Pokémonastics research  
85 paradigm, which explores the nature of sound symbolism in the context of Pokémon names  
86 (Kawahara et al. 2018) (for a discussion of why it is useful to use specifically Pokémon names  
87 to explore sound symbolic patterns, see e.g. Kawahara & Breiss 2021 for a summary). In the  
88 Pokémon world, some characters, when they get stronger, can evolve into a different character,  
89 and in so doing their names change (e.g. /iwaaku/ → /hageneeru/ and /messon/ → /zímereon/).

90 A quantitative study of the names of the existing Pokémon names (including those up to the  
91 6th generation) reported by Kawahara et al. (2018) shows that the number of voiced obstruents  
92 contained in their names tend to increase as Pokémon characters evolve, a correlation which was  
93 later replicated with a larger set of data by Shih et al. (2019). A number of experimental studies  
94 that followed used nonce words and demonstrated that Japanese speakers judge nonce names  
95 with voiced obstruents to be more likely as those of post-evolution characters than nonce names  
96 without voiced obstruents (Kawahara 2020b; Kawahara & Kumagai 2019a). The first experiment  
97 reported below took advantage of this sound symbolic connection between voiced obstruents  
98 and Pokémon evolution status to address the question of whether three segments cause stronger  
99 sound symbolic images than two segments.

## 100 **1.3 Previous observations about sound symbolisms**

101 Before moving on, we review some previous studies which addressed the counting capability of  
102 sound symbolism. First, Thompson & Estes (2011) built upon the observations that some sounds  
103 are associated with images of largeness (e.g. Sapir 1929 *et seq.*). In one of their experiments,  
104 they presented native speakers of English with pictures of an imaginary creature (referred to as  
105 “greeble”) in different sizes, and different nonce names containing different numbers of “large  
106 phonemes.” Their results showed that the larger the size of the named objects, the more “large  
107 phonemes” were contained in their chosen names. Their result, reproduced below as Figure 1,  
108 shows that the counting behavior goes well beyond two; e.g. the largest greebles were assigned

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<sup>2</sup>One candidate for a constraint that appears to require counting three segments in its structural description is the one that is responsible for intervocalic lenition, which needs to prohibit a configuration in which the target consonant is flanked by two vowels (e.g. \*[VTV]). However, see Katz (2021) for arguments that intervocalic lenition is a matter of phonetic implementation rather than being a phonological process.

109 names with about 4.5 “large phonemes” on average.

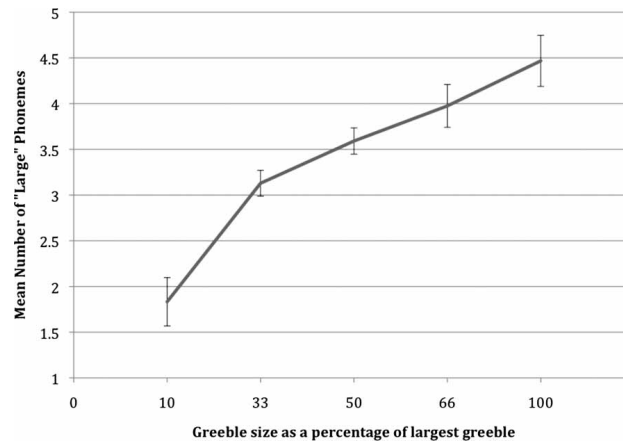


Figure 1: Results of Thompson and Estes 2011 (their Figure 3), in which the larger the named objects, the more “large phonemes” their names contained.

110 However, this analysis collapsed three different classes of sounds (i.e. back vowels, sonorants,  
111 and voiced stops) into one set of “large phonemes,” and therefore it is impossible to tell whether it  
112 truly instantiates an unambiguous case of counting—the pattern was instead likely to have arisen  
113 from additive effects of three different factors influencing the judgment patterns. Similarly, there  
114 exist several other studies which showed cumulative effects of sound symbolism, but their results  
115 are likely to have arisen from additive effects of different factors (Cuskley 2013; D’Onofrio 2014;  
116 Dingemanse & Thompson 2020; Priestly 1994).

117 The first two experiments reported below improve upon this aspect by using a class of sounds  
118 that is unambiguously a natural class, both from the phonetic and phonological perspectives. The  
119 third experiment used only one kind of segment to unambiguously exclude the possibility that  
120 the counting behavior arise from influences of different types of segments adding up.

121 Another candidate of counting in sound symbolism in the previous literature comes from the  
122 Pokémonastics experiments reported in Kawahara (2020b), in which he varied the numbers of  
123 moras from two to six. The results showed that each mora count increased the post-evolution  
124 responses. However, to the extent that a mora is a suprasegmental property—which seems to  
125 be a fair assumption to make (McCarthy & Prince 1986)—it is not clear whether these results  
126 truly instantiate a case of counting at the *segmental* level: recall that Paster (2019) identifies  
127 phonological systems may be able to count, but only at the suprasegmental level. Moreover,  
128 given the well-established status of bimoraic feet in Japanese phonology (Ito 1990; Mester 1990;  
129 Poser 1990) and the possibility of recursive prosodic phrasing (Ito & Mester 2012), the apparent  
130 counting behavior may be recast in terms of different foot and prosodic word structures.

131 In short, the current experiments attempted to address the counting capability of sound sym-  
132 bolism at the segmental level in the least unambiguous way possible. The first two experiments  
133 also had an advantage of being able to make a fairly direct comparison with a phonological pat-  
134 tern, against the recent result reported by Kawahara & Kumagai (2023a), who tested the counting  
135 behavior of voiced obstruents in Japanese phonology.

## 136 2 Experiment 1

137 In this experiment, the participants were given one nonce word per trial and were asked to judge  
138 whether that name is more suitable for a pre-evolution Pokémon character or a post-evolution  
139 Pokémon character. The aim was to explore whether the numbers of voiced obstruents contained  
140 in nonce names, ranging from zero to three, would impact the sound symbolic judgment of these  
141 names, and more importantly, *how*. A previous study has shown that nonce words containing one  
142 voiced obstruent is more likely to be judged as post-evolution names than those without a voiced  
143 obstruent (Kawahara 2020b), and other studies have found that, in addition to that difference,  
144 those words containing two voiced obstruents are more likely to be judged as post-evolution  
145 names than those containing only one (e.g. Kawahara & Kumagai 2019a).

146 The novel addition of the current experiment is therefore to have explored the difference  
147 between the two voiced obstruent condition and the three voiced obstruent condition. This ad-  
148 dition is an important one, however, because it will address the question of how (dis-)similar  
149 sound symbolic patterns are with respect to the nature of segmental, phonological constraints,  
150 as discussed in §1.1. If sound symbolic patterns can count only up to two, just like phonological  
151 constraints, we should not expect a difference between those words with two voiced obstruents  
152 and those with three voiced obstruents. On the other hand, if sound symbolic patterns simply  
153 count without a restriction, and then we should observe a difference between the two conditions.

### 154 2.1 Method

155 The raw data, the R markdown file as well as the Bayesian posterior samples are available at the  
156 OSF repository (for the open science policy in linguistic studies, see e.g. Cho 2021, Garellek et al.  
157 2020 and Winter 2019). The link to this repository is provided at the end of the paper.

#### 158 2.1.1 Stimuli

159 The experiment had four conditions, differing in the numbers of voiced obstruents that they con-  
160 tain (zero, one, two and three). Each condition had 10 items, and they were all nonce names  
161 in Japanese. They consisted of three light CV syllables. The position of voiced obstruents was

162 controlled within each condition; e.g. in one voiced obstruent condition, they were all placed at  
 163 the word-initial position (see Adelman et al. 2018 for the importance of word-initial position in  
 164 sound symbolism). Because /p/ is known to evoke a sound symbolic effect of cuteness (Kumagai  
 165 2019; see also Experiment III), it was not used in the current stimulus set. The actual list of the  
 166 stimuli is shown in Table 1.

Table 1: The list of stimuli used in the first two experiments.

VcdObs=0	VcdObs=1	VcdObs=2	VcdObs=3
[kuçiju]	[bitare]	[gebiki]	[dagigo]
[suçuma]	[birejo]	[dedara]	[bigade]
[neçuri]	[ganija]	[zodotçi]	[zabade]
[neriru]	[bejumi]	[zugawa]	[zegizo]
[çihone]	[bojatçi]	[zudani]	[buçido]
[karutsu]	[bikohe]	[zoçike]	[bogebi]
[jakama]	[baheho]	[zadoja]	[gegige]
[sawake]	[geseçi]	[çiboru]	[baçizu]
[rihojo]	[çihana]	[babohi]	[gubebi]
[sojuki]	[bijuri]	[gibuse]	[bibogo]

### 167 2.1.2 Procedure

168 The experiment was administered online using SurveyMonkey. The participants were first pre-  
 169 sented with the basic background about the Pokémon world, namely, that some Pokémon char-  
 170 acters can evolve, and that when they evolve, they tend to get heavier, bigger and stronger.  
 171 In the main session, within each trial, the participants were presented with one nonce name  
 172 and were asked to judge whether each name is suitable for a pre-evolution character or a post-  
 173 evolution character. The stimuli were presented in the *katakana* orthography, which is used for  
 174 real Pokémon names in general. Although the stimuli were presented in written forms, the par-  
 175 ticipants were asked to read and pronounce each stimulus before they register each response.  
 176 The order of the stimuli was automatically randomized for each participant by SurveyMonkey.

### 177 2.1.3 Participants

178 We obtained data from 110 native speakers of Japanese using the Buy Response function of Sur-  
 179 veyMonkey. The qualification requirements for participation were that (1) they had to be a native  
 180 speaker of Japanese, (2) they had not previously participated in an experiment on Pokémon names  
 181 and (3) they had not studied sound symbolism before. Additional data from 38 native speakers  
 182 of Japanese were collected using a snowball sampling method on the first author’s X (formerly

183 Twitter).

#### 184 2.1.4 Statistics

185 For statistical analyses, we made use of a Bayesian mixed effects logistic regression model, using  
186 the `brms` package (Bürkner 2017). We will not attempt to explicate the mechanics of Bayesian  
187 analyses in detail here, but instead refer the interested readers to accessible introductory articles,  
188 including Franke & Roettger (2019), Kruschke & Liddell (2018) and Vasishth et al. (2018). In a  
189 nutshell, Bayesian analyses combine prior information (if any) with the obtained experimental  
190 data and produce a range of possible values—which are referred to as posterior distributions—for  
191 each estimated parameter.

192 One advantage of Bayesian analyses is that we can interpret the posterior distributions as  
193 directly representing the likely values of the estimated parameters. One heuristic to interpret the  
194 results of Bayesian modeling is to examine the middle 95% of the posterior distribution, known  
195 as 95% Credible Interval (henceforth, abbreviated as “95% CrI”), of the coefficient we are inter-  
196 ested in. If the 95% CrI of a parameter does not include 0, then that parameter can be considered  
197 to be credible/meaningful. However, unlike in a frequentist analysis, we do not have to rely on  
198 a strict—but yet arguably arbitrary—dichotomy (i.e. “significant” vs. “non-significant” or “credi-  
199 ble/meaningful” vs. “not credible/meaningful”). We can instead examine how many samples in  
200 the posterior distribution are in the expected direction, i.e., the probability of a particular hypoth-  
201 esis being true.

202 Another advantage of Bayesian analysis is that we can also address the question regarding  
203 with how much confidence we can conclude a null effect (Gallistel 2009). This is an important  
204 feature for the case at hand, because if sound symbolism were to behave like phonological pat-  
205 terns, we would expect a null difference between the two voiced obstruent condition and the  
206 three voiced obstruent condition (cf. Kawahara & Kumagai 2023a). If it turned out to be that way,  
207 we wanted to explore how likely it is that there are truly no differences, which is impossible to  
208 test with a frequentist analysis.

209 Moving on to the specifics of the model specifications for the current experiment, the binary  
210 dependent variable was whether each item was judged as a post-evolution character name (=1)  
211 or not (=0). The fixed independent variable was the number of voiced obstruents contained in  
212 the stimuli. This factor was coded as a categorical factor, so that we could make the targeted  
213 comparison between the two voiced obstruent condition and three voiced obstruent condition,  
214 which was implemented using `hypothesis` function. The baseline of this factor was arbitrarily  
215 chosen as the condition with zero voiced obstruents. In addition to this fixed factor, a random  
216 intercept of items and participants as well as the random slopes of participants for the fixed factor  
217 were included in the model. For prior specifications, a Normal(0, 1) weakly informative prior for



218 the intercept (Lemoine 2019) and a Cauchy prior with scale of 2.5 for the slope (Gelman et al.  
219 2018) were used.

220 Four chains with 2,000 iterations were run, and the first 1,000 iterations from each chain were  
221 discarded as warmups. All the  $\hat{R}$ -values for the fixed effects were 1.00 and there were no divergent  
222 transitions. See the R markdown file available at the OSF repository for further details.

## 223 2.2 Results

224 Figure 2 shows the distribution of post-evolution response ratios for each voiced obstruent condi-  
225 tion in the form of violin plots, in which the widths represent normalized probability distributions.  
226 Transparent light-blue circles, jittered slightly to avoid overlap, represent average responses for  
227 each condition from each participant. Solid red circles are the grand averages in each condition,  
228 with their 95% confidence intervals calculated by `ggplot`: (Wickham 2016).

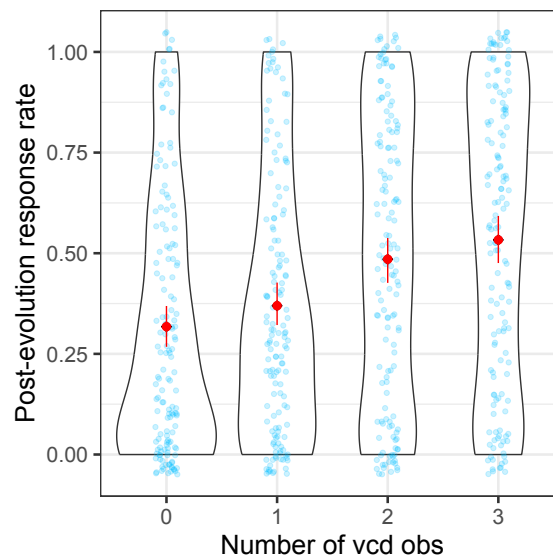


Figure 2: The results of Experiment 1, showing the distribution of post-evolution responses for each number of voiced obstruents contained in the stimuli.

229 We observe a steady increase in the post-evolution responses, as the number of the voiced  
230 obstruents contained in the stimuli increase: the four conditions resulted in the following aver-  
231 ages: 0.32 vs. 0.37 vs. 0.49 vs. 0.53.<sup>3</sup> The central coefficient estimate of the difference between the  
232 baseline (no voiced obstruents) and one voiced obstruent is 0.27, with its 95% CrI being [-0.16,

<sup>3</sup>Even those nonce words that contain three voiced obstruents were judged to be post-evolution names only slightly above 50%, which was a bit surprising. Some participants reported after the experiment that post-evolution names should be longer than three moras. See Kawahara et al. (2018) and Kawahara (2020b) for the effects of name length.

233 0.70]. Although this 95% CrI interval includes zero, the posterior distribution is skewed toward  
234 positive values, and 90% of the posterior samples were positive.

235 More importantly, a targeted comparison between the two voiced obstruent condition and  
236 three voiced obstruent condition shows that the central coefficient estimate for this difference is  
237 -0.39 with its 95% CrI being [-0.67, -0.11] and the posterior probability supporting this difference  
238 is 0.99. For the sake of completeness, the difference between one voiced obstruent condition and  
239 the two voiced obstruent condition was also calculated, which turned out to be robust, with its  
240 central coefficient and 95% CrI being -0.77 and [-1.1, -0.44], respectively. Its posterior probability  
241 was 1.00. In short, we observe that each difference between the four conditions was meaningful  
242 (although we can be only 90% confident about the difference between the first two conditions).

## 243 2.3 Discussion

244 The current experiment first of all replicated the findings of the previous studies that given nonce  
245 words, Japanese speakers do indeed generally associate voiced obstruents with post-evolution  
246 Pokémon names (Kawahara 2020b; Kawahara & Kumagai 2019a). It moreover found that names  
247 with three voiced obstruents were more likely to be associated with post-evolution characters  
248 than those with two voiced obstruents, suggesting that sound symbolic patterns can function in  
249 an additive fashion, and count at least up to three (cf. Thompson & Estes 2011). This case may  
250 be likened to cases of *counting cumulativity* in linguistic patterns (Breiss 2020; Hayes 2022; Jäger  
251 2007; Jäger & Rosenbach 2006), in which multiple violations of the same phonological constraint  
252 function in an additive manner.<sup>4</sup>

253 The current result is particularly interesting in the light of the general question of how simi-  
254 lar phonological patterns and sound symbolic patterns are, given the recent proposals that these  
255 two systems may have more in common than previously thought (e.g. Alderete & Kochetov 2017;  
256 Kawahara 2020a,b), as reviewed in §1.1. Assuming that it is indeed a true property of phonolog-  
257 ical constraints that it can count only up to two segments (e.g. Ito & Mester 2003; McCarthy &  
258 Prince 1986; Prince & Smolensky 1993/2004), just as Japanese phonology counts only up to two  
259 voiced obstruents (Ito & Mester 2003; Kawahara & Kumagai 2023a), the fact that sound symbolic  
260 patterns related to voiced obstruents can count up to three would instantiate a non-trivial differ-

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<sup>4</sup>The cases of counting cumulativity in phonology may raise the question of whether phonology may indeed be able to count. However, we are not aware of any convincing case of counting cumulativity that involves three loci, either in phonological alternations or in phonotactics (McCarthy 2003). See Breiss (2020) for an informative review of the cases of counting cumulativity, as well as the other type of cumulativity (i.e. ganging-up cumulativity).

If we are to deploy a theoretical mechanism to allow for counting cumulativity like MaxEnt Harmonic Grammar, then we would have to make sure that constraints do not assign a violation mark based on a structural description that involves more than two segments. In other words, the grammar may be able to count the number of violations (and multiply them by the constraint weights), but the constraints themselves cannot count the number of segments. See Kawahara & Kumagai (2023a) for discussion on this point.

261 ence between the two systems. At least within Japanese, the way its phonology handles voiced  
262 obstruents and the way voiced obstruents invoke their sound symbolic images differ from one  
263 another.

## 264 **3 Experiment II**

### 265 **3.1 Preamble**

266 To extend the scope of the findings from Experiment I, we tested another semantic dimension that  
267 can be symbolically signaled by voiced obstruents. In Japanese (and perhaps other languages),  
268 voiced obstruents are associated with general negative images (Hamano 1998; Kubozono 1999;  
269 Suzuki 1962), and in the context of Pokémon names, they are overrepresented in the names of  
270 villainous characters (Hosokawa et al. 2018; Uno et al. 2020). More specifically, some Pokémon  
271 characters belong to particular “types”, and it has been found that voiced obstruents are over-  
272 represented in the names of the “dark type” characters. The productivity of this sound symbolic  
273 relationship has been confirmed by an experiment using nonce words (Kawahara & Kumagai  
274 2019b). Experiment II made use of this previously identified sound symbolic relationship to fur-  
275 ther address the counting capability of sound symbolic patterns.

276 There are a few differences between Experiment I and Experiment II. In Experiment II, the  
277 participants were asked whether each name was suitable for a dark-type character or normal-  
278 type character. Before the main trials, they were told that all Pokémon characters belong to at  
279 least one type, with two examples; /çitokage/ ‘Charmander (fire lizard)’ belong to the “fire” type,  
280 and /goosu/ belong to both “ghost” type and “dark” type. The stimuli used in the experiment  
281 were identical to those used in Experiment I. The participants were university students from  
282 Meiji University.<sup>5</sup> After excluding data from those who are not native speakers of Japanese and  
283 those who were familiar with research on sound symbolism, the data from 141 native speakers  
284 entered the statistical analysis. The details of the statistical modeling were identical to those of  
285 Experiment I.

### 286 **3.2 Results**

287 Figure 3 shows the results of Experiment II. As with Experiment I, we observe a steady increase in  
288 the dark-type response ratio, as the number of voiced obstruents contained in the stimuli increase.  
289 The grand averages for each conditions were 0.18 vs. 0.43 vs. 0.71 vs. 0.79.

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<sup>5</sup>We would like to thank ANONYMIZED for her assistance with the participant recruitment for this experiment.

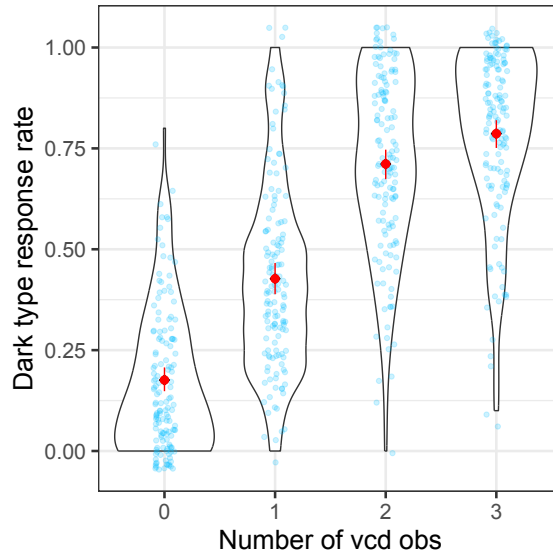


Figure 3: The results of Experiment II. The distribution of dark-type response ratios for each voiced obstruent condition.

290 This effect of voiced obstruents is a very robust one according to the Bayesian modeling. The  
 291 difference between the no voiced obstruent condition (i.e. the baseline) and one voiced obstruent  
 292 was very credible, with its central coefficient estimate being 1.48, with its 95% CrI being [0.78,  
 293 2.16]. All the posterior samples were positive. More importantly, the difference between the  
 294 two voiced obstruent condition and the three voiced obstruent condition was also credible. The  
 295 central coefficient estimate is -0.62 and its 95% CrI is [-1.15, -0.09]. The posterior probability of  
 296 this targeted comparison is 0.97. The difference between the one voiced obstruent and two voiced  
 297 obstruents was also robust (central estimate = -1.15, 95% CrI=[-2.09, -1.03], posterior probability  
 298 supporting the difference = 1).

### 299 3.3 Discussion

300 The sound symbolic effects of voiced obstruent were clearer in Experiment II than in Experiment  
 301 I—names with zero voiced obstruents were unlikely to be judged as dark-type characters, whereas  
 302 names with three voiced obstruents were very likely to be judged as dark-type characters. And  
 303 most importantly for the current purpose, we have found a solid distinction between the two  
 304 voiced obstruent condition and the three voiced obstruent condition. The fact that this difference  
 305 holds is unlike how voiced obstruents are treated by the Japanese phonological system (Ito &  
 306 Mester 2003; Kawahara & Kumagai 2023a), which is arguably a general property of phonological  
 307 constraints at the segmental level in natural languages (McCarthy 2003; McCarthy & Prince 1986;  
 308 Prince & Smolensky 1993/2004).

## 4 Experiment III

### 4.1 Introduction

The previous two experiments have shown that a distinction between two segments and three segments matters when it comes to sound symbolic patterns—a distinction that phonological constraints arguably do not make. However, in both experiments, the target sounds were voiced obstruents, so it seemed important to us to examine how generalizable this counting property is, i.e. whether this counting capability is observed for sound symbolic patterns that are caused by segments other than voiced obstruents.

Also, we felt it useful to address the possibility that the patterns we observed in the previous two experiments arose from different types of voiced obstruents—e.g. [z] and [d]—“ganging-up” rather than the patterns arising from pure counting (cf. Jäger & Rosenbach 2006; Jäger 2007). We reiterate that it is safe to say that a voiced obstruent is a coherent set of sounds both from the phonetic and phonological perspective in Japanese (Ito & Mester 1986, 2003). Ultimately, the distinction between counting cumulativity and ganging-up cumulativity depends on whether what adds up is multiple violations of the *same* constraint or those of *different* constraints, in the parlance of constraint-based theories such as Optimality Theory (Prince & Smolensky 1993/2004). Thus, the results of the first two experiments instantiate *counting* cumulativity to the extent that we can formulate EXPRESS(VCD OBS) as a single constraint, rather than there being EXPRESS(/B/), EXPRESS(/D/), etc. Given that voiced obstruents behave as a natural class both in phonological and sound symbolic patterns in Japanese (Ito & Mester 1986, 2003; Hamano 1998; Kubozono 1999), we believe that this is a fairly safe assumption to make.

Nevertheless, it is safer to be conservative and entertain the possibility that effects of different voiced obstruents are governed by different constraints, or to put it in a more theory-neutral term, different sound symbolic forces. To this end, we took advantage of the sound symbolic connection between [p] and “cuteness” (Kumagai 2019, 2022), which also manifests itself in the fact that labial sounds, including [p] are, overrepresented in the cute, fairy type Pokémon characters (Hosokawa et al. 2018; Kawahara & Kumagai 2019b; Uno et al. 2020).

### 4.2 Method

Experiment III used the set of stimuli shown in Table 2. The experiment, like Experiments I and II, varied the number of [p]s that are contained in the stimuli. The position of [p] was controlled within each condition. Each condition had 10 items, all of which contain only light CV syllables. Since there could be a difference between sonorants and obstruents in terms of their impact on cuteness judgments (Perfors 2004; Shinohara & Kawahara 2013), the syllables not containing [p]

342 all had a voiceless obstruent onset.

Table 2: The list of stimuli used in Experiment III.

[p]=0	[p]=1	[p]=2	[p]=3
[kuçisu]	[pitahe]	[pepiki]	[papipe]
[sutsuka]	[piketo]	[papeka]	[pipape]
[kusuki]	[patçiha]	[pepotçi]	[popape]
[teçiku]	[pekuçi]	[pupata]	[pepipo]
[çihake]	[posatçi]	[popaçi]	[pupipo]
[kesutsu]	[pikohe]	[popike]	[popepi]
[tokaha]	[paheto]	[papoka]	[pepipe]
[sahake]	[peseke]	[popitsu]	[papupi]
[teçihoto]	[pihaka]	[papoçi]	[pupepi]
[sokuki]	[pisutçi]	[pipuse]	[pipope]

343 The responses were gathered using the Buy Response function of SurveyMonkey. Data from  
344 a total of 150 native speakers of Japanese were obtained. In this experiment, the participants were  
345 asked, for each name, whether the name is more suitable for a normal type character or a cute  
346 fairy type character. The details of the statistical analysis were identical to those of Experiments  
347 I and II.

### 348 4.3 Results

349 The results are presented in Figure 4, which shows the distribution of the fairy type character  
350 responses for each condition having different numbers of [p]. Similar to the two previous experi-  
351 ments, we observe a steady increase in the fairy response, as the number of [p]s contained in the  
352 names increases. The grand averages were: zero [p] = 0.21; one [p] = 0.39; two [p]s = 0.47; three  
353 [p]s = 0.57.

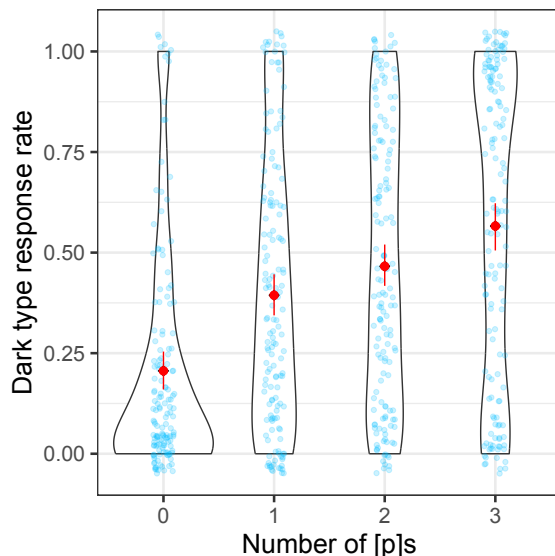


Figure 4: The results of Experiment III. The distribution of fairy-type response ratios for each condition, which contained different numbers of [p]s.

354 The results of the Bayesian logistic regression show that there is a clear difference between  
 355 the baseline ([p]=0) and the condition which contains one [p] ( $\beta = 1.50$ , its 95% CrI = [0.97, 2.03],  
 356 with all their posterior samples supporting the difference). The difference between the two [p]  
 357 condition and the three [p] condition, which is most important for the purpose of the current  
 358 study, was also very robust ( $\beta = -0.8$  with its 95% CrI [-1.24, -0.38], and all the posterior samples  
 359 support this difference). To be complete, the difference between the one [p] condition and the two  
 360 [p] condition was also a reliable one ( $\beta = -0.45$ , its 95% CrI [-0.82, -0.08] and 97% of the posterior  
 361 samples supporting the difference). In short, every addition of [p] in the names reliably increased  
 362 the fairy-type responses.

#### 363 4.4 Discussion

364 This experiment again shows that sound symbolism can count up to three. In other words, the  
 365 counting capability is not a specific property of voiced obstruents, possibly different kinds of  
 366 voiced obstruents “ganging-up” (Jäger & Rosenbach 2006; Jäger 2007), but it holds with one kind  
 367 of segment—[p]—invoking the image of cuteness.

## 368 5 General discussion

369 We started with a general question—how (dis-)similar sound symbolic patterns are with respect  
 370 to phonological patterns. To address this question, we focused on one property of phonological

371 constraints which seems to hold robustly across languages; at least when it comes to the con-  
372 straints related to segmental phonology, it can count only up to two segments, but no more. No  
373 known languages have been identified to prohibit three occurrences of the same segment/feature,  
374 whereas there are a plethora of examples in which two occurrences of the same segment are  
375 banned. Japanese precisely instantiates a case of this kind in which two voiced obstruents within  
376 morphemes are prohibited (Ito & Mester 2003), and experiment-wise too, Japanese speakers treat  
377 forms with three voiced obstruents on a par with forms with two voiced obstruents (Kawahara  
378 & Kumagai 2023a).

379 To the extent that sound symbolic patterns and phonological patterns are governed by the  
380 same system (see Alderete & Kochetov 2017 and Kawahara 2020b, in particular), we would have  
381 expected that a similar restriction would hold—that Japanese speakers would treat forms with  
382 three voiced obstruents just like forms with two voiced obstruents, when they make sound sym-  
383 bolic judgements. However, the results of two experiments show that this expectation did not  
384 hold up, when Japanese speakers make sound symbolic judgments of forms with different num-  
385 bers of voiced obstruents. These results were further corroborated by an additional experiment  
386 which shows that three [p]s can evoke stronger sound symbolic images than two [p]s. It thus  
387 seems safe to conclude, given these results, that there is a non-negligible difference between  
388 the segmental, phonological constraints and sound symbolic patterns, at least in terms of their  
389 counting capabilities.

390 As Alderete & Kochetov (2017) and others have argued (Akinbo 2021; Akinbo & Bulkaam 2024;  
391 Akita 2020; Klamer 2002; Dingemanse & Thompson 2020; Kumagai 2019, to appear; Jang 2021;  
392 Mithun 1982; Monaghan & Roberts 2021), sound symbolic requirements may be able to affect—or  
393 at least interact with—phonological patterns. To the extent that our conclusion is on the right  
394 track, then, when such sound symbolic effects are incorporated into a phonological grammar,  
395 there should be some kind of filter that “strips off” the counting capability of sound symbolic  
396 mechanisms. Otherwise, we would expect there to be a constraint like EXPRESS(THREEVCD OBS),  
397 which requires that there be at least three voiced obstruents to express a particular semantic no-  
398 tion. While it remains to be seen that such patterns are indeed impossible in human languages,  
399 at this point we find it very unlikely. And if such filtering mechanism is to be required, it may  
400 be something that is akin to an abstraction mechanism that is at work when phonetic effects  
401 are grammaticalized into a phonological system (Gordon 2002; Hayes 1999; Smith 2002), which  
402 reflects a general observation that even when phonetic factors appear to drive phonological gen-  
403 eralizations, some details are abstracted away from in the phonology system.



## Conflicts of interest

We declare no conflicts of interest.

## Availability of data and code

The data and the code are available at

<https://osf.io/zhnda/?viewonly=de5ffbd83dc24a1eb6db3b11af08c550>

## References

Adelman, James S., Zachary Estes & Martina Coss. 2018. Emotional sound symbolism: Languages rapidly signal valence via phonemes. *Cognition* 175. 122–130.

Akinbo, Samuel. 2021. Featural affixation and sound symbolism in Fungwa. *Phonology* 38(4). 537–569.

Akinbo, Samuel & Michael Bulkaam. 2024. Iconicity as the motivation for the signification and locality of deictic grammatical tones in Tal. *Glossa* 24(9).

Akinbo, Samuel Kayode. 2023. Reduplication, repetition and sound symbolism in fungwa. *Phonological Data and Analysis* 5(2). 1–24.

Akita, Kimi. 2015. Sound symbolism. In Jan-Ola Östman & Jef Verschueren (eds.), *Handbook of pragmatics, installment 2015*, Amsterdam and Philadelphia: John Benjamins.

Akita, Kimi. 2020. A typology of depiction marking: The prosody of Japanese ideophones and beyond. *Studies in Language*.

Alderete, John & Alexei Kochetov. 2017. Integrating sound symbolism with core grammar: The case of expressive palatalization. *Language* 93. 731–766.

Bennett, Wm. G. 2015. *The phonology of consonants*. Cambridge: Cambridge University Press.

Breiss, Canaan. 2020. Constraint cumulativity in phonotactics: Evidence from artificial grammar learning studies. *Phonology* 37(4). 551–576.

Bürkner, Paul-Christian. 2017. brms: An R Package for Bayesian Multilevel Models using Stan. *Journal of Statistical Software* 80(1). 1–28.

Cho, Taehong. 2021. Where we are at: Impact, special collections, open science and registered report at the *Journal of Phonetics*. *Journal of Phonetics* 89.

Chomsky, Noam. 1965. *Aspects of the theory of syntax*. Cambridge: MIT Press.

Cuskley, Christine. 2013. Mappings between linguistic sound and motion. *The Public Journal of Semiotics* 5(1). 39–62.

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.

Dingemanse, Mark & B. Thompson. 2020. Playful iconicity: structural markedness underlies the relation between funniness and iconicity. *Language and Cognition* 12(1). 203–224.

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

- 441 Franke, Michael & Timo B. Roettger. 2019. Bayesian regression modeling (for factorial designs):  
442 A tutorial. Ms. <https://doi.org/10.31234/osf.io/cdxv3>.
- 443 Gallistel, Randy C. 2009. The importance of proving the null. *Psychological Review* 116(2). 439–453.
- 444 Garellek, Marc, Matthew Gordon, James Kirby, Wai-Sum Lee, Alexis Michaud, Christine  
445 Mooshammer, Oliver Niebuhr, Daniel Recasens, Timo B. Roettger, Adrian Simpson & Kris-  
446 tine Yu. 2020. Toward open data policies in phonetics: What we can gain and how we can  
447 avoid pitfalls. *Journal of Speech Sciences* 9(1).
- 448 Gelman, Andrew, Aleks Jakulin, Maria Grazia Pittau & Yu-Sung Su. 2018. A weakly informative  
449 default prior distribution for logistic and other regression models. *Annual Applied Statistics*  
450 2(4). 1360–1383.
- 451 Gil, David. 1990. Speaking backwards in tagalog. paper presented at 8th asanal international  
452 conference, kuala lumpur. Tech. rep.
- 453 Goldsmith, John. 1976. *Autosegmental phonology*: MIT Doctoral dissertation.
- 454 Goldwater, Sharon & Mark Johnson. 2003. Learning OT constraint rankings using a maximum  
455 entropy model. *Proceedings of the Workshop on Variation within Optimality Theory* 111–120.
- 456 Gordon, Matthew. 2002. A phonetically driven account of syllable weight. *Language* 78(1). 51–80.
- 457 Hamano, Shoko. 1998. *The sound-symbolic system of Japanese*. Stanford: CSLI Publications.
- 458 Hansson, Gunnar Olafur. 2001. *Theoretical and typological issues in consonant harmony*: University  
459 of California, Berkeley Doctoral dissertation.
- 460 Haspelmath, Martin. 2014. Comparative syntax. In *The Routledge handbook of syntax*, 490–508.  
461 Routledge.
- 462 Hayes, Bruce. 1995. *Metrical stress theory: Principles and case studies*. Chicago: The University of  
463 Chicago Press.
- 464 Hayes, Bruce. 1999. Phonetically-driven phonology: The role of Optimality Theory and inductive  
465 grounding. In Michael Darnell, Edith Moravcsik, Michael Noonan, Frederick Newmeyer &  
466 Kathleen Wheatly (eds.), *Functionalism and formalism in linguistics, vol. 1: General papers*, 243–  
467 285. Amsterdam: John Benjamins.
- 468 Hayes, Bruce. 2020. Assessing grammatical architectures through their quantitative signatures.  
469 Talk presenetd at BLS.
- 470 Hayes, Bruce. 2022. Deriving the wug-shaped curve: A criterion for assessing formal theories of  
471 linguistic variation. *Annual Review of Linguistics* 8. 473–494.
- 472 Hayes, Bruce & Colin Wilson. 2008. A maximum entropy model of phonotactics and phonotactic  
473 learning. *Linguistic Inquiry* 39. 379–440.
- 474 Hewitt, Mark & Alan Prince. 1989. OCP, locality and linking: The N. Karanga verb. In E. J. Fee &  
475 K. Hunt (eds.), *Proceedings of West Coast Conference on Formal Linguistics* 8, 176–191. Stanford:  
476 Stanford Linguistic Association.
- 477 Hinton, Leane, Johanna Nichols & John Ohala. 2006. *Sound symbolism, 2nd edition*. Cambridge:  
478 Cambridge University Press.
- 479 Hockett, Charles. 1959. Animal “languages” and human language. *Human Biology* 31. 32–39.
- 480 Hosokawa, Yuta, Naho Atsumi, Ryoko Uno & Kazuko Shinohara. 2018. Evil or not? Sound sym-  
481 bolism in Pokémon and Disney character names. Talk presented at the 1st international con-  
482 ference on Pokémonastics.
- 483 Ito, Junko. 1990. Prosodic minimality in Japanese. In Michael Ziolkowski, Manual Noske & Karen  
484 Deaton (eds.), *Proceedings of Chicago Linguistic Society: Parasession on the syllable in phonetics*  
485 *and phonology*, 213–239. Chicago: Chicago Linguistic Society.

- 486 Ito, Junko & Armin Mester. 1986. The phonology of voicing in Japanese: Theoretical consequences  
487 for morphological accessibility. *Linguistic Inquiry* 17. 49–73.
- 488 Ito, Junko & Armin Mester. 2003. *Japanese morphophonemics*. Cambridge: MIT Press.
- 489 Ito, Junko & Armin Mester. 2012. Recursive prosodic phrasing in Japanese. In Toni Borowsky,  
490 Shigeto Kawahara, Takahito Shinya & Mariko Sugahara (eds.), *Prosody matters*, 280–303. Lon-  
491 don: Equinox Publishing.
- 492 Jäger, Gerhard. 2007. Maximum Entropy Models and Stochastic Optimality Theory. In Joan W.  
493 Bresnan (ed.), *Architectures, rules, and preferences: Variations on themes*, 467–479. CSLI.
- 494 Jäger, Gerhard & Anette Rosenbach. 2006. The winner takes it all—almost: Cumulativity in gram-  
495 matical variation. *Linguistics* 44(5). 937–971.
- 496 Jang, Hayeun. 2021. How cute do I sound to you?: Gender and age effects in the use and evaluation  
497 of Korean baby-talk register, Aegyo. *Language Sciences* 83. 101289.
- 498 Katz, Jonah. 2021. Intervocalic lenition is not phonological: Evidence from Campidanese Sar-  
499 dinian. *Phonology* 38(4). 651–692.
- 500 Kawahara, Shigeto. 2020a. Sound symbolism and theoretical phonology. *Language and Linguistic*  
501 *Compass* 14(8). e12372.
- 502 Kawahara, Shigeto. 2020b. A wug-shaped curve in sound symbolism: The case of Japanese  
503 Pokémon names. *Phonology* 37(3). 383–418.
- 504 Kawahara, Shigeto & Canaan Breiss. 2021. Exploring the nature of cumulativity in sound sym-  
505 bolism: Experimental studies of Pokémonastics with English speakers. *Laboratory Phonology*  
506 12(1). 3, <https://doi.org/10.5334/labphon.280>.
- 507 Kawahara, Shigeto & Gakuji Kumagai. 2019a. Expressing evolution in Pokémon names: Experi-  
508 mental explorations. *Journal of Japanese Linguistics* 35(1). 3–38.
- 509 Kawahara, Shigeto & Gakuji Kumagai. 2019b. Inferring Pokémon types using sound symbolism:  
510 The effects of voicing and labiality. *Journal of the Phonetic Society of Japan* 23(2). 111–116.
- 511 Kawahara, Shigeto & Gakuji Kumagai. 2023a. Lyman’s law counts only up to two. *Laboratory*  
512 *Phonology*.
- 513 Kawahara, Shigeto & Gakuji Kumagai. 2023b. Rendaku is not blocked by two nasal consonants:  
514 A reply to Kim (2022). *Glossa*.
- 515 Kawahara, Shigeto, Atsushi Noto & Gakuji Kumagai. 2018. Sound symbolic patterns in Pokémon  
516 names. *Phonetica* 75(3). 219–244.
- 517 Kim, Seoyoung. 2022. A maxent learner for super-additive counting cumulativity. *Glossa* 7(1).
- 518 Klamer, Marian. 2002. Semantically motivated lexical patterns: A study of Dutch and Kambera  
519 expressives. *Language* 78(2). 258–286.
- 520 Kruschke, John K. & Torrin M. Liddell. 2018. The Bayesian new statistics: Hypothesis testing, esti-  
521 mation, meta-analysis, and power analysis from a Bayesian perspective. *Psychological Bulletin*  
522 *and Review* 25. 178–206.
- 523 Kubozono, Haruo. 1999. *Nihongo-no onsei: Gendai gengogaku nyuumon 2 [Japanese phonetics: An*  
524 *introduction to modern linguistics 2]*. Tokyo: Iwanami Shoten.
- 525 Kumagai, Gakuji. 2019. A sound-symbolic alternation to express cuteness and the orthographic  
526 Lyman’s Law in Japanese. *Journal of Japanese Linguistics* 35(1). 39–74.
- 527 Kumagai, Gakuji. 2022. What’s in a Japanese *kawaii* ‘cute’ name? A linguistic perspective.  *Fron-*  
528 *tiers in Psychology* <https://doi.org/10.3389/fpsyg.2022.104>.
- 529 Kumagai, Gakuji. to appear. EXPRESS[P] in expressive phonology: Analysis of a nicknaming  
530 pattern using ‘princess’ in Japanese. *Phonology*.

- 531 Lemoine, Nathan P. 2019. Moving beyond noninformative priors: Why and how to choose weakly  
532 informative priors in Bayesian analyses. *Oikos* 128. 912–928.
- 533 McCarthy, John J. 2003. OT constraints are categorical. *Phonology* 20(1). 75–138.
- 534 McCarthy, John J. & Alan Prince. 1986. Prosodic morphology. Ms., University of Massachusetts  
535 and Rutgers University.
- 536 McPherson, Laura & Bruce Hayes. 2016. Relating application frequency to morphological struc-  
537 ture: The case of Tommo So vowel harmony. *Phonology* 33. 125–167.
- 538 Mester, Armin. 1990. Patterns of truncation. *Linguistic Inquiry* 21. 475–485.
- 539 Mithun, Marianne. 1982. The synchronic and diachronic behavior of plops, squeaks, croaks, sighs,  
540 and moans. *International Journal of American Linguistics* 48(1). 49–58.
- 541 Monaghan, Padraic & Seán G. Roberts. 2021. Iconicity and diachronic language change. *Cognitive*  
542 *Science* 45(4). e12968.
- 543 Myers, Scott. 1997. OCP effects in Optimality Theory. *Natural Language and Linguistic Theory*  
544 15(4). 847–892.
- 545 Nelson, Diane & Ida Toivonen. 2000. Counting and the grammar: case and numerals in inari sami.  
546 In Diane Nelson & Paul Foulkes (eds.), *Leeds working papers in linguistics* 8, 179–182.
- 547 Newman, Stanley. 1933. Further experiments on phonetic symbolism. *American Journal of Psy-*  
548 *chology* 45. 53–75.
- 549 Nielsen, Alan K. S. & Mark Dingemans. 2021. Iconicity in word learning and beyond: A critical  
550 review. *Language and Speech* 64(1). 52–72.
- 551 Paster, Mary. 2019. Phonology counts. *Radical* 1. 1–61.
- 552 Perfors, Amy. 2004. What’s in a name?: The effect of sound symbolism on perception of facial  
553 attractiveness. In K. Forbus, D. Gentner & T. Regier (eds.), *26th annual conference of the cognitive*  
554 *science society*, Chicago, IL: Psychology Press.
- 555 Perniss, Pamela, Robin L. Thompson & Gabriella Vigiliocco. 2010. Iconicity as a general prop-  
556 erty of language: Evidence from spoken and signed languages. *Frontiers in Psychology*  
557 doi:10.3389/fpsyg.2010.00227.
- 558 Poser, William. 1990. Evidence for foot structure in Japanese. *Language* 66. 78–105.
- 559 Priestly, Tom. 1994. On levels of analysis of sound symbolism in poetry, with an application  
560 to Russian poetry. In Leane Hinton, Johanna Nichols & John Ohala (eds.), *Sound symbolism*,  
561 237–238. Cambridge: Cambridge University Press.
- 562 Prince, Alan & Paul Smolensky. 1993/2004. *Optimality Theory: Constraint interaction in generative*  
563 *grammar*. Malden and Oxford: Blackwell.
- 564 Sapir, Edward. 1929. A study in phonetic symbolism. *Journal of Experimental Psychology* 12.  
565 225–239.
- 566 Saussure, Ferdinand de. 1916. *Cours de linguistique générale*. Paris: Payot.
- 567 Shih, Stephanie S. 2017. Constraint conjunction in weighted probabilistic grammar. *Phonology*  
568 34(2). 243–268.
- 569 Shih, Stephanie S, Jordan Ackerman, Noah Hermalin, Sharon Inkelas, Hayeun Jang, Jessica John-  
570 son, Darya Kavitskaya, Shigeto Kawahara, Miran Oh, Rebecca L Starr & Alan Yu. 2019. Cross-  
571 linguistic and language-specific sound symbolism: Pokémonastics. Ms. University of Southern  
572 California, University of California, Merced, University of California, Berkeley, Keio Univer-  
573 sity, National University of Singapore and University of Chicago.
- 574 Shinohara, Kazuko & Shigeto Kawahara. 2013. The sound symbolic nature of Japanese maid  
575 names. *Proceedings of the 13th Annual Meeting of the Japanese Cognitive Linguistics Association*

- 576 13. 183–193.
- 577 Sidhu, David & Penny M. Pexman. 2018. Five mechanisms of sound symbolic association. *Psy-*  
578 *chonomic Bulletin & Review* 25(5). 1619–1643.
- 579 Smith, Jennifer. 2002. *Phonological augmentation in prominent positions*: University of Mas-  
580 sachusetts, Amherst Doctoral dissertation.
- 581 Smolensky, Paul. 1986. Information processing in dynamical systems: Foundations of harmony  
582 theory. In D. Rumelhart, J. McClelland & PDPR Group (eds.), *Parallel distributed processing:*  
583 *Explorations in the microstructure of cognition*, vol. 1: Foundations, 194–281. Cambridge, MA:  
584 Bradford Books/MIT Press.
- 585 Suzuki, Keiichiro. 1998. *A typological investigation of dissimilation*: University of Arizona Doctoral  
586 dissertation.
- 587 Suzuki, Takao. 1962. Oninkookan to igibunka no kankei ni tsuite-iwayuru seidakuon tairitsu-o  
588 chuushin toshite. *Gengo Kenkyu [Journal of the Linguistic Society of Japan]* 42. 23–30.
- 589 Thompson, Patrick D. & Zachary Estes. 2011. Sound symbolic naming of novel objects is a graded  
590 function. *Quarterly Journal of Experimental Psychology* 64(12). 2392–2404.
- 591 Uno, Ryoko, Kazuko Shinohara, Yuta Hosokawa, Naho Ataumi, Gakuji Kumagai & Shigeto Kawa-  
592 hara. 2020. What’s in a villain’s name? Sound symbolic values of voiced obstruents and bilabial  
593 consonants. *Review of Cognitive Linguistics* 18(2). 428–457.
- 594 Vasishth, Shravan, Bruno Nicenboim, Mary Beckman, Fangfang Li & Eun Jong Kong. 2018.  
595 Bayesian data analysis in the phonetic sciences: A tutorial introduction. *Journal of Phonet-*  
596 *ics* 71. 147–161.
- 597 Walker, Rachel. 2001. Round licensing, harmony, and bisyllabic triggers in Altaic. *Natural Lan-*  
598 *guage and Linguistic Theory* 19. 827–878.
- 599 Wickham, Hadley. 2016. *ggplot2: Elegant graphics for data analysis*. New York: Springer-Verlag.
- 600 Winter, Bodo. 2019. *Statistics for linguists*. New York: Taylor & Francis Ltd.
- 601 Zuraw, Kie & Bruce Hayes. 2017. Intersecting constraint families: An argument for Harmonic  
602 Grammar. *Language* 93. 497–548.