Gotta name'em all: an experimental study on the sound symbolism of Pokémon names in Brazilian Portuguese

Abstract: Sound-symbolic patterns which relate to the perception of size were found to motivate the behavior of English and Japanese speakers in the naming of pre- and post-evolution Pokémon. The current study builds from this finding and investigates which sound-symbolic association speakers of Brazilian Portuguese (BP) employ to name Pokémon characters. Results from 3 experiments show that vowel quality, phonological length and voiced obstruents, usually used to signal differences in size, are used to signal differences in evolution; however, the effects of voiced obstruents are not identical to what was previously observed in the behavior of Japanese speakers. We argue that although there is a universal sound symbolism associated with these sounds and the perception of largeness, its manifestation differs cross-linguistically. To the best of our knowledge, this is one the first experimental research to investigate sound symbolism and the perception of size in BP.

Keywords: Sound Symbolism, Brazilian Portuguese, Pokémon

1. Introduction

Over the past decade, Psycholinguistics has witnessed a renewed interest in iconicity. Corpora studies and experimental research have increasingly reported systematic and iconic relations between form and meaning across different languages (Dingemanse et al., 2013; Dingemanse et al., 2016; Lockwood and Dingemanse, 2015, among others), providing empirical evidence for a long-held intuition (see Plato, Cratylus: 427a) that some consonants and vowels summon images or sensations associated to an object's physical properties such as shape, size, speed or brightness.

Recent experimental studies report various types of sound-symbolic associations, including correlations between vowel height and redness/yellowness (Moos et al., 2014), vowel backness and speed (Cuskley 2013) or precision (Maglio et al., 2014), consonant voicing and darkness (Asano and Yokosawa, 2011) or blackness (Hirata et al., 2011), and consonant articulation (stop/sonorant) and geometric shapes (Nielsen and Rendall, 2013). We believe that the current amount of evidence for sound symbolism allows us to shift the question of "*whether* sound symbolism exists" to "*how* it co-exists with arbitrariness" in natural languages (Lockwood and Dingemanse, 2015) and what is its role in linguistic phenomena. In this context, one of the new exciting questions that needs to be addressed is to what extent sound symbolic patterns are universal or language-specific.

In this paper, we address this issue by presenting three experiments devised to test whether speakers of Brazilian Portuguese (henceforth, BP) name pre- and post-evolution Pokémon characters using the same sound symbolic patterns that speakers of other languages employ to signal differences in the size of an object. Specifically, we build on a previous study by Kawahara and Kumagai (2019) that reports sound-symbolic associations in Pokémon names observed in the behavior of Japanese speakers. To the best of our knowledge this is the first study on the size-related sound symbolism in BP, and more generally, one of the few studies on sound symbolism in this language so far.

1.1 Language-specific and universal sound symbolism: the case for a study in Brazilian Portuguese

Evidence that speakers of typologically different languages are prone to the same sound symbolic associations comes from independent studies that detect the same patterns in different languages (Dingemanse et al., 2013; Maurer et al., 2006; Bremner et al., 2013), cross-linguistic work that directly compare speakers of different languages (Shinohara and Kawahara, 2010;

Wiseman and Van Peer 2003) and language learning research showing that children and adults from different speaking communities make the same sound symbolic associations (Imai et al. 2008; Iwasaki et al., 2007a, 2007b; Nygaard, Cook and Namy 2009; Lockwood et al., 2016).

One of the earliest experimental findings on sound symbolic patterns shows that English speakers perceive the word *mal* as a better fit to name large objects, while *mil* is preferably used to name smaller ones (Sapir, 1929). Following this work, other studies targeting speakers of different languages have reported that small objects tend to be associated with high and/or front vowels, while larger objects are often associated to low and/or back vowels (e.g., Berlin 2006; Coulter and Coulter 2010; Shinohara and Kawahara, 2010; Ohtake and Haryu 2013). Another classic finding on sound symbolic associations comes from an early study that reported a pattern of choosing names with voiceless stop consonants to label angular shapes and names with sonorant consonants to refer to round figures (Köhler, 1947). This finding, which is now also known as the *bouba-kiki* effect (Ramachandran and Hubbard 2001), has been replicated in many scenarios and languages (Hollard and Wertheimer, 1962; Maurer et al., 2006; Nielsen and Rendall, 2011; Fort et al., 2015; but see Styles and Gawne, 2017).

However, research on this topic also report some instances of sound symbolism that seem to be specific to a given language. Iwaski et al. (2007b) report that English speakers could decode the meaning of Japanese ideophones related to laughter and pain, which implies that these sound-symbolic patterns are available to English speakers. However, these same speakers were not as successful in guessing the meaning of walking-related ideophones. Similarly, a naming task study by Saji et al. (2013) reported that English and Japanese show same or similar sound symbolic associations; however, the study revealed that sometimes these sounds were mapped in opposite directions (e.g., /tʃ/ being associated to light and fast motion in Japanese, but to heavy and non-energetic motion in English).

Reasons for these disparities across languages may be related to cross-linguistic differences in the phonological status of these sounds and on the different phonotactic restrictions of the languages at issue. Imai and Kita (2014) hypothesize that children are initially sensitive to all possible sound symbolic correspondences, which are probably grounded in iconic relationships between meaning and the acoustics/articulatory properties of these sounds. After acquiring a language, children keep only those symbolic correspondences that are compatible with their language's phonological inventory. In fact, Saji et al. (2013) point out that the status of [tʃ] is different in English and Japanese, occurring just as the result of palatalization in the latter. The hypothesis that specificities in the phonological inventory of a language may affect sound symbolic mapping is also supported by a meta-analysis of the *bouba-kiki* effect in 17 experiments, including two failed attempts to replicate the finding with speakers of Songe and Syuba (Styles and Gawne, 2017). In this study, Styles and Gawne (2017) point out that the failure to replicate the effect may be related to the phonological legality of the experimental stimuli in the target language, as some of the words used in the failed replications violated the language phonotactics.

The reason why some symbolic associations are more common across languages than others is a matter of debate that may shed light on why these associations occur in the first place (Morton, 1994; Ohala, 1994) and the role they play in first and second language learning (Iwasaki et al., 2007a, Tzeng et al., 2016; Imai et al., 2018), language evolution (Perlman and Lupyan, 2018; Berlin, 2006; Ramachandran and Hubbard, 2001), and language universals (Blasi et al., 2016; Dingemanse et al., 2013). Therefore, mapping cross-linguistic and language-specific sound symbolic associations is the necessary groundwork to foster future research that delves into these questions.

Studies on sound symbolism in BP are rare and are, to the best of our knowledge, limited to corpus-based research on ideophones in regional dialects (Cruz and Fernandes, 2004), acoustic and perceptual analysis of speech expressivity (Madureira and Camargo, 2010) and experimental work that investigates the *bouba-kiki* effect (Godoy et al. 2018), and the use of nasals and plosives to convey emotional states (Wiseman and Van Peer 2003, see Aryani et al. 2013). To our knowledge, these latter two studies are the only ones that map phonemes to perceptual categories or emotional states by investigating cross-linguistic similarities with a set of experiments. Their findings show that speakers of Brazilian Portuguese are sensitive to the *kiki-bouba* effect (Godoy et al. 2018), and that when asked to produce fantasy words associated to emotions experienced at funerals and weddings, they are prone to associate nasal sounds to sad feelings and plosives to happiness (Wiseman and Van Peer 2003).

In order to expand what is known about sound symbolic associations in BP, our main goal is to test three linguistic aspects that have been shown to correlate with images of smallness/largeness in other languages: the use of voiced obstruents (e.g. /b/ and /z/: Newman, 1933; Ohala, 1984; Shinohara and Kawahara, 2010), vowel quality (e.g. /a/ vs. /i/: Sapir, 1929; Newman, 1933) and length of linguistic expression (Dingemanse et al., 2015). A detailed account of our hypotheses and their theoretical justification will be presented later in the paper.

1.2 Sound symbolism in Pokémon names

Because our goal was comparing the behavior of BP speakers to speakers of other languages, we chose experimental stimuli that were used in previous experiments and that, at the same time, would make our experimental task relevant to participants. The use of Pokémon characters as a way to evaluate sound symbolic associations fulfills these criteria in two ways. First, Pokémon characters have been used to investigate sound symbolism in Japanese (Kawahara et al., 2018; Kawahara and Kumagai, 2019), English (Shih et al. 2018), Russian (Kavitskaya, 2018), Mandarin and Cantonese (Starr et al., 2018). Therefore, results from BP – particularly those from our free-naming task (Experiment 1) – can contribute to building a cross-linguistic corpus on this subject. Second, Pokémon characters are familiar to most undergraduates who take part in psycholinguistics experiments, which opens up the possibility of investigating sound symbolism with stimuli that are not unknown to participants, but at the same time make the experimental task more engaging.

Pokémon is a Japanese media franchise centered on fictional characters – the Pocket Monsters, or Pokémon – that are caught by humans and trained to fight against each other in competitions. The franchise started as a video game, and quickly developed into tv shows, comic books, card games and movies. Each Pokémon character has numerical parameters associated with their size, weight and strength. At some point, most of these characters undergo evolution, and this usually leads to an increase in their parameters and a change in their names (e.g., *Pikachu* changes its name to *Raichu*; *Poppo* changes its name to *Pijotto*).

Inspired by research on proper names and animal names suggesting that naming patterns might be not entirely random (Berlin, 2006; Perfors, 2004; Wright et al., 2005), Kawahara et al., (2018) investigated whether sound symbolic patterns are tangible among the 720 Japanese Pokémon characters. In their corpus study, they report that post-evolution characters usually have longer names (measured by the number of moras, the basic counting unit in Japanese: Otake et al., 1993) and more voiced obstruents (i.e. /b/, /d/, /g/, and /z/). These naming features also correlate positively with size, weight and most of the strength parameters. Vowel height also depict sound symbolism regarding size and weight, although this effect was small: /a/ positively correlated with height and size, while high vowels (/i/ and /u/) showed a negative correlation with these parameters.

Because Pokémon characters receive different names in different communities of speakers, more corpora studies followed. In general, length of linguistic expression correlated positively with evolution or measures of size such as weight and height in English (Shih et al., 2018), Mandarin and Cantonese (Starr et al., 2018). In English, number of voiced obstruents and low vowels also correlated positively with measures of size such as weight and height (Shih et al., 2018), mirroring the results of Japanese[1] (Kawahara et al. 2018). Language-specific patterns were also identified. In Mandarin and Chinese, tonal features correlate with height, weight and evolutionary status (Starr et al., 2018). Comparing English and Japanese, Shih et al. (2018) report that the only the latter shows a negative correlation between the number of labial consonants (e.g. /b, p, m/) and height. In English (but not in Japanese), the number of alveolar consonants (e.g. /t, s, n/) correlates positively with height and power statistics.

Kawahara and Kumagai (2019; henceforth, K&K) later investigated whether these sound symbolic patterns hold only in the name of original Pokémon, or could be employed by Japanese speakers when they name new Pokémon characters. The results show that Japanese speakers preferred longer words and names with more voiced obstruents for post-evolution characters, in line with the findings of the corpus study. English speakers showed a similar result, but with two major differences. They were more likely to choose longer words and words with a voiced obstruent to name a post-evolution Pokémon, but the effect size was smaller. Furthermore, English speakers, unlike Japanese speakers, were not sensitive to the number of voiced obstruents within a name. These results imply that although Japanese and English speakers associate voiced obstruents to largeness, the magnitude of this association may differ cross-linguistically.

It is not possible to explore sound symbolic patterns in Pokémon names with a corpus study in BP, because the franchise in Brazil adopts the English names. Therefore, our study employs naming experiments similar to the ones described in K&K. As a consequence, some of our manipulations may be described as a replication of the original study in Japanese, while others were designed to test new hypotheses that arise from the results of Experiment 1. In the next section, we present our hypothesis based on the original study in Japanese.

[1] Starr et al. (2018) did not report any finding for these variables.

1.3 Specific hypotheses tested

As outlined in the introduction of this paper, sound symbolic patterns can be connected to many different physical attributes of an object, but here we aim to investigate specifically size-related sound symbolisms. The first hypothesis tested is that vowel quality relates to the concepts of largeness and smallness. While some studies report that vowel height correlates with size (e.g. /a/ vs. /i/: Sapir 1929; Kawahara et al. 2005), others have reported that it is vowel backness (e.g. /i/ vs. /o/) that dictates this relation between sound and meaning (Berlin 2006). In a cross-linguistic study involving four languages (Chinese, English, Japanese, and Korean), Shinohara and Kawahara (2010) assessed how vowel backness and height may influence the ways in which speakers construct images of size using nonce word stimuli. In general, both backness and height influenced participant's perception of magnitude: back and low vowels were rated to be larger than front and high vowels, which were rated to be smaller. However, the corpus analysis of existing Pokémon names in Japanese and English showed that vowel height, but not backness, correlated with largeness (measured as a matter of height and weight) (Kawahara et al., 2018; Shih et al., 2018).

We do not know of any work that investigates whether vowel quality influences the perception of size in Portuguese. Therefore, we analyze the vowels produced by BP speakers to name Pokémon characters in order to test the hypothesis that vowel height or backness are used to name larger characters. If these sound symbolic associations are also available to BP speakers, we expect to find that lower and back vowels would appear more frequently in the names of post-evolution Pokémon, as these characters are usually depicted as being larger than their pre-evolution pair[2]. However, we do not adhere to any specific hypothesis as to what

[2] When a Pokémon undergoes evolution, size is not the only change it experiences: it becomes stronger, faster, and sometimes its looks becomes more aggressive (see Figure 1). Of all these changing features, size is the one that can be visually perceived and can clearly show that two related Pokémon are the pre and post-evolution

would cause such correlations. As Shinohara and Kawahara (2010) point out, there are currently articulatory and acoustic explanations for their results, but none of them can provide a perfect account of what is known about the correlations between vowel quality and the perception of size. At this point, our study is mainly exploratory and descriptive, and aims at identifying tendencies BP speakers may have while using articulatory features of vowel production to signal differences in size.

The second hypothesis that is tested is the Frequency Code Hypothesis (Ohala 1983, 1994), which states that the frequency of a sound is inversely proportional to the size that is associated with it. In other words, large objects would be associated with low-pitched sounds, whereas small objects would be associated with high-pitched sounds. Because speakers expand their oral cavities to produce voiced obstruents (Ohala, 1983; Shinohara and Kawahara, 2010) and produce low frequency sounds during voiced obstruents and in vowels next to them, the Frequency Code Hypothesis predicts that voiced obstruents are associated with largeness. In the context of Pokémon names, this explains why the corpus study by Kawahara et al. (2018) found that the number of voiced obstruents in names positively correlates with almost every character attribute, including size and evolution. This is also a possible explanation as to why experimental results from K&K show that voiced obstruents were more common in names given by Japanese speakers to post-evolution Pokémons. Based on these previous results and the prediction made by the Frequency Code Hypothesis, we expect to find more voiced obstruents in names associated with post-evolution Pokémons.

The third hypothesis tested in the present study is related to what Kawahara et al. (2018) call the "longer-is-stronger" principle. In both the corpora and the experimental studies that

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version of the same character. In our study, we made this difference even more striking by making the pictures of post-evolution Pokémon characters larger (section 2.1). For this reason, we take any effect that shows a correlation between sound and evolutionary status to be at least partially grounded on the size of these characters.

analyzed Pokémon names, stronger, larger and post-evolution characters received longer names, measured by their number of moras in Japanese (Kawahara et al. 2018; K&K 2019), number of segments in English (Shih et al., 2018), and number of syllables in Cantonese and Mandarin (Starr et al., 2018). According to K&K, this would be the manifestation of what is described as iconicity of quantity (Haiman 1980, 1985), which predicts that linguistic expressions that are phonologically longer tend to convey more information. Examples of this principle in natural language can be observed in Japanese in the use of reduplication to express intensity (kuro = black; kuro-guro = very black), repetition (goro = a heavy object rolling; goro-goro = a heavy object rolling repeatedly), or plurality (yama = mountain; yama-yama = mountains), and in Portuguese in the use of longer forms for superlative adjectives (forte (strong) > fortíssimo). If BP speakers apply this principle as a way to signal magnitude, we expect post-evolution Pokémon characters to receive longer names.

Finally, we address an issue raised by K&K: the possibility that any symbolic association found in such studies may be the result of implicit learning. In Brazil, Pokémon players are familiar with the English version of Pokémon names, which, in general, present the patterns we intend to investigate: larger characters have longer names, with low vowels and more voiced obstruents (Shih et al. 2018). It may be the case that experienced players would learn these patterns from exposure to actual Pokémon names, and reproduce them in naming tasks. To address this concern, we assess Pokémon familiarity as a variable that may influence speaker's behavior in Experiment 1. Because the sound symbolisms we test have previously been reported with other stimuli than Pokémon characters, we do not expect familiarity with Pokémon to determine whether speakers produce these symbolic associations. This issue is of particular interest for testing the Frequency Code Hypothesis and the iconicity of quantity principle, as their predictions are based on the physics law of vibration and on general principles that should hold in any language.

2. Experiment 1

K&K reported that Japanese speakers used words with more moras and more voiced obstruents to name post-evolution Pokémons. The goal of Experiment 1 was to test whether native BP speakers would use a similar sound symbolic strategy to signal a difference between pre-evolution and post-evolution characters. Following other studies that report the association between vowel quality and large/small objects (Sapir 1929; Newman, 1933; Kawahara et al. 2005, Shinohara and Kawahara, 2010), we also assessed whether evolutionary status would shift the distribution of vowels in Pokémon names. In order to do so, we analyzed which vowels were used in the first syllable, as word-initial elements have a greater impact on speech processing than elements in other positions (e.g. Nooteboom, 1981; Kawahara and Shinohara, 2011), including sound symbolic effects (Kawahara et al., 2008).

2.1 Materials and procedures

Participants were told to name new pairs of Pokémon characters using Portuguese-sounding names. The experimental stimuli consisted of a pre-evolution Pokémon and its post-evolution version (see Figure 1). Participants were instructed not to use words in Portuguese or other languages. This was done to encourage the creation of nonce words that would be more susceptible to the use of sound symbolism than real, arbitrary words. They were also asked not to use any prefix or suffix, such as "mega", "super", "-inho" (diminutive suffix in BP) and -ão (augmentative suffix in BP), and to avoid using existing Pokémon names. After receiving these instructions and before starting the experiment, they were given a practice trial. In total, each participant named 20 pairs in experimental trials. These 20 pairs were organized in 4 lists that differed solely in the order of presentation. Stimuli were presented and written responses were recorded through the use of *Googleforms*.

Figure 1. Sample pairs used in Experiment 1

[Figure 1]

Pictures were drawn by digital artist toto-mame[3] and were from the same set of pictures used by K&K. Pokémon characters within each pair had the same motif (a bee, a bear, etc.), so it was clear to the participants that they represented different evolutionary stages of the same Pokémon. To emphasize the difference in evolution between characters, pictures of pre-evolution characters were 75% the size of the pictures their post-evolution pair.

A total of 141 native BP speakers took part voluntarily in the experiment after giving their formal consent. At the end of the session, they were asked how familiar they were with the Pokémon universe.

2.2 Exclusion criteria and phonological transcription

Each name was analyzed independently by two referees[4] who decided whether data should be excluded due to not conforming to the instructions given to the participants. The first author made the final decision when the two referees disagreed in their judgment. Both names of a pair were excluded if one of them fell in at least one of the exclusion criteria.

Phonotactics was the first criterion for exclusion. Because we wanted to test our hypothesis regarding BP, we excluded names that used foreign-looking orthography and/or violated BP phonotactics, including borderline cases. This included names with double vowels in any position (e.g., "Bumee"), names ending with any consonant other than /s, r, m, n, x/, which are the only permissible word-final consonants in BP (e.g., Tolok, Zanzarp), and names with consonant clusters that violates BP phonotactics (e.g., 'schr' in "Schrorox"). Names with

[3] https://t0t0mo.jimdo.com/. The pictures were used in the experiment with the permission of the artist.
[4] Our referees for the first experiment were the second and the fourth co-author of this paper, and an undergraduate student at the UFRN English Language program.

a “w” in the onset of a syllable were also excluded because it was not possible to tell whether the intended pronunciation was /w/ or /v/ (both mappings are common in BP). The latter case does not violate phonotactics most of the time, but the decision to exclude these names came from the fact that the occurrence of /v/ is one of the dependent variables that would be assessed to investigate the role of voiced obstruents in sound symbolism.

We also excluded names that used a Portuguese word or a blend of words when there was a relation with the depicted Pokémon (e.g., “chamorco” - chama = flame; porco = pig/boar - for a boar Pokémon with flames in its tail). Since we wanted to test whether Pokémon evolution would lead to the adoption of some phonemes over others, we opted for this exclusion criterion to avoid having a bias driven by existing words in BP. Furthermore, participants were required to avoid words in BP, so the usage of known words was considered as a sign that they did not follow the instructions properly.

Finally, pairs that used BP suffixes and prefixes to express evolution were also excluded. Following K&K, pairs that created new suffixes and prefixes to express evolution were also excluded (e.g., Aboni > Abonimo; Bipelon > Musbipelon). Although infixation is not productive in BP, we also excluded such cases (e.g., Cari > Capuri). This procedure ensured that it is phonological length, not morphological complexity, that matters when it comes to signaling post-evolution characters.

Data from 70 participants were excluded because 50% or more of their responses fell into at least one of these exclusion criteria. The remaining dataset was comprised of 2240 names produced by 71 participants (mean age = 27.6 years, SD = 6.45, 43 male), representing 39% of the initial dataset. Phonological transcription of these names was obtained with SILAC (Oushiro, 2018), an automated grapheme-to-phoneme mapping system. This was important as the phoneme/grapheme relation in BP can sometimes be misleading for our purposes. While "s" in a name such as "Sofila" is pronounced /s/, in "Presida" its pronunciation would be the voiced obstruent /z/. Therefore, all analyses presented here considered the phonological transcription rather than the name's orthography.

2.3 Analyses and Results

All analyses in this paper were conducted using R packages *lme4* and *glmmTTB*. To control for Type I and Type II errors, results from multiple model comparisons and post-hoc tests were adjusted using the false discovery rate method (Hochberg and Benjamini, 1995).

2.3.1 Vowel quality

In order to build a comprehensive picture of vowel quality and sound symbolism, we analyzed each of the five vowels independently. Table 1 shows the distribution for vowels /a/, /e/, /i/, /o/, /u/ in the first syllable of each name across evolutionary statuses.

Table 1. counts for each vowel in initial syllables

[Table 1]

We ran logistic regressions to test the effect of evolution in vowel quality. The occurrence of each vowel was coded as a binary factor: when the effect of evolution on having an /a/ in the first syllable was tested, the response variable was “a” or “other”; for /e/, the response variable was “e” or “other” and so on. Our models included evolution as an independent variable and random intercepts for participants and items. Model comparison with a nested model that had no fixed effects showed that evolution was a significant factor in modeling the occurrences /a/ and /i/, but not the others vowels. The best fitting models show that pre-evolution names tend to have less occurrences of /a/ than pre-evolution names (β = -0.42, p < 0.0001), while there is an opposite effect for the vowel /i/ (β = 0.56, p < 0.0001).

2.3.2 Number of voiced obstruents and name length

Using data from the phonological transcription of all names, a script automatically counted how many occurrences of /b/, /d/, /g/, /v/, /z/, and /ʒ/ there were in each name. On average, pre-evolution names had less occurrences than post-evolution ones, although this difference was smaller when compared to the difference reported in Japanese (0.60 vs 0.75 in BP, 0.44 vs 0.8 in Japanese, as reported by K&K).

Because data for voiced obstruents had a great number of zeroes and ones, we ran a Poisson regression to test the effect of evolution in the number of voiced obstruents. Our model included evolution as an independent variable, number of voiced obstruents as a response variable and random intercepts for participants and items. Model comparison showed that evolution was a significant factor in predicting the number of voiced obstruents in Pokémon names ($\chi^2 = 18.384$, $p < 0.0001$). Coefficients for the best fitting model show that pre-evolution names (the reference level in the statistical model) had fewer voiced obstruents than post-evolution names ($\beta = -0.21$, $p < 0.0001$).

Finally, we tested the effect of evolutionary status on name length by counting the number of syllables in the phonological transcription of each name. The dataset for the number of syllables was comprised of count data with no values equal to zero. For this reason, we ran a Truncated Poisson regression to test the effect of evolution in the number of syllables. Our model included evolution as an independent variable, number of syllables as response variable and random intercepts for participants and items. Model comparison showed that evolution was a significant factor in predicting the number of syllables ($\chi^2 = 52.573$, $p < 0.0001$). Coefficients for the best fitting model show that pre-evolution names had fewer syllables than post-evolution names ($\beta = -0.20$, $p < 0.0001$). Although participants named pairs of characters, our analyses so far considered all the names separately. To address this issue, we also ran additional analyses in which the number of voiced obstruents and syllables was coded within a pair. Each pair was annotated on the basis of whether the number of syllables or voiced obstruents in the names of post-evolution Pokémon increased, decreased or stayed constant (cf. Table 2). We performed a χ^2-test to assess if the distribution of these responses was uniform.

Table 2. Example of annotated data for the within-analyses

[Table 2]

Tests for the number of voiced obstruents ($\chi^2 = 234.44$, df = 2, $p < 0.0001$) and number of syllables ($\chi^2 = 305.16$, df = 2, $p < 0.0001$) revealed that the distribution was skewed and, therefore, different from what would be expected by chance. *Post-hoc* analyses for the number of syllables showed that the category "increase" and "constant" are overrepresented, while "decrease" is underrepresented. For the number of voiced obstruents, the only overrepresented category is "constant", which shows that pre and post-evolution names have a significant tendency to have the same number of voiced obstruents. Both "increase" and "decrease" categories were underrepresented. Table 3 shows a summary of these findings.

Table 3. Within-pair analyses for number of voiced obstruents and number of syllables

[Table 3]

2.4 Discussion

2.4.1 Sound symbolic effects and size

Some of the results from our analyses support the hypotheses discussed in section 1.4. First, results on name length can be explained by the longer-is-stronger principle (Kawahara et al., 2018), as longer names were more commonly created to refer to larger, post-evolution Pokémons. In K&K, name length is measured by the number of moras in a name, because that is the most salient counting unit in Japanese (Otake et al. 1993); here the same effect was found by measuring the number of syllables.

Second, regarding vowel quality, our results show that the opposition between /a/ vs. /i/ seems to be used to signal evolutionary status: /i/ was associated with smaller, pre-evolution characters, while /a/ was more often used in names created for larger, post-evolution creatures. These results seem to reflect what was previously reported in English and Japanese for associations between size and vowel quality (Shinohara and Kawahara, 2010), although the substantial effects were observed only for /a/ and /i/. Indeed, we can consider this result to be a replication of what Sapir (1929) found with English speakers, in the context of Pokémon names using BP speakers.

Finally, the Frequency Code Hypothesis (Ohala 1984, 1994) predicted that post-evolution characters would receive names with more voiced obstruents, as sounds with low frequency energy would be perceived as referring to larger entities. Our results, however, were not so clear. Post-evolution names had more voiced obstruents in general, but the within-pairs analysis showed there was no preference in increasing or decreasing the number of voiced obstruents as a function of evolutionary status. This apparent contradiction could be explained by assuming that when there was a difference in the number of voiced obstruents between pre and post-evolution names, this difference would be in the magnitude of 2 or greater. This explanation is in line with the findings of K&K that Japanese speakers are not only sensitive to the presence of a voiced obstruent, but also to how many of these phonemes a name contain. They report that when, within a pair, a name has one voiced obstruent and another has two voiced obstruents, Japanese speakers tend to associate the name with more occurrences of this phoneme to post-evolution characters. Therefore, it may be the case that BP speakers would increase their odds of choosing a particular word to name a post-evolution Pokémon as a function of the number of voiced obstruents presented in this word. This hypothesis was tested in two subsequent experiments that compared pairs of names whose differences in the number of voiced obstruents were manipulated.

2.4.2 Familiarity and sound symbolism

One of the questions addressed by K&K was whether people with no or little familiarity with the Pokémon universe would exhibit the same sound symbolic patterns as those participants who are experienced players. As noted in their work, there is an extensive body of research showing that people learn phonological regularities from exposure to lexicon (Daland et al., 2011; Ernestus and Baayen, 2003; Hay et al., 2003). Because existing Pokémon names exhibit some of the sound symbolisms investigated in this research (Kawahara et al., 2018), any pattern reported here could be interpreted as the result of phonological learning rather than the emergence of sound symbolic associations.

To address this issue, data on Pokémon familiarity was collected through a post-experimental questionnaire. Participants answered two questions using a 1-to-7 Likert scale: (a) how well do you know first generation Pokémon names? (1 labeled as "I don't know any or I just know Pikachu" and 7 labeled as "I know almost all of them"); (b) how much have you played Pokémon? (1 labeled as "I have never played it" and 7 labeled "I have played it all my life"). By averaging these two answers, we created a familiarity score for each participant, and then we repeated the same analyses on a subset of 30 participants who scored 3 or less.

The results were similar to the ones obtained for the full dataset. The vowel /i/ was more common in the first syllable of pre-evolution names than in post-evolution names (β = 0.65, $p < 0.0001$), and the effect was the opposite for vowel /a/ (β = -0.51, p = 0.0006). Post-evolution names were longer than pre-evolution names (β = 0.15, p = 0.0001) and voiced obstruents were more common in post-evolution names (β = 0.209, p = 0.008). Within-pair analyses also showed similar results (Table 4). *Post-hoc* analyses for number of syllables showed that the category "increase" and "constant" are overrepresented, while "decrease" is underrepresented. For the number of voiced obstruents, the only overrepresented category is "constant", which shows that pre and post-evolution names have a significant tendency to have the same number of voiced obstruents.

Table 4. Within-pair analyses for number of voiced obstruents and number of syllables for participants less familiar with the Pokémon universe

[Table 4]

These results suggest that the patterns expressed by participants while naming Pokémons cannot be explained by the learning of phonological patterns from existing Pokémon names. It instead seems more likely that the reported effects are the result of sound symbolism. Moreover, as these same effects were found in names created by Japanese speakers, it lends further support to the idea that these symbolisms are probably not language-specific.

3. Experiment 2

Experiment 2 was a forced-choice task designed to reexamine the findings of Experiment 1 with a set of controlled stimuli. In Experiment 1, our analyses were based on the names provided by participants, and although Portuguese is mostly transparent regarding its orthography (Borgwaldt et al., 2005), there are still some situations in which it may be difficult to assess how the names provided would be pronounced. One example is the letter "s", which was considered to be the voiced obstruent /z/ intervocalically, as this is the orthographic rule for Portuguese. However, it may be the case that some participants would not abide by those rules for the experiment. Because Pokémons are known in Brazil by their English names, some participants may have felt less inclined to follow strict orthographic rules to name the pictures. For this reason, Experiment 2 was conducted to assess whether the findings regarding vowel quality, name length and voiced obstruents would hold when participants had to make a choice about a name for a new Pokémon. Furthermore, two of our conditions were designed to test the hypothesis that there is a cumulative effect of the number of voiced obstruents on the chances of naming a post-evolution Pokémon.

3.2 Stimuli

One of the problems of using a forced-choice task is the possibility that experimenters will choose stimuli that they already believe would show the expected effect during the experiment (Westbury 2005). To address this concern, we created our stimuli pseudo-randomly (see Appendix A). Letters that formed each name were drawn from a pool of possibilities as long as they could be added to the name without violating BP phonotactics. There were also specific rules for name formation in each of the 4 experimental conditions. We also ensured that syllable structure was the same within a pair: in case one name had a consonant cluster, its pair would also have one. This was done to avoid that one of the names could be perceived as longer for having an extra segment.

Condition 1: vowel quality

This condition investigated the correlation between vowel quality in first syllable and evolutionary status. Names for this condition had 2 or 3 syllables (name length was constant within a pair). Consonants differed across names, but no voiced obstruents were included. Vowels were the same for both names of a pair, except for the first, critical syllable, that differed in vowel quality: one of the names had the high vowel /i/ and the other had the low vowel /a/ (e.g. "Lapo/Nito"). We expected that participants would prefer names with an /i/ in the first syllable to name pre-evolution Pokémons.

Condition 2: name length

Condition 2 tested the correlation between name length and evolutionary status. Names within a pair differed on their number of syllables: 2 or 3. Vowels for first and last syllables were always the same. For the name with three syllables, the vowel in the middle syllable always was always /u/, /o/ or /e/ (e.g., “Onura/Oma”). This was done to control for effects of sound symbolism that may be associated with /a/ or /i/. We expected that participants would choose longer names to name post-evolution Pokémon characters.

Conditions 3 and 4: number of voiced obstruents

Conditions 3 and 4 were designed to test whether a name with voiced obstruents would have more chance to be associated to a post-evolution Pokémon and whether this effect is cumulative. Names within a pair had the same number of syllables (3), but one name had 0 voiced obstruents and the other had one (condition 3) or two (condition 4) voiced obstruents. Vowels were the same within a pair and voiced obstruents always appeared in the first syllable (e.g., Condition 3: “Dilapa/Rilata”; Condition 4: “Bovomam/Noporam”). We expected the effect of sound symbolism to be greater in Condition 4 than in Condition 3.

Norming study

Fifteen names for each condition were created. They were subsequently presented to 19 participants (mean age = 25.2, standard-deviation = 5, 19 male) who took part in our first experiment and reported to have a great knowledge of the Pokémon universe (familiarity score greater than 5). These participants were asked to rate how likely it would be to use each stimulus to name a Pokémon. This was done in order to select 10 pairs with the greatest average score and to ensure that names were not too odd. We did not expect the ratings to be high, as participants in Experiment 1 had already reported that it is uncommon to have Portuguese-sounding Pokémon names. Nevertheless, ratings were above average and similar across conditions. In a scale from 1 to 7, the selected names in each condition had the following rates: Condition 1: 4.28 (SD: 1.87); Condition 2: 4.60 (Sd: 1.94); Condition 3: 4.51 (SD: 1.92); Condition 4: 4.47 (SD: 1.97).

3.3 Procedures and participants

Forty pairs of names (10 in each condition) were selected after our norming study. The pictures used in Experiment 2 were a superset of the ones used in Experiment 1, and they depicted a pair of pre and post-evolution characters. Participants were presented with a pair of names and were asked to choose which name would best fit the pre and post-evolution characters. Forty trials were presented randomly in different orders across 8 different lists. Stimuli was presented using *Googleforms*.

The pairing of names and pictures was randomized. If a pair of Pokémon was presented in a list with the names “Lapo/Nito”, for example, this same pair would be presented with another pair of names in a different list. This was done to allow generalizations regarding the names’ properties in each condition, and to avoid that any pattern would result from idiosyncrasies of specific name-picture pairings. The presentation order for each pair of Pokémon was also randomized.

Ninety-two participants took part in the experiment voluntarily after giving their formal consent. We excluded data from 11 participants because they were not native speakers of BP (1 participant), reported having participated in Experiment 1 (8 participants) or had previous knowledge of sound symbolism (2 participants). Our analyses focused on data from the remaining 81 participants (mean age = 28, SD = 6.4, 61 male).

3.4 Results

Responses were coded binarily according to whether their decision was expected or unexpected given our hypotheses. Table 5 shows the number of expected and unexpected responses by condition.

Table 5. Responses in Experiment 2

[Table 5]

We ran for each condition a mixed logistic regression with Pokémon names and participants as random factors. In condition 1, our results showed that pre-evolution Pokémon characters were preferably paired with names whose first syllable had the vowel /i/ rather than the vowel /a/ ($\beta = 0.6$, $p = 0.0004$). For condition 2, the analyses showed that the participants preferred to use longer names for post-evolution Pokémon, and shorter names for pre-evolution Pokémon ($\beta = 1.8$, $p < 0.0001$).

The results for Condition 3 showed that there was no preference toward assigning names with or without a voiced obstruent to pre or post-evolution characters, although participants responded according to our hypothesis most of the time ($\beta = 0.25$, $p = 0.08$). For Condition 4 there was a preference for assigning names with two voiced obstruents to post-evolution characters ($\beta = 0.35$, $p = 0.01$).

Finally, we ran a mixed logistic regression model in a subset of the data comprised of responses for Conditions 3 or 4. One more time, the dependent variable was a yes/no binary response reflecting whether the participant's choice was expected according to our hypothesis. The independent variable was condition (3 or 4), and Pokémon names and participants were included as random factors. A comparison with a nested model with no independent variables showed that there was no difference on the rates of expected responses in Conditions 3 and 4 ($\chi^2 = 0.25$, p = 0.6), which means that adding an extra voice obstruent did not significantly change the rate of expected responses even though it increased this rate above chance.

3.5 Discussion

Our results regarding vowel quality in the first syllable and name length further corroborate the findings of Experiment 1. Once again, there was a tendency to give shorter names to pre-evolution creatures when names differed in number of syllables. Similarly, names with an initial /i/ were assigned to pre-evolution Pokémons at a rate greater than chance, while names with an initial /a/ were associated with post-evolution characters.

Results regarding voiced obstruents are suggestive but not decisive. On one hand, the fact that there was a clear effect of sound symbolism in Condition 4, though not in Condition 3, is in line with our prediction that the effect of voiced obstruents is cumulative and can explain the mixed results we had with the within-pair and independent analyses in Experiment 1. On the other hand, model comparison showed that condition did not influence the odds of choosing the expected names, which challenges the cumulative hypothesis. One could argue that our results show that there is no cumulative effect and that the reported effects for Condition 4 are probably due to chance. However, it may also be the case that the cumulative effect is real, but its effect size is not so large that it is hard to detect. We therefore expanded our analyses with a third experiment devised to test whether the cumulative effect increases if the distance in the number of voiced obstruents within a pair of names keeps increasing.

4. Experiment 3

Experiment 3 was a forced-choice task similar to Experiment 2, but aimed at further investigating the sound symbolic effects of voiced obstruents. If the cumulative effect on sound symbolism is subtle, the steady increase in the difference on the number of voiced obstruents within a pair of names would lead to an increase in the odds of choosing names with more voiced obstruents to name post-evolution Pokémons. On the other hand, if the effect observed in Experiment 2 was due to chance, we should not expect such result.

4.1 Stimuli

Experimental stimuli consisted of three conditions that differed on how great was the difference on the number of voiced obstruents within a pair of names. Conditions 0x1 and 0x2 used the names created respectively for Conditions 3 and 4 in Experiment 2. Additionally, ten new pairs of names were created for Condition 0x3 (see Appendix B). These pairs were created using the same rules applied for the creation of names in Conditions 3 and 4 in the previous experiment; however, this time one of the names within a pair had 3 voiced obstruents, while the other name had none. As a result, participants were presented with a list of 30 experimental items, 10 in each condition.

4.2 Procedures and participants

Procedures were the same as Experiment 2. A total of 116 participants took part in the experiment voluntarily after giving their formal consent. We excluded 9 participants because they were not native speakers of BP (1 participant), reported having participated in previous experiments (5 participants) or had previous knowledge of sound symbolism (3 participants). Our analyses focused on data from the remaining 107 participants (mean age = 26.5, standard deviation = 5.5, 67 male).

4.3 Results

Participants' responses were coded binarily according to whether their response was expected or unexpected from the hypothesis (i.e. voiced obstruents = post-evolution). Table 6 shows the number of expected and unexpected responses by condition.

Table 6. Responses in Experiment 3

[Table 6]

We ran for each condition a mixed logistic regression with Pokémon names and participants as random factors. Expected responses were not chosen in a rate above chance in Condition 0x1 ($\beta = 0.2$, $p = 0.18$), but in Conditions 0x2 ($\beta = 0.38$, $p = 0.03$) and 0x3 ($\beta = 0.5$, $p < 0.0001$) participants chose the expected responses at a rate greater than chance.

Finally, we ran a mixed logistic regression to test whether condition influenced the odds of having an expected response. The dependent variable was a yes/no binary response reflecting whether the participant's choice was expected according to our previous hypothesis. The independent variable was condition, and Pokémon names and participants were included as random factors. A comparison with a nested model with no independent variables showed that condition had a significant influence on how likely it was for participants' choice to conform to our hypothesis ($\chi^2 = 15.5$, p = 0.0004). *Post hoc* analyses showed no difference between Conditions 0x1 and 0x2 ($z = 1.7$, $p = 0.07$), but a significant difference between Conditions 0x2 and 0x3 ($z = 2.1$, $p = 0.043$) and between Conditions 0x1 and 0x3 ($z = 3.9$, $p = 0.0003$). Figure 2 shows how the odds of choosing a name in agreement with our initial hypothesis changes across conditions.

Figure 2. Participants responses across conditions; the error bars represent standard errors

[Figure 2]

4.4 Discussion

The results of the third experiment replicate the findings of Experiment 2: the odds of choosing a word with voiced obstruents to name a post-evolution Pokémon can be explained by chance in Condition 1x0, but not in Condition 2x0. Despite this, there is no significant difference between these two conditions.

Results for Condition 3x0 expands this picture by showing that the odds of expected responses increase cumulatively. As shown in Figure 2, adding a voiced obstruent contributes to the increase of expected responses by about 4% to 5%. Furthermore, the addition of voiced obstruents was a significant predictor of expected responses according to our model: the greater the difference in the number of voiced obstruents within a pair of names, the greater the chance for a participant to choose the expected response. This trend would explain why the results regarding voiced obstruents in Experiment 1 seem contradictory at first. In this experiment, within-pair analyses showed there was no preference in increasing or decreasing the number of voiced obstruents as a function of evolutionary status, but a logistic regression model applied to the whole dataset found that the evolution was a reliable predictor of the number of voiced obstruents in Pokémon names. In the light of the cumulative effect reported in Experiment 3, one could argue that when there was a difference in the number of voiced obstruents between pre and post-evolution names in the free naming task, this difference would be in the magnitude of 2 or greater.

These results show that speakers of BP are sensitive to the sound symbolic association between voiced obstruents and size. Furthermore, they show that this sensitivity is not due to the mere presence/absence of voiced obstruents, but to the number of these phonemes within a pair of names. K&K also report that Japanese speakers are sensitive to the number of voiced obstruents when choosing names for Pokémon characters. In a forced choice task, they analyzed a condition in which names differed regarding the presence of a voice obstruent (similar to our 1x0 condition) and a second condition in which the contrast was the number of voiced obstruents: one of the names within a pair contained one voiced obstruent and the other contained two. Although their conditions cannot be directly compared to ours because the difference within pairs was kept constant (one name always had an extra voiced obstruent compared to the other), their results show that Japanese speakers do consider the number of voiced obstruents while choosing the best name for pre and post-evolution Pokémon.

In general, results from both languages, Japanese and BP, are ultimately in line with the prediction of the Frequency Code Hypothesis (Ohala, 1984, 1994): low frequency sounds, such as voiced obstruents, should evoke larger images. However, a contrast between these two languages indicates that there might be some cross-linguistic variability on how the manifestation of this specific sound symbolism occurs. For Japanese speakers, the mere presence of a voiced obstruent within a pair of names was enough to increase the odds of expected responses at a level above chance. For BP speakers, it takes at least two voiced obstruents in a word for it to be regarded as more likely to name a post-evolution Pokémon. Taken together, data from BP and Japanese speakers show that the latter are more sensitive to the presence of voiced obstruents.

At this point, we can only speculate as to what is the source of this difference in sensitivity. A possible explanation for this variability may rely on phoneme frequency. BP has more voiced obstruents in its inventory than Japanese, which leads to these phonemes being more frequent in this language. In fact, two independent corpora studies found that 23.6% of consonants were voiced obstruents in BP (Viaro and Guimarães-Filho, 2007), against 16.73% in Japanese (Tamaoka and Makioka, 2004)[5]. As a consequence, the presence of a single voiced obstruent in a name is "not that special", and may not trigger a sound symbolism effect as robust for a speaker of BP as it would for a Japanese speaker. However, the effect would increase as more voiced obstruents were added to the word. An alternative hypothesis is that

[5] As we mentioned, these studies are independent and differ in their methodology. The corpus for the study in Japanese was comprised of texts published in newspapers, while the study in BP used a dictionary. We use their results here to present an estimative of frequency for the voiced obstruents in these languages, but a thorough investigation of this issue would require a new and more balanced cross-linguistic corpus study.

sound symbolism of voiced obstruents, rooted in their psychoacoustics, is reinforced for Japanese speakers, because of their frequent use of onomatopoetic words, in which voiced obstruents carry a special meaning (e.g. Hamano, 1988). These hypotheses should be tested in future work that includes more studies on the sound symbolism of voiced obstruents in BP, and the study of the cumulative effect in other languages.

5. Overall conclusion

The experiments reported in this paper were devised to test whether the naming of pre- and post-evolution Pokémon creatures could be explained by sound symbolic principles related to size. Results from Experiments 1 and 2 show a clear tendency for BP speakers to give longer names to post-evolution characters. This could be explained by the iconicity of quantity principle (Haiman, 1980, 1985), which predicts that more information is conveyed by longer linguistic forms. These experiments also support the existence of sound symbolism between size and vowel height: our results show that speakers of BP associate the vowel /i/ to pre-evolution characters, and the vowel /a/ to their post-evolution pair.

Experiment 3, along with Experiments 1 and 2, provide evidence that, in BP, the odds of choosing a word to name a post-evolution Pokémon increases with the addition of more voiced obstruents. This cumulative effect remains to be tested in other languages, but it is in line with the predictions of the Frequency Code Hypothesis, which states that low frequency sounds, such as voiced obstruents, tend to be associated to largeness. However, we found no evidence that just the presence of one voiced obstruent is enough to make participants consider a name as a better suit for a post-evolution Pokémon. This differs from what was found for Japanese speakers in the previous study by K&K, and it also opens the possibility that, although there is a demonstrably universal sound symbolism associated with low frequency sounds as predicted by the Frequency Code Hypothesis, its manifestation may differ cross-linguistically.

Finally, we stress that, to the best of our knowledge, this is the first study to show experimental results on sound symbolism and size perception in BP. By mapping the sound symbolic associations available for BP speakers, we hope to encourage future research on this language that builds from our findings to investigate other aspects related to sound symbolism, especially its role on language use and language acquisition. Therefore, the findings presented in this paper can also be viewed as a groundwork that may foster future research on this topic.

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Compliance with Ethical Requirements

The authors declare that they have no conflict of interest.

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Figure 1. Sample pairs used in Experiment 1

Figure 2. Participants responses across conditions; the error bars represent standard errors

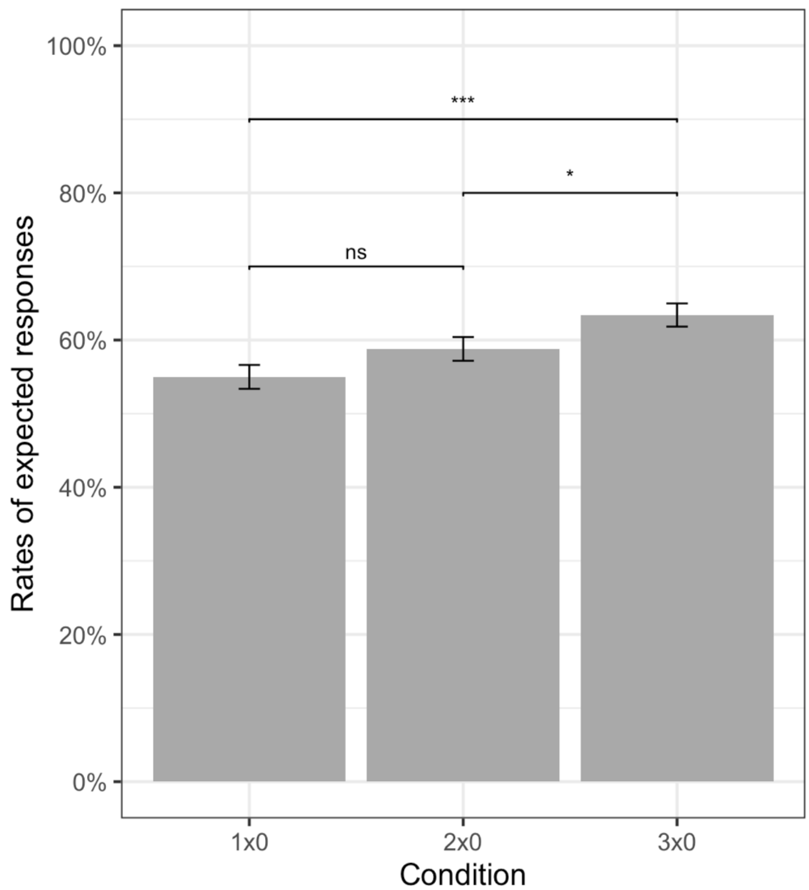

Table 1. *counts for each vowel in initial syllables*

evolutionary status	a	e	i	o	u
post	383	181	176	240	142
pre	288	181	274	214	165

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Table 2. *Example of annotated data for the within-analyses*

Pair (Examples)	Number of syllables within pair	Number of voiced obstruents within pair
Fan.tis (pre) – Fla.mi.go (post)	increase	increase
Xe.ri.po.te (pre) – Xe.ri.zau (post)	decrease	increase
Por.gi (pre) – Cu.ru.ra.qui (post)	increase	decrease
Con.fer.de (pre) – An.pe.de (post)	constant	constant

****

Table 3. *Within-pair analyses for number of voiced obstruents and number of syllables*

	Number of voiced obstruents		Number of syllables	
increase	331 (29%)	$p = 0.014$	516 (46%)	$p < 0.0001$
decrease	189 (16%)	$p < 0.0001$	98 (9%)	$p < 0.0001$
constant	601 (53%)	$p < 0.0001$	507 (45%)	$p < 0.0001$

****

Table 4. *Within-pair analyses for number of voiced obstruents and number of syllables for participants less familiar with the Pokémon universe*

	Number of voiced obstruents		Number of syllables	
increase	144 (39%)	p = 0.14	198 (41%)	p < 0.0001
decrease	85 (17.5%)	p < 0.0001	51 (10.5%)	p = 0.0002
constant	254 (52.5%)	p < 0.0001	234 (48.5%)	p < 0.0001

****

Table 5. *Responses in Experiment 2*

Condition	Expected responses	Unexpected responses
Condition 1: vowel quality	573 (63.7%)	327 (36.3%)
Condition 2: name length	754 (83.8%)	146 (16.2%)
Condition 3: voiced obstruents: 0x1[1]	500 (56.1%)	391 (43.8%)
Condition 4: voiced obstruents: 0x2	527 (58.5%)	373 (41.5%)

[1] Due to a problem in one of the lists, 9 observations for Condition 3 were lost. This corresponds to 1% of the total data for this condition.

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Table 6. *Responses in Experiment 3*

Condition	Expected responses	Unexpected responses
Condition 0x1	588 (55%)	482 (45%)
Condition 0x2	628 (58.7%)	442 (41.3%)
Condition 0x3	677 (63.3%)	393 (36.7%)