International Journal of English Linguistics; Vol. 15, No. 2; 2025
ISSN 1923-869X E-ISSN 1923-8703
Published by Canadian Center of Science and Education

Sound Symbolism in Speakers of English: A Qualitative Synthesis

Szymon Pindur[1]

[1] Doctoral School in the Humanities, Jagiellonian University in Krakow, Krakow, Poland

Correspondence: Szymon Pindur, Instytut Filologii Angielskiej, Wydział Filologiczny, Uniwersytet Jagielloński, Collegium Paderevianum, al. Adama Mickiewicza 9, 33-332 Kraków, Poland.

Received: December 19, 2024   Accepted: February 20, 2025   Online Published: March 16, 2025

doi:10.5539/ijel.v15n2p52   URL: https://doi.org/10.5539/ijel.v15n2p52

Abstract

The present article contains a systematic synthesis of behavioral studies of sound symbolism—associations of speech sounds and their features with certain semantic or perceptual features—among speakers of English. We first offer a cut-through view of the concepts and ideas relevant to the study of sound symbolism, including empirical approaches and proposed explanations of this phenomenon, and the association mechanisms that it might involve. In light of these theoretical considerations, we present the associations between phoneme features and semantic dimensions, such as size, shape, etc., identified in the systematically compiled behavioral experiments. We pay attention to the most consistent associations and attempt to derive more general tendencies while also considering the magnitude of the effects and noting the limitations of the approach. At the end of the article, a hypothetical explanation of such association patterns is proposed, stipulating that they align along the perceived complexity of the sound wave, measured in terms of its entropy.

Keywords: sound symbolism, iconicity, research synthesis, semantic features, psycholinguistics, entropy

1. Introduction

Sound symbolism, sometimes referred to as phonetic/phonological iconicity (see, e.g., Akita, 2013), holds that certain speech sounds or their features are, to some extent, inherently associated with different elements of meaning or aspects of human perceptual experience. The simplest correspondences include front (back) vowels and small (large) size—the *mil/mal* effect (Sapir, 1929), obstruent (sonorant) consonants and sharp (round) shape—the *maluma/takete* effect (Köhler, 1929; Ramachandran & Hubbard, 2011; Ćwiek et al., 2021). The article aims to systematically survey such correspondences reported in behavioral studies with speakers of English to offer a more thorough view of sound symbolism in that language and hypothesize on its possible underpinnings.

Sound symbolism has been traditionally viewed as opposing Saussure's theory of the arbitrariness of linguistic sign (1966/1916, pp. 67–68), with the latter proposing that the individual phonemes that make up words are merely contrastive units used for distinguishing between them, that the form of words is established by convention and that it has no direct bearing on the words' semantics. This opposition is traced back to the ancient φύσει (physei) versus θέσει (thesei) debate on whether or not the sign has a natural link to its meaning (Plato, 1961; Robins, 2013, p. 23).

The resurgence of the debate has drawn more scholarly attention toward the most basic mechanism that language is predicated on, i.e., the symbolic activity itself involving as in the original meaning of the Greek συμβάλλω (symballo)—'bringing together' (cf. Liddell & Scott, 1996), in this case, form and meaning. The arbitrariness theory, offering a simplistic explanation for this mechanism and widely accepted in structuralism, has thus arguably weakened the drive for scrutinizing the relationship of form and meaning in language during that period in linguistics.

However, especially since the rise of cognitivism, there has been an increasing tendency to question arbitrariness and inquire into the links between the form and meaning of words, with different patterns identified through a variety of methods, mostly psycholinguistic experiments.

These attempts have led to a more nuanced view of the sound-meaning relation in language, with the recent integrative approaches acknowledging the facilitative role of both arbitrariness/conventionality and naturalness (non-arbitrary form meaning links) with the former maximizing the distinctiveness of semantically close words and the latter facilitating word learning (cf. Lockwood & Dingemanse, 2015; Dingemanse, Blasi, Lupyan, Christiansen, & Monaghan, 2015).

A vital issue considered in research on sound symbolism is its universality as a feature of language (for a detailed exploration, see Hunter-Smith, 2007). Evidence for non-arbitrary phonosemantic biases in languages across the world, as well as the presence of ideophonic or mimetic words, suggests its importance as a design feature of language alongside arbitrariness, as discussed above (cf. Dingemanse, Schuerman, Reinisch, Tufvesson, & Mitterer, 2016; Saji, Akita, Kantartzis, Kita, & Imai, 2019). Apart from that, a number of studies have addressed the cross-linguistic or even universal nature of specific sound symbolic phenomena. The most often cited cross-linguistic tendencies (cf. Hinton, Nichols, & Ohala, 1994, pp. 8–9 as quoted in Aboul-Enein, 2014, p. 12) include the use of reduplication to achieve an iconic effect (as in ding-dong), the presence of uncommon forms (sometimes defying the phonotactics of the given language, as in 'wild' onomatopoeic words), and the above-mentioned phonosemantic biases—associations of certain phoneme classes with specific semantic fields, e.g., the size sound symbolism as seen in the *mil/mal* effect and the corresponding Frequency Code Hypothesis discussed in section 3 (Ohala, 1983).

Sound symbolism can also be relevant in the context of studying language origin. It is present in the traditional 'bow-wow' and oral gesture theories, with either the form of the sounds or the articulatory movements resembling specific referents (Müller, 1996/1861). It is also echoed in Ramachandran and Hubbard's conjecture on the emergence of the protolanguage being buttressed by non-arbitrary synesthetic links between the cortical representations of articulatory movements, speech sounds, and visual features of objects (2001, p. 20).

2. Approaches to Sound Symbolism

Sound symbolism has been addressed from various research perspectives, which are briefly described here. More detailed treatment of various strands of modern sound symbolism and iconicity research are in Dingemanse, Perlman and Perniss (2020), Lockwood and Dingemanse (2015), Perniss, Thompson and Vigliocco (2010), Svantesson (2017), Kawahara (2021), Schmidtke, Conrad and Jacobs (2014), Sidhu and Pexman (2018), and a comprehensive review of the historical approaches in Magnus (2001). Extensive bibliographies of sound symbolism research can be found in Magnus (1997) and Akita (2010a, 2010b).

Given the relevance of the linguistic form in artistic and religious uses of language, the relationship between sound and meaning has received considerable attention in poetics and literary studies, see, e.g., Fónagy (1961), Genette (1995), Jakobson (1971/1966 and 1981), Tsur (1992), and Waugh (1980), as well as research on sacred texts (see, e.g., Aboul-Enein, 2014). Such qualitative and theoretical works have significantly contributed to the modern understanding of sound symbolism and shown its applicability.

The interdisciplinary tendencies in linguistics, particularly the insights and methods drawn from behavioral psychology, neuroscience, and computer science, have broadened the scope of modern sound symbolism research and enhanced its descriptive and explanatory potential. The tradition of qualitative studies of sound symbolism, e.g., Jakobson (1971/1966), Firth (1964/1930, pp. 180–194), and Bolinger (1949), has been complemented by a wealth of quantitative and experimental work encompassing behavioral studies with human participants involving lexical decision tasks or rating scales. Such studies test associations between specific features of sound and meaning (e.g., Sidhu, Vigliocco, & Pexman., 2022) or obtain direct ratings of word iconicity (e.g., Winter, Lupyan, Perry, Dingemanse, & Perlman, 2023). The former kind will be the focus of the present synthesis.

Other approaches involve neurocognitive studies utilizing neuroimaging techniques to identify brain regions relevant for the processing of sound symbolism (see, e.g., Kitada et al., 2021) or developmental studies with preverbal and early-verbal children, examining from which point in the development sound symbolism associations are made, whether they are learned or more deeply ingrained, and what role they play in language acquisition (e.g., Imai, 2008, 2015; Imai & Kita, 2014).

There are also computational/statistical studies analyzing the systematicity of sound-to-meaning mappings (e.g., Monaghan, Shillcock, Christiansen, & Kirby, 2014, or Gutiérrez, Levy, & Bergen, 2016) or associations between specific features (e.g., Thompson, Van Hoey, & Do, 2019) and cross-linguistic studies examining the biases in associating sound and meaning across the vocabulary of different languages and language families (e.g., Blasi, Wichmann, Hammarström, Stadler, & Christiansen, 2016; Erben Johansson, Anikin, Carling, & Holmer, 2020). Such studies are usually based on a presupposition that cross-linguistic phonosemantic systematicity can largely predict non-arbitrary associations.

The growth of sound symbolism research has also brought about several meta-analyses to date. These include Fort et al. (2018), comparing the effects of the *kiki/bouba* contrast in children by analyzing data from 425 participants across 11 experiments and finding a moderate sound symbolism effect, as well as Styles and Gawne (2017) analyzing data from 13 experiments in different languages and indicating high replicability of the effect granted that the stimuli include the standard phoneme contrasts, i.e., /b, m, l, u, o/ vs. /t, k, i, e/.

Apart from meta-analyses in the strict sense, there have also been several systematic reviews of such research done, including Kawahara (2021), examining the reported associations between vowel and consonant features with several perceptual/semantic features and proposing acoustic and articulatory explanations for each of them. Another one was Lockwood and Dingemanse (2015), analyzing associations of articulatory features of vowels and semantic dimensions such as precision, brightness, size, shape, speed, etc, collected from several studies.

3. Mechanisms of Associating Sound and Meaning

Whereas many studies identify specific phonosemantic associations, there are fewer attempts to explain them systematically. Among these is the so-called Frequency Code Hypothesis (Ohala, 1983, 1984, 1994; Kawahara, 2021, p. 7), which explains size-related sound symbolism, stating that lower frequency sounds are associated with larger objects due to lower frequency waves resonating in longer resonators, and thus, e.g., individuals with longer vocal tracts speaking at lower pitches than those with shorter vocal tracts. This association is mapped onto object size, as in the *mil/mal* effect mentioned in section 1, due to close vowels having higher F0 frequency than open vowels (Ohala & Eukel, 1987, p. 207, as in Sidhu & Pexman, 2018). Given its prevalence (see, e.g., Shinohara & Kawahara, 2010), the Frequency Code can be considered a cross-linguistic tendency largely independent of the specific linguistic system—though not without variation (cf. Winter et al., 2021; Calhoun, Warren, Mills, & Agnew, 2024).

As Sidhu and Pexman (2018) observe in their comprehensive review of sound symbolic association mechanisms, this mapping likely arises from the co-occurrence of such sounds and creature sizes in nature. However, according to Ohala (1994, p. 339, quoted ibid.), it might have become an evolutionary adaptation due to, e.g., male voices becoming lower at puberty, when they need to 'sound bigger' in competing for a mate against other males.

Another such pattern (as in Sidhu & Pexman, ibid.—in a different order) likely rooted in both co-occurrence and adaptation mechanisms are harsh sounds associated with threat and smooth sounds with contentment. It is visible in harsh vs. smooth sounds made by animals and patterns of voicing in humans when stressed vs. relaxed. An extension of this theory sees obstruent sounds as more 'threatening' and sonorants as more 'content' (Nielsen & Rendall, 2011), illustrated, e.g., by the prevalence of obstruents in curse words (Van Lancker & Cummings, 1999).

Another mechanism lies in neural activation patterns whereby the stimulus intensity (e.g., high intensity for high-volume sounds and bright light) results in similar firing rates in neurons, thus making a neural-based association between such pairs of stimuli (Stevens, 1957, cf. Sidhu & Pexman, 2018).

Yet another mechanism refers to systematic patterns in the lexicon of a given language, which either stem from or secondarily influence specific non-arbitrary associations in its speakers. This is related to Firth's idea of phonetic habits (1964/1930, p. 180), stating that the associations between speech sounds and their sequences (even submorphemic ones such as the negatively connoting 'sl' in 'slack,' 'sludge,' 'slime,' 'slink,' 'slip,' etc.) and elements of meaning are instinctively learned by language users and that they form phonaesthetic patterns characteristic of a given language.

The mechanism most relevant for the present synthesis includes sounds and meanings sharing the same experiential features, either perceptual or conceptual, as discussed by Sidhu and Pexman (2018). This is because it allows one to more precisely categorize and analyze the relationships between form and meaning. It is based on the observation that speech sounds are experienced (at least to some extent) in a fashion similar to other kinds of external stimuli. It expands the structuralist view of phonemes as mere building blocks for distinguishing between words and morphemes, adding the layer of experiencing speech sounds in terms of features other than those relevant to their phonemic differentiation.

The dimensions relevant to experiencing speech sounds stem from human auditory mechanisms and include amplitude (loudness), frequency (pitch), and periodicity (air pressure regularity)—relevant for distinguishing sound categories, such as tones (crucial elements of vowels and sonorants like /m/ or /w/) and aperiodic noises (prominent in obstruents like /t/ or /f/). Furthermore, as time-series phenomena, sounds also vary in length and modulation (changes in frequency and amplitude) as they also involve the temporal dimension.

Thus, the tentative basic experiential features relevant to sound include *long, short*, *high*, *low*, *quiet*, *loud*, *abrupt, intermittent, continuous, tonal* (as in 'with a recognizable tone'), and *modulating*. These, in turn, can either be directly present in other sensory modalities, for example, the temporal features of *short* and *long*, or map onto other perceptual features. For instance, *high* and *low* features referring to frequency can be experienced to some extent in the haptic modality (e.g., in vibrations). The same goes for *abrupt*, *continuous*, and *intermittent*. In addition, these features (along with *short* and *long*) may also be present in the visual perception of movement. If, for example, a voiceless stop /k/ is experienced as shorter than a sonorant /l/, that experience may be mapped onto the visual experience of short (or quick) movement.

Such mappings can also be made using more conceptual features through metaphorical extensions. For instance, the abruptness of a plosive sound might be metaphorically linked to sudden or forceful actions and thus, the concept of aggressiveness or activity. Besides, as further elaborated by Sidhu et al. (2022), the basic experiential features can be generalized into higher-order ones, as first shown in factor analyses by Osgood, Suci, & Tannenbaum (1957), revealing dimensions such as valence (good-bad), potency (ability to effect change), and activity (energetic potential). Subsequent research identified other factors like familiarity, complexity, and reality. (Bentler & LaVoie, 1972; Malhotra, 1981; Trofimova, 2014; as in Sidhu et al., 2022).

Higher-order features derivable from the lower-order ones allow for explaining an even bigger proportion of sound symbolic associations since the more abstract features are not bound to a specific sensory modality but are based on similar patterns and analogies in processing different kinds of stimuli. Thus, for example, the more pleasant sounds could be associated with the visual or tactile experience of pleasantness via the shared feature of positive valence, though more research should be done to test that particular association.

There is no definite list of such features (whether perceptual, conceptual, or higher-order), as their isolation is largely dependent on the chosen level of analysis and categorization of the human experience of the world. Also, many of these features can be seen as forming continuous dimensions, chiefly bipolar ones, such as the *small-big*, *hot-cold*, or *good-bad*.

In this vein, in section 4, we present synthesized results of our review of behavioral studies of sound symbolism in English speakers, reporting associations between dimensions of meaning and features of speech sounds. By doing this, we attempt to extract some general patterns that could inform future advances in the description and explanation of sound symbolism in a more systematic way, building on the discussed association mechanisms.

4. Synthesis of Behavioral Studies of Sound Symbolism in English

4.1 Scope and Purpose of the Synthesis

As suggested in the title, the present synthesis is not to be viewed as a classical quantitative meta-analysis of the research data. It is rather an attempt to offer the widest possible summary of the reported sound-meaning associations present in speakers of the English language, to see which of these appear the most stable and well-documented, and to tentatively discuss the magnitude of the reported effects. The details and caveats of effect size calculation in such a heterogeneous set of data are presented in section 4.5. Such a format of analysis is due to the wide range of experimental designs and statistical methods used in the studies, as well as diverse reporting practices. The psycholinguistic studies of sound symbolism employ many kinds of tasks, response collection methods, and data analysis methods, which pose difficulties in comparing effect sizes across studies.

For our synthesis, we have collected sound symbolic associations reported in different behavioral studies done specifically with English native speakers as participants. The choice to concentrate on the English language was motivated by several pragmatic reasons. The first one was the desire to offer a coherent outlook on one language since, as noted above, every language can have its own sound symbolic patterns. Furthermore, the number of behavioral studies done on English in this respect is larger compared to other languages, making an attempt at a general synthesis particularly applicable here. By solely focusing on behavioral studies of sound symbolism in English, the present work aims to offer a coherent breakdown of the phonosemantic associations in that language and avoid the risk of only partially accounting for analogous effects in languages inaccessible to the author. A detailed analysis of the latter would require expertise and familiarity with the literature on those languages often published in their native sources. Furthermore, introducing multiple languages into the already highly heterogeneous dataset would create another source of variability, resulting in greater noise in the emergent patterns.

4.2 Data Selection Criteria

Given the purposes of our synthesis outlined above, our criteria for selecting the studies were the following:

1) The study had to expressly address the topic of sound symbolism or form-meaning associations between words/speech sounds in a visually or auditorily presented form and clearly defined semantic/perceptual categories based on contrasted stimuli or anchor words/category labels.

2) The study had to include native to near-native English-speaking participants and report their number.

3) The study had to rigorously collect participants' response data in clearly defined experimental conditions.

4) a) The study had to report statistically significant phonosemantic associations identified through a transparently described statistical method.

b) The study had to provide the results and/or raw data enabling the calculation of standardized effect sizes.

The criteria intentionally retain some vagueness, such as "clearly defined experimental conditions," to include a broad range of studies on sound symbolism and explore their insights across diverse methods. Since there is no standardized framework for studying sound symbolism, addressing methodological heterogeneity can be viewed as natural in this field.

We compiled a comprehensive array of semantic and perceptual dimensions studied in the experiments, including experiential features, personality traits (e.g., conscientiousness, agreeableness), axiological dimensions (e.g., ethicality, beauty), higher-order features (e.g., activity, valence), and specific features like bitterness or color contrasts (e.g., blue/yellow). This variety highlights the diverse experimental interests in sound symbolism and the multifaceted ways form aligns with meaning, as reflected in the patterns discussed in section 4.6.6.

A slight exception was made for the category of *sharp-round* since studies addressing it often employ the *kiki-bouba* paradigm (sharp vs. rounded visual shapes associated with front vs. back vowels and voiceless vs. voiced consonants), which is by far the most studied and well-documented dimension of sound symbolism. The *kiki-bouba* effect is relatively stable and predictable, cf. Ćwiek et al. (2021) has already been the subject of meta-analyses (see Fort et al., 2018; Styles & Gawne, 2017—as in section 3). Furthermore, in addition to the *mil/mal* phenomenon, this effect is another candidate for a quasi-universal tendency, given its robustness across languages and cultures (cf. Ramachandran & Hubbard, 2001; Bremner et al., 2013). Thus, five studies utilizing the *kiki/bouba* paradigm in English have been included to represent this strand of research, along with six other studies addressing the dimension of *sharp-round* with other methods. More studies of this kind could be sought; however, given the replicability of the effect, including them would mostly confirm the overall recurring pattern—see section 4.6.2. For this reason, we decided not to overemphasize this effect further and pay due attention to the less-studied associations.

4.3 The Dataset

The criteria (except 4.b pertaining to effect size assessment) resulted in compiling 43 studies spanning 25 articles, further narrowed down to 32 studies (20 articles) in which the effect sizes were available or possible to calculate. The studies are presented along with their basic design features in Table 1.

Table 1. Behavioral studies of sound symbolism in English with experimental design features, data analysis methods, and no. of reported (significant) associations

No.	Short citation & study no.	N	Stimuli	Task	Statistical method	Reported stats	Reported associations
1	Kawahara & Moore, 2018 (1)	48	pseudowords/Pokémon images	2AFC	paired t	t, N	6
2	Kawahara & Moore, 2018 (2)	48	pseudowords/Pokémon images	2AFC	paired t	t, N	2
3	Kawahara & Shinohara, 2015	84	pseudowords/personality traits	2AFC	Wilcoxon	d', N	2
4	Klink & Wu, 2017	107	pseudowords/semantic feature labels	2AFC	binomial z	outcome proportions, N	4
5	Klink, 2000 (1)	265	pseudowords/semantic feature labels	2AFC	binomial z	outcome proportions, N	50
6	Klink, 2000 (2)	85	pseudowords/semantic feature labels	1-end scales	1-way between subj. ANOVA	group means, SDs	10
7	Klink, 2003	134	pseudowords/abstract images	2AFC	binomial z	outcome proportions, N	10
8	Maglio et al., 2014 (1)	187	pseudowords/imaginary city maps	city map division	independent t	Cohen's d, N	2
9	Maglio et al., 2014 (2)	100	pseudowords/action names	action classification	2-way between subj. ANOVA	group means, SDs, N	2
10	Maglio et al., 2014 (3)	62	pseudowords/product features	product evaluation	2-way between subj. ANOVA	group means, SDs, N	2
11	Maglio et al., 2014 (4)	66	pseudowords/product features	product evaluation	2-way between subj. ANOVA	group means, SDs, N	2
12	Maglio et al., 2014 (5)	100	pseudowords/product features	product evaluation	independent t	Cohen's d, N	1
13	Maurer, Pathman, & Mondloch, 2006	20	pseudowords/shape images	2AFC	paired t	t, N	2

14	McCormick et al., 2015 (1)	34	pseudowords/semantic feature labels	2AFC	paired t; 2-way within subj. ANOVA	t, N; partial eta squared	8
15	McCormick et al., 2015 (2)	16	pseudowords/semantic feature labels	1-end scales	1-way within subj. ANOVA; paired t	eta squared; means, SDs, N	5
16	McCormick et al., 2015 (3)	15	pseudowords/semantic feature labels	1-end scales	1-way within subj. ANOVA; paired t	eta squared; means, SDs, N	3
17	Monaghan & Fletcher, 2019	92	pseudowords/semantic feature labels	1-end scales	mixed effects models	means differences, model coefficients (binary predictors), N	10
18	Nielsen & Rendall, 2011 (1)	24	pseudowords/shape images	2AFC	paired t	t, N	2
19	Nielsen & Rendall, 2011 (2)	88	pseudowords/shape images	2AFC	paired t	t, N	2
20	Nielsen & Rendall, 2012	48	pseudowords/shape images	2AFC	independent t	t, N	2
21	Nielsen & Rendall, 2013	22	shape images	pseudoword construction	binomial z	outcome proportions, N	2
22	Preziosi & Coane, 2017 (1)	350	pseudowords/semantic feature labels	2-end scales	multiple regression	t, N	2
23	Sidhu et al., 2019 (1)	60	first names/personality traits	2AFC	Bayesian mixed effects models	model coefficients (log odds ratio), N	6
24	Sidhu et al., 2019 (2)	60	first names/personality traits	1-end scales	Bayesian mixed effects models	model coefficients (log odds ratio), N	6
25	Sidhu et al., 2019 (3)	60	first names/personality traits	1-end scales	Bayesian mixed effects models	model coefficients (log odds ratio), N	10
26	Sidhu et al., 2022	85	pseudowords/semantic feature labels	2-end scales	mixed effects models	emmeans difference, model coefficients (binary predictors)	78
27	Simner, Cuskley, & Kirby, 2010	65	tastes	vowel quality adjustment	2-way within subj. ANOVA; paired t	F, N; t, N	6
28	Thompson & Estes, 2011 (1)	47	pseudowords/real images	label selection task	2-way within subj. ANOVA	partial eta squared	4
29	Thompson & Estes, 2011 (2)	19	pseudowords/real images	label selection task	2-way within subj. ANOVA	partial eta squared	4
30	Westbury, Hollis, Sidhu, & Pexman, 2018	214	pseudowords/semantic category labels	yes/no decision	binomial regression models	model coefficients (log odds ratio)	33
31	Wu, Klink, & Guo, 2013 (1)	97	pseudowords/semantic feature labels	2AFC	paired t	t, N	2
32	Wu, Klink, & Guo, 2013 (2)	182	pseudowords/brand preference	2AFC	1-way between subj. ANOVA	F, N	2

All studies were conducted after 2000, with over half (18) in the last decade involving 2884 participants. Most were native English speakers, with about 150 near-native participants, though exact numbers were unclear due to inconsistent reporting. Participant numbers varied widely (m = 90.1, SD = 74.8), influenced by experiment length, responses per participant, and collection methods (in-person vs. online). For instance, McCormick et al. (2015) gathered ratings from 15 participants for 570 pseudowords, while Preziosi and Coane (2017) collected 10 ratings from 350 participants online. Of the 32 studies, 25 were conducted in person, five online, and two used both methods.

Pseudowords were used as stimuli in 27 studies, assessed via scales, matching tasks, label selection, or yes/no decision tasks. Exceptions included Nielsen and Rendall (2013), who had participants invent pseudowords based on shape stimuli, and Simner et al. (2010), adjusting vowel quality using sliders with tastes as stimuli. Sidhu et al. (2019) used real names to assess personality traits. Some studies employed more unique tasks, e.g., dividing a city map (Maglio et al., 2014).

It should be noted that most studies (24) presented the linguistic stimuli in an orthographic form, while 7 presented them aurally, and one (Westbury et al., 2018) employed both methods. Using orthographic stimuli and extrapolating the results onto the features of the corresponding speech sounds might raise concerns, as it allows for possible differences in the participants' reading of the words. Nevertheless, the studies using this approach took measures to mitigate this effect by tailoring their pseudowords' orthography to unambiguously correspond to a specific reading along the rules of English pronunciation.

A total of 282 significant ($p < 0.05$) associations were reported, linking 34 phoneme features with 45 semantic dimensions (repeated across studies). In the analysis, the dimensions are presented as bipolar by pairing the features accordingly, e.g., *small-big,* etc. This is due to the fact that in most studies, these features were treated as such, while in others, the poles were studied separately (allowing for correlations in the same direction, thus accounting for the possible orthogonality in the given feature pairing—see, e.g., Westbury et al., 2018), yet often (but not always—see example below) yielded complementary results. In the case of the former, we reported the associations as bidirectional, while in the case of the latter, only the associations with the given pole were reported.

The naming conventions were only unified for unambiguously synonymous semantic and phonological categories, e.g., ‘large’ and ‘big,’ were classified as the same dimension. Terms such as open vowels and high vowels, etc, were also unified. The detailed spreadsheet containing all the collected data is available in the online supplementary materials in an OSF repository: https://osf.io/pnm5a/.

The largest studies—Sidhu et al. (2022), Klink (2000), and Westbury et al. (2018)—reported 78, 50, and 33 associations, respectively. Most studies reported two associations (14 studies). The statistical methods employed in the studies reflected the diversity of experimental designs and tasks, likewise varying in simplicity and, thus, in the precision of modeling the patterns in the data. Simpler methods, such as paired and independent t-tests as well as binomial z-tests, were the most frequently used (10, 3, and 4 instances, respectively), particularly in two-alternative forced-choice (2AFC) tasks. More complex designs often used ANOVAs (13 instances), while several newer studies (5) utilized mixed effects models.

4.4 Effect Size Calculation Methods

For the present comparison, we chose Cohen’s *d* and its further conversion into Hedges’ *g*—applying a correction since *d* tends to be upwardly biased for small samples (see Borenstein et al., 2021, p. 27). This measure expresses the difference of means in terms of standard deviation in the given distribution, which is a common standardization method to enable cross-study comparison.

For each recorded association, Cohen’s *d* was first calculated or recorded from the available data using methods recommended in the literature and converted into Hedges’ *g* using the standard approximation from Borenstein et al. (*ibid.*) and Borenstein and Hedges (2019, p. 213) utilizing the degrees of freedom (*df*):

$$g^* = d \times \left(1 - \frac{3}{4(df)-1}\right) \tag{1}$$

This correction eliminates most of the bias in *d* for smaller samples (the asterisk denotes that it is an approximation of *g*). The formulae used for calculating *d* given the reported data from each statistical method are recorded in Table 2, along with their sources.

Table 2. Cohen's *d* calculation methods

Statistical method: reported stats	Cohen's *d* formula
1-way within subjects ANOVA: eta squared	$d = \sqrt{\frac{4\eta^2}{(1-\eta^2)}}$ Brysbaert et al. (2018: 2)
1-way between subjects ANOVA (equal groups): F, N	$d = 2\sqrt{\frac{F}{N}}$ Lipsey and Wilson (2000: 174)
2-way within subjects ANOVA: partial eta squared	$d = \sqrt{\frac{(N-1)}{N} \times \frac{\eta^2_{partial}}{(1-\eta^2_{partial})}}$ Jin (2024)
between subjects ANOVA: group means, SDs	$d = \frac{m_1 - m_2}{SD_{pooled}}$ where: $SD_{pooled} = \sqrt{\frac{(n_1-1)S_1^2 + (n_2-1)S_2^2}{n_1+n_2-2}}$ Borenstein and Hedges (2019: 212)
Binomial regression models: model coefficients (log odds ratio)	$d = \ln(OR) \times \frac{\sqrt{3}}{\pi}$ Sanchez-Meca et al. (2003)
Linear mixed effects models (binary predictors): model coefficient (*β*), residual SD	$d = \frac{\beta_x}{\sigma_{residual}}$ Hedges (2007) as in Erosheva et al. (2020)
Linear mixed effects models (multilevel predictors): estimated marginal means (EMMs) difference, residual SD	$d = \frac{EMM\ difference}{\sigma_{residual}}$ Lenth (2024)
binomial z-test: outcome proportions, N	$Cohen's\ h = 2\ arcsin\sqrt{p_1} - 2\ arcsin\sqrt{p_2}$ Cohen (1988)
independent t-test: t, N	$d = \frac{2t}{\sqrt{df}}$ Rosenthal (1994), Howell (2013)
paired t-test, within subjects ANOVA: means, SDs	$d = \frac{m_1 - m_2}{SD_{pooled}}$ where: $SD_{pooled} = \sqrt{\frac{S_1^2 + S_2^2}{2}}$ Borenstein and Hedges (2019: 214)
paired t-test: t, N	$d = \frac{t}{\sqrt{N}}$ Lenth (2006)

As can be seen, sometimes different sets of statistics were used to calculate the *d* for the same statistical method (in the case of ANOVA and t-tests), as some studies using them did not include the more detailed data, only reporting, e.g., the t or F along with N, either omitting the means and group SD's altogether or only reporting the former. Whenever possible, the data yielding arguably more accurate results was used (i.e., the means and SDs).

Two studies utilizing mixed effects models (Sidhu et al., 2022; Monaghan & Fletcher, 2019) made all of their raw data and code available online. In those cases, the statistics were recomputed, and the model coefficients and estimated marginal means differences (for non-binary effects) were standardized with the estimated model sigma.

In the case of binomial z-tests based on sample proportions, a related measure of Cohen's *h*—with the same interpretation as *d* was used (see Cohen, 1988).

4.5 Caveats and Limitations of Calculating and Interpreting Effect Sizes

Given the diversity of the studies, several important caveats must be considered when calculating and interpreting effect sizes. Firstly, the wide range of experimental paradigms, including 2AFC tasks, Likert-type rating scales, yes/no decision tasks, etc., while reflecting the multifaceted nature of sound symbolism research, can also influence the effect sizes. For instance, 2AFC tasks may exaggerate dichotomous associations, leading to larger effect sizes compared to tasks allowing more nuanced responses, e.g., Likert scales.

Furthermore, different stimuli contrasts, e.g., more general features, such as fricatives vs. stops, or finer-grained distinctions, e.g., adding the voicing variable, c.f. Sidhu et al. (2022), introduced a degree of relativity into the collected associations and their effect sizes—accounted for in our reporting by indicating the relevant contrasts for the given association.

Likewise, the sample sizes vary widely across studies, from as few as 15 participants to over 300. Small sample sizes may inflate effect sizes due to greater susceptibility to sampling error. This bias is addressed to some extent by correcting for small samples using Hedges' *g,* which relies on the degrees of freedom and is thus sensitive to sample size.

Finally, the different statistical methods used also complicate the comparison of effect sizes. For example, a Cohen's *d* calculated from a paired t-test may not be directly comparable to a partial eta-squared derived from a within-subjects ANOVA or a log odds ratio from a mixed-effects regression model, which have to be converted into Cohen's *d* using a specific approach. Besides, the conversion methods may also be subject to a certain degree of error due to their reliance on approximation and estimation.

Given these caveats, the present synthesis is to be viewed primarily as an attempt at cataloging the sound symbolic associations in the literature to see how different features align with each other and only secondarily considering the magnitude and stability of such patterns.

4.6 The Associations

4.6.1 General Makeup and Interpretation Criteria

The study count of each sound symbolic association reported in the studies is presented in Figure 1.

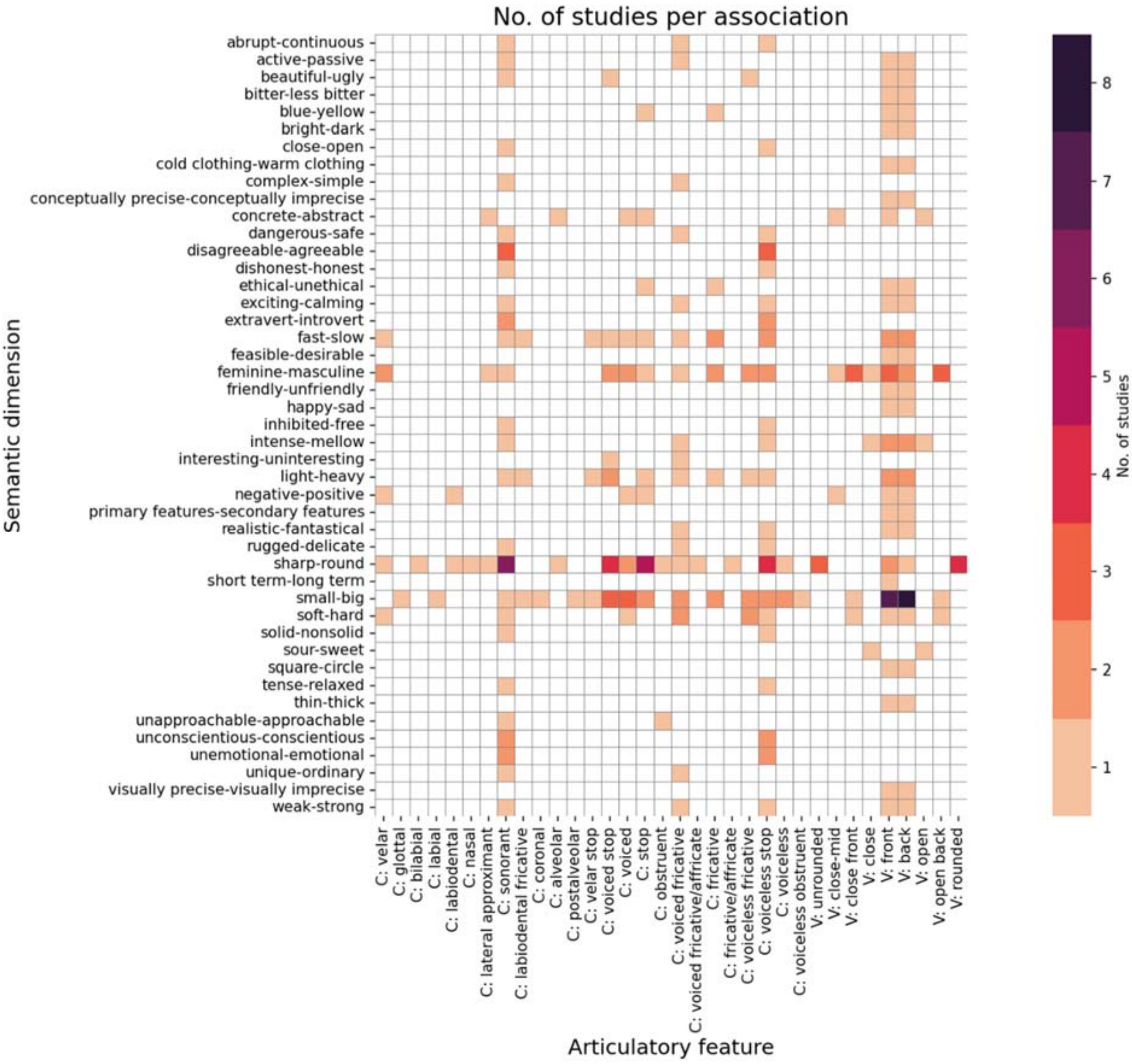

Figure 1. Heatmap of study counts reporting each sound symbolic association. An interactive HTML version of the graph with specific studies and effects displayed upon hovering on the grid is available in an Open Science Framework repository here: https://osf.io/thf68

In addition to shape, the most often reported associations involved the size dimension (*big-small*)—11 studies, followed by gender (*feminine-masculine*)—7 studies. Speed (*fast* vs. *slow*) and hardness (*hard* vs. *soft*) were reported in 4 studies each, while weight (*heavy* vs. *light*), intensity (*intense* vs. *weak*), and agreeableness (*disagreeable* vs *agreeable*) in 3. Five other dimensions (*beautiful-ugly*, *extravert-introvert*, *unconscientious-conscientious*, *unemotional-emotional*, and *weak-strong*) had associations in 2 studies each, while the remaining 32 dimensions had associations in only one study each. The spreadsheets with the analyzed data are in the OSF repository.

Apart from documenting the reported associations, some general attention is paid to the effect sizes—presented in Figure 2 with colors reflecting the direction of the association and interpreted magnitude of the effect (either large, medium, small, or negligible). As Hedges' *g* in each dimension follows skewed distributions, the interpretations utilize the median instead of the mean. In most cases, they are positively skewed (with most values being lower), so the median led to a more conservative interpretation of effect size.

The guidelines for interpretation were as follows: median values of *g* below 0.1 were categorized as a negligible effect; those around 0.2, i.e., within 0.1–0.4 as a small effect; those closer to 0.5, i.e., between 0.4–0.6 as a medium effect, and those closer to 0.8, i.e., anywhere above 0.6 as a large one. This is an approximation of the approach suggested by Cohen (1988), i.e., small effect (*d* = 0.2), medium (*d* = 0.5), and large (*d* = 0.8), based on arbitrary values. These, however, are only meant to facilitate a general assessment of how big a given difference tends to be.

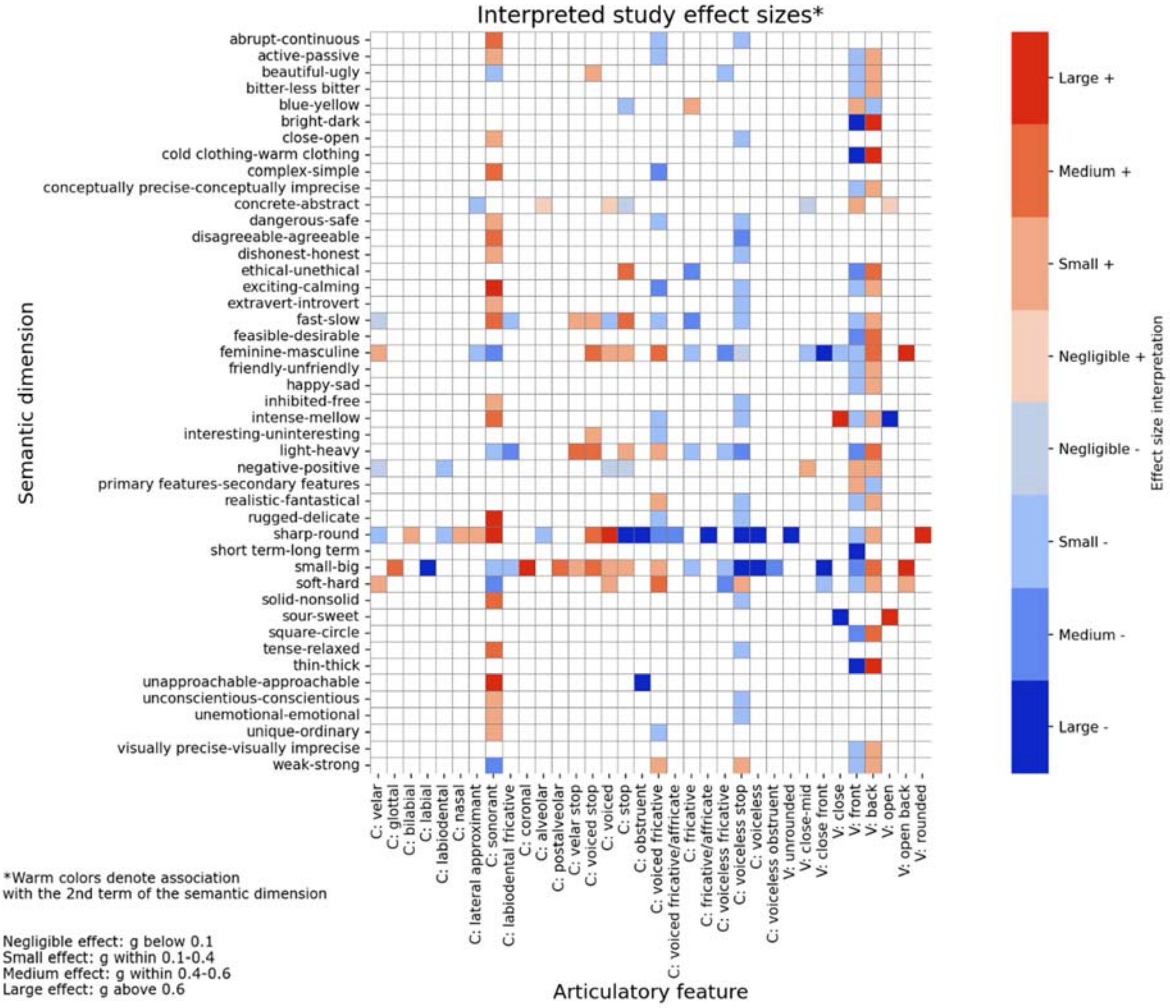

Figure 2. Heatmap of associations of semantic dimensions and phoneme features reported in all studies with colors reflecting the direction and magnitude of each effect—interactive version available here https://osf.io/urpwq.

In the five most frequently reported dimensions, the largest median absolute effect size was in shape (*sharp-round*), with med(*g*) = 0.7, followed by middling values in size (*small-big*) and gender (*feminine-masculine*) equal to 0.46 and 0.44, and smaller values in the remaining two dimensions of speed (*fast-slow*) and hardness (*soft-hard*): 0.36 and 0.35 respectively. This incidentally aligns with the number of studies reporting these effects.

4.6.2 Shape Associations

When it comes to the shape feature (Figure 3), in vowels, the studies reported associations of *round* with rounded (4, med(*g*) = 0.9) and back (1) vowels, while those of *sharp* with unrounded (3, med(*g*) = –0.92) and front (2) vowels. Those associations are consistent with the *kiki-bouba* effect (see, e.g., section 4.2).

The largest effects in vowels (g = 1.21 for rounded vs unrounded) come from Maurer et al.’s 2006 study, which, however, might be linked to their smaller sample size (N = 20) and the use of a 2AFC task. The latter was also the case in McCormick et al. (2015), with a *g* = 0.92.

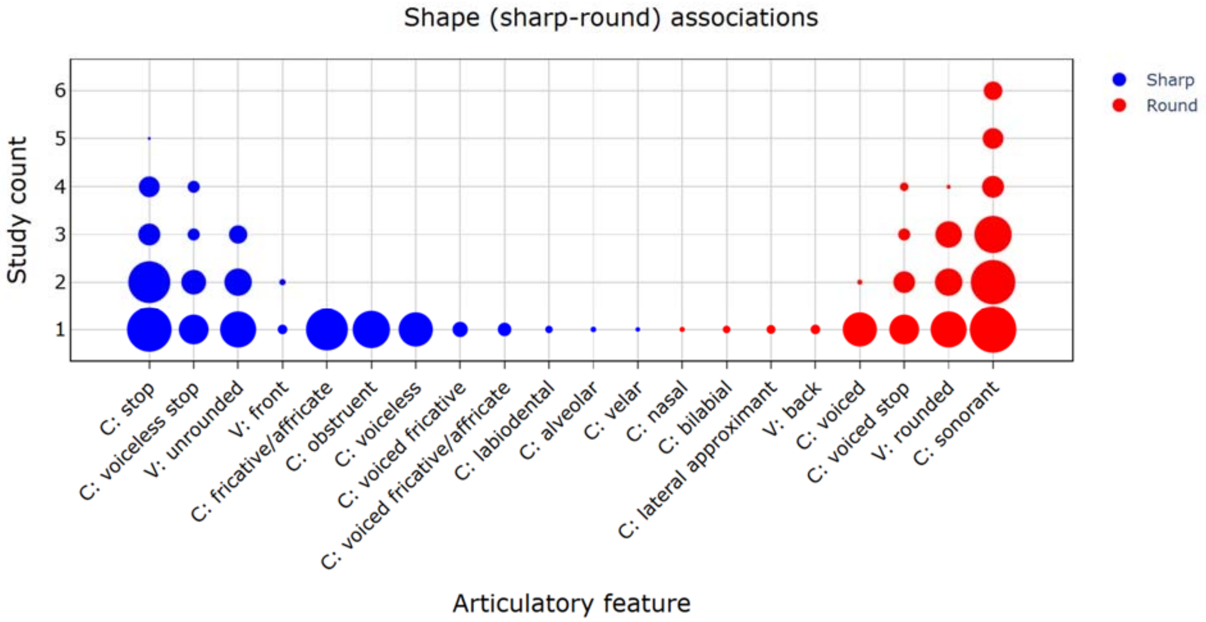

Figure 3. Individual studies reporting associations of the semantic dimension of shape (*sharp-round*) with dots scaled by effect size (Hedges' *g*). An interactive HTML version with dots displaying study names and effect sizes is available here https://osf.io/hnkf6

Rounded vowels paired with round shapes appear to be intuitively explained by the analogous shape of the mouth—thus sharing a first-order experiential feature of shape. The front vs. back associations can stem from the different frequencies of the vowels, with the front vowels having a higher f2, spectral centroid, and greater formant dispersion. General features of *intensity* and *arousal* may be at play here, as higher frequency sounds can be perceived as more intense and stimulating and matched with, e.g., more acute shapes (likely connoting with sharp objects perceived as potentially harmful) as opposed to the duller rounded shapes.

As in the previous case, the consonant associations were less clear-cut, though, e.g., sonorants were consistently reported to go with *round* shape (6 studies, med(g) = 0.99), while, for instance, stops (5 studies, med(g) = –0.73), voiceless stops (4 studies, med(g) = –0.62), voiced fricatives (1), fricatives/affricates (1), and obstruents (1) to go with *sharp*. Therefore, the sonorant vs. obstruent distinction may be relevant for these associations with the abrupt sound patterns of obstruents corresponding to acute shapes. This tendency might also have its explanation in the entropy of sound, as proposed and briefly discussed in section 6.

The largest effects in the consonants come from McCormick et al.'s (2015) second and third study utilizing Likert scale ratings, however with smaller sample sizes (15 and 16 respectively, with g = –1.4 for stops and g = 1.56 for sonorants), as well as from Nielsen and Rendall's 2011 study (bidirectional g = 1.49 for sonorants and stops). For comparison, the effect for sonorants associated with *round* reported in Sidhu et al. (2022) with a larger sample size and more nuanced methodology (mixed effects models with post hoc EMM comparison) had an effect of g = 0.62, which still can be considered medium-to-large effect, yet a more moderate one.

The voicing feature seems to work differently in stops and fricatives/affricates, as voiced stops are matched with *round* as opposed to voiceless stops, while voiced fricatives/affricates with *sharp*. Sidhu et al. (2022) hypothesize that it may be due to the more 'strident' sound of voiceless stops and voiced fricatives compared to their respective counterparts—the voiced fricatives such as /z/ or /v/ have a more intense, vibrating quality (also seen in the high entropy values of some voiced fricatives/affricates).

4.6.3 Size Associations

In the 11 studies with the dimension of size on a continuum between *big* and *small* (Figure 4), the most reported associations are with back (8 studies, med(g) = 0.5) and front vowels (7 studies, med(g) = –0.5), suggesting a medium-sized effect. One study (Kawahara & Moore, 2018) reported a more specific association of *big* with open-back vowels and *small* with close-front vowels.

Open and back vowels being associated with *big* as opposed to front and close-front vowels associated with *small* follow Ohala's Frequency Code Hypothesis since the latter tend to be of a higher frequency than the former (higher spectral centroid and f0), which may be linked to small objects/creatures producing higher sounds in nature.

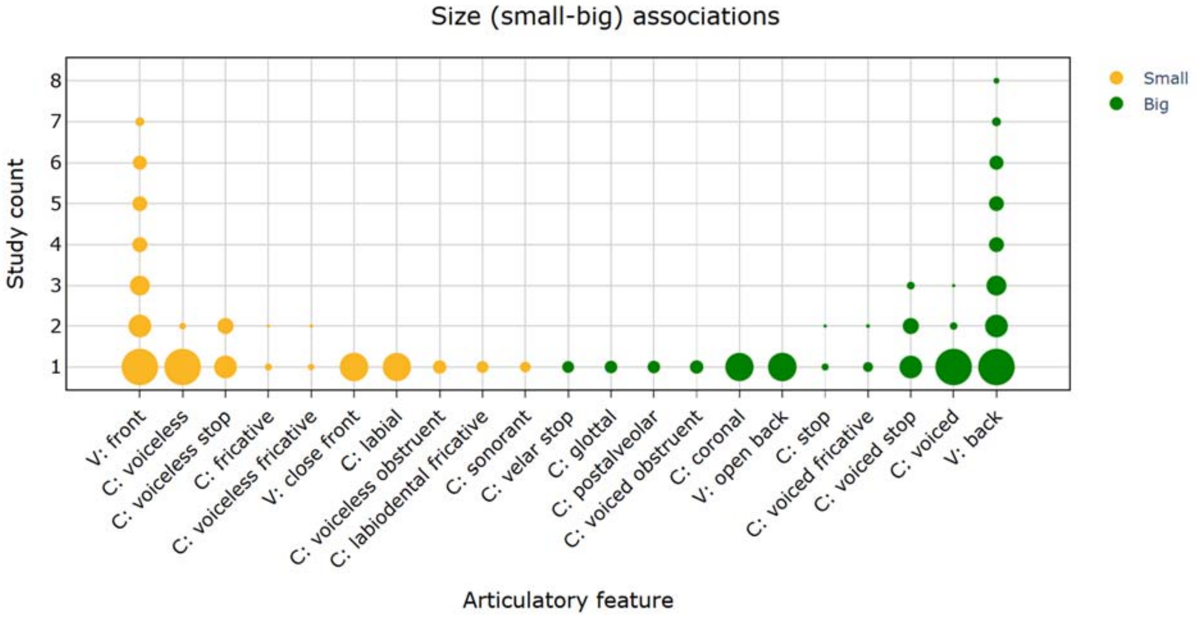

Figure 4. Individual studies reporting associations of the semantic dimension of size (*small-big*) with dots scaled by effect size (Hedges' *g*). An interactive HTML version with dots displaying study names and effect sizes is available here https://osf.io/7ybnu

The most commonly reported size associations in the consonants appeared to be more intricate. In 2 studies, *big* was paired with stops (generally as opposed to continuants), while in 3, with voiced stops in particular (med(*g*) = 0.54). *Small* was paired with fricatives, voiceless stops, and voiceless fricatives in 2 studies each.

A common pattern for those associations seems to be the voicing, with *big* associated with voiced consonants and *small* with voiceless ones (apart from the above differentiation, this was directly reported in 3 and 2 studies, respectively). There are several possible explanations for that, including voiced consonants having more acoustic energy in the lower frequency bands—following the Frequency Code, or, in the case of stops, voiced stops being longer on average due to their voicing onset time.

The largest effects (bidirectional *g* = 1.23) in this dimension come from the first study by Thompson and Estes (2011) with voiced vs voiced consonants and back vs front vowels associated with bigger vs smaller objects. The study used a label selection task, having participants choose one of a semi-random set of five pseudowords for a fictional object of varying size embedded in a photo, with the results analyzed with a within-subjects ANOVA. However, they only measured the general effect of the "large sounding" phonemes, which makes it impossible to disentangle the effects of vowels and consonants. Furthermore, the participants were presented with orthographic words, and the study reported a correlation between the graphical width of the word and the number of large-sounding phonemes in its pronunciation, which suggests a possible effect of orthography on the choices as well—their second study using recorded pseudowords involved a smaller effect of large vs small sounding phonemes (*g* = 0.76)

The second largest group of effects comes from Kawahara and Moore's (2018) two studies, including *g* = 0.96 for close front vs open back vowels and *g* = 0.95 for labial vs coronal consonants and *small* vs *big* size. These studies utilized 2AFC tasks in the experiments, which, as mentioned before, can pose risks for overemphasizing dichotomous outcomes.

The other studies involved less pronounced effects for front vs. back vowels and *small* vs. *big* size, with Klink's 2000 2AFC task, which resulted in an effect of *g* = 0.67, and others going lower, e.g., Sidhu et al. (2022) with *g* = 0.5, which was also the median of these effect sizes.

4.6.4 Associations of Gender, Hardness, Weight, and Speed

Examining the number of studies reporting specific associations in other dimensions would be of limited utility due to their numbers ranging between 0 and 2. Hence, we shall now simply consider their more general makeup.

For the third most studied dimension of gender (7 studies), the *masculine* end was associated more with back and open back vowels (overall med(g) = 0.6), voiced fricatives, voiced stops, and stops in general (overall med(g) = 0.28) as opposed to front, close, close-mid, and close-front vowels (overall med(g) = –0.38) and fricatives, voiceless fricatives, and sonorants (overall med(g) = –0.44) associated with the *feminine* end. Most of these associations could be explained in terms of the above-described statistical tendency of female voices being of a higher frequency than male and the analogous impact of consonant voicing and vowel backness and openness lowering the spectral centroid of a sound.

Similar patterns were observable in the hardness dimension with *soft* matched with front (g = 0.22, from Klink, 2000—2AFC), close front vowels (g = 0.38, from Klink, 2000—1-end scales), voiceless fricatives (g = 0.86, from Klink, 2000—2AFC) and sonorants (g = 0.37, from Sidhu et al., 2022—2-end scales).

In the weight dimension, *heavy* and *light* were matched with back vs. front vowels (bidirectional g = 0.92—Klink, 2000—2AFC), voiced vs. voiceless fricatives (g = 0.25 and g = –0.24—Sidhu et al., 2022—2-end scales), voiced vs voiceless stops, and stops vs fricatives in general (g = 0.59 and g = 0.29—Klink, 2000—2AFC), This also appears to follow the Frequency Code via the projection of size onto weight (i.e. larger weight—lower frequency).

In the speed dimension, *slow* vs *fast* was matched with back vs. front vowels (bidirectional g = 0.42 and g = 0.34 from Klink, 2000 and Sidhu et al., 2022, respectively)—also likely following the Frequency Code, with bigger and heavier objects/creatures usually moving more slowly—though perhaps also due to higher frequency sounds and faster speeds being typically associated with a higher intensity.

Such tendencies have also been evidenced to some extent in other languages, though with methods other than psycholinguistic experiments, e.g., corpus-based approaches) and limited numbers of studies (Wong & Kang, 2019 for gender associations in Cantonese; Shinohara, Kawahara, & Tanaka, 2020 for speed associations in Japanese; Walker & Parameswaran, 2019 for weight associations in a mixed group of speakers of various languages). Determining the cross-linguistic nature and productivity of such associations would either call for a wide study with speakers of different languages, or the existence of a larger body of studies in those languages enabling their meta-analysis.

4.6.5 Conflicting Associations

There were four conflicting associations reported. The first two involved the intensity dimension with front vs back vowels associated with *intense* vs. *mellow* in Simner et al. (2010) with bidirectional g = 0.68, and the reverse being the case in Klink, 2000—2AFC, bidirectional g = 0.29). This might be due to the generalization of this feature in our reporting (the first study involved the concentration of a given taste in a sample given to participants, while the second contrasted soap intensity, i.e., *mild* with *intense* as a verbal stimulus). Furthermore, the first study had participants adjust the heard vowel quality to match it with a taste stimulus, while the second study asked the participants which product name sounded *milder*. Besides, the intensity dimension can be considered a higher-order one, so the more concrete associations put into that category actually might have a more orthogonal relationship.

Another conflicting association comes from a single study, i.e., Westbury et al. (2018), in which close-mid vowels were both paired with increased levels of *concrete* feature as well as *abstract*, which are usually considered as opposing ends of the same dimension, however, this study, as mentioned earlier, addressed the poles of a given dimension separately, measuring the strength of a given feature's association with both of them. Also, both of these effects are very small, with g = -0.13 for *concrete* and g = 0.09 for abstract).

The last conflict was in the gender dimension, with voiceless stops associated with *feminine* in Klink (2000) with g = –0.53 but with *masculine* in Sidhu et al. (2022) with g = 0.44. This most likely stems from the former contrasting voiceless stops with voiced stops, which were more associated with masculine (cf. the discussion of gender associations above, given the lower spectral centroid of voiced consonants). In the latter, both voiced, and unvoiced stops were associated with *masculine* as opposed to sonorants, which appears to be a different association mechanism, likely rooted in the more strident nature of obstruents as opposed to sonorants.

4.6.6 Other Patterns

The more pronounced hotter and colder vertical lines in the heatmap in Figure 2 reveal some general consistencies in the associations of specific articulatory features. For instance, front as opposed to back vowels, are associated with higher activity, beauty, bitterness, bright light, cooler clothing, higher conceptual precision, ethicality, excitement, higher speed, feasibility, femininity, friendliness, happiness, higher intensity, lightness, reality, sharpness, smallness, thinness, and higher visual precision (overall med(*g*) of –0.34 for front vowels and 0.37 for back vowels in the corresponding dimensions).

The second interesting pattern appears in voiceless stops, which are associated with features such as abruptness, closure, danger, disagreeableness, dishonesty, excitement, extraversion, higher speed, inhibition, higher intensity, lightness, reality, ruggedness, sharpness, smallness, solidity, tension, and unconscientiousness (overall med(*g*) = –0.31 in the corresponding dimensions).

A similar pattern can be seen in voiced fricatives associated with features such as abruptness, activity, higher complexity, danger, excitement, higher speed, higher intensity, higher interest, reality, ruggedness, sharpness, and uniqueness (overall med(*g*) = –0.31 in the corresponding dimensions). Hypothetically, such a pattern could be related to voicing, further magnifying the vibrating quality in fricatives.

Finally, a seemingly reverse tendency appears in sonorants, which are associated with features such as continuity, passiveness, beauty, openness, simplicity, safety, agreeability, honesty, calming nature, introversion, slow speed, freedom, low intensity, delicateness, round shape, smallness, softness, nonsolid state, relaxation, approachability, conscientiousness, emotionality, and ordinary nature (overall med(*g*) = –0.4 in the corresponding dimensions). These less ‘chaotic’ features are potentially attributable to the more flowing qualities in the sonorants.

5. Discussion

Summarizing the magnitude and counts of the reported effects, they appear to largely reflect the most attested sound symbolic phenomena as expected, i.e., the *kiki-bouba* effect and the Frequency Code Hypothesis, with *sharp-round* and *small-large* as the most often reported ones and with the largest median Hedges’ *g*. These dimensions show stability across different methodologies, corroborating the widespread character of these effects.

However, an interesting underlying structure manifests to some extent in the alignment patterns of the wider arrays of features. Many seem to vary along the dimensions of vowel frontness and consonant voicing, which roughly correspond with the perceived speech-sound frequency. Some associations also appear to vary along the prominent type of the sound wave components in consonants (periodic vs. aperiodic), with sonorants coinciding with the more ‘orderly’ and ‘dull’ dimension ends and obstruents with the more ‘chaotic,’ ‘arousing,’ and ‘acute’ ends (cf. the hotter regions in Figure 2 for front vowels and voiceless obstruents).

In light of these patterns, a candidate measure can be proposed that could potentially explain those tendencies, namely, entropy, i.e., the measure of uncertainty, complexity, or surprise of a given time series, in this case, that of sound. It is modeled on the information theory concept of entropy, characterized as the amount of uncertainty inherent in a source of information, first introduced by Shannon (1948), and closely linked to the variability of elements within a distribution (Carcassi, Aidala, & Barbour, 2021). In simple terms, the more variable the signal, the more uncertain it is (higher entropy), and the more information is needed for its description.

In this vein, sounds with higher wave frequencies would typically have higher entropy values due to more frequent wave fluctuations. Likewise, sounds with more prominent aperiodic wave components would have higher entropy values than those with more periodic ones. From the psychological perspective, entropy should align with certain perceptual and semantic dimensions, with its higher values associated with the more chaotic, arousing, and acute poles, as discussed above.

This hypothesis draws parallels to Friston’s Free Energy Principle (FEP), which briefly states that any self-organizing system, e.g., a living organism, has to minimize its internal entropy to keep its state and form despite the changing environment around it. The organism does this by constructing mental ‘models’ of reality that capture the regularities in the sensory information reaching it. Such modeling helps it predict the events and act accordingly to promote survival. The mismatch between its expectations and reality can be interpreted as free energy or surprise (Friston, 2010; Parr, Pezzulo, & Friston, 2022). From this, it should follow that a more complex or less predictable sensory input would a) have a higher level of surprise and b) pose more difficulty in modeling, thus being more computationally expensive than a predictable one.

The dimension of entropy is, at this stage, merely a candidate for a higher-order feature that can be abstracted from the underlying convergence patterns across other lower-order features of experience. Yet, the fact that such features can be identified has already been documented (e.g., Osgood et al., 1957).

The above hypothesis needs yet to be empirically tested, for instance, by measuring the entropy of auditory stimuli used in sound symbolism experiments and modeling its correlation with participant responses, e.g., ratings on different semantic scales. This would allow for verifying if these ratings directly align with the objectively measured stimulus entropy. It could even be done on the existing experimental data, pending the availability of the original stimuli.

The present article thus aimed to catalog the sound symbolic associations confirmed experimentally among speakers of English to explore their makeup and discernible patterns while acknowledging the diversity of approaches toward sound symbolism. It could serve as a bird's eye view of the landscape of sound symbolic patterns among English speakers and a stepping stone for their subsequent comparison with other languages—which, however, poses the need to collect cross-linguistic data from a wider array of behavioral studies in different languages pending their future availability. Future comparative analyses of sound symbolic patterns across languages could thus concentrate on individual semantic dimensions (in the vein of the meta-analysis of sound symbolism of shape in Fort et al., 2018), which would allow for their in-depth comparison thanks to the narrowed scope.

Finally, the existence of higher-order features of experience discussed above, including entropy as arguably the most general one, could provide a unified framework for explaining such associations, which could be further refined by adding other variables explaining the more specific patterns. Such a model-based approach to sound symbolism could lay grounds for a more coherent description of its mechanisms and contribute to assessing the scale of this phenomenon in language.

Acknowledgments

Not applicable.

Authors' contributions

Not applicable.

Funding

The research was partially funded by the program Excellence Initiative – Research University at the Jagiellonian University in Krakow.

Competing interests

Not applicable.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Canadian Center of Science and Education.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

References

Aboul-Enein, H. (2014). *Sound Symbolism of Tajwiid Rules: An Investigation of the Meanings of Madd in Some Qur'anic Verses*. Fikr wa- Ibdaa.

Akita, K. (2010a). *Bibliography A: A Bibliography of Sound-Symbolic Phenomena in Japanese*. Retrieved from https://sites.google.com/site/akitambo/Home/biblio/bib

Akita, K. (2010b). *Bibliography B: A Bibliography of Sound-Symbolic Phenomena in Languages Other than Japanese*. Retrieved from https://sites.google.com/site/akitambo/Home/biblio/bibb

Akita, K. (2013). The lexical iconicity hierarchy and its grammatical correlates. In L. Elleström, O. Fischer & C. Ljungberg (Eds.), *Iconic Investigations* (pp. 331–350). Amsterdam: John Benjamins. https://doi.org/10.1075/ill.12.24aki

Barsalou, L. (2003). Situated simulation in the human conceptual system. *Language and Cognitive Processes*, *18*(5–6), 513–562. https://doi.org/10.1080/01690960344000026

Barsalou, L. W., Kyle Simmons, W., Barbey, A. K., & Wilson, C. D. (2003). Grounding conceptual knowledge in modality-specific systems. *Trends in Cognitive Sciences*, *7*(2), 84–91. https://doi.org/10.1016/S1364-6613(02)00029-3

Baxter, S., & Lowrey, T. M. (2011). Sound symbolism and children's brand name preferences. *Journal of Consumer Marketing*, *28*(7), 516–523. https://doi.org/10.1108/07363761111181509

Bentler, P. M., & LaVoie, A. L. (1972). An extension of semantic space. *Journal of Verbal Learning and Verbal Behavior*, *11*, 174–182. https://doi.org/10.1016/S0022-5371(72)80074-4

Blasi, D. E., Wichmann, S., Hammarström, H., Stadler, P. F., & Christiansen, M. H. (2016). Sound–meaning association biases evidenced across thousands of languages. *Proceedings of the National Academy of Sciences*, *113*(39), 10818–10823. https://doi.org/10.1073/pnas.1605782113

Bolinger, D. L. (1949). The Sign is not Arbitrary. *Boletín del Instituto Caro y Cuervo*, *5*, 56–62.

Borenstein, M., & Hedges, L. V. (2019). Effect sizes for meta-analysis. *The Handbook of Research Synthesis and Meta-Analysis*, *3*, 207-243. https://doi.org/10.7758/9781610448864.14

Borroff, M. (1992). Sound Symbolism as Drama in the Poetry of Robert Frost. *PMLA*, *107*(1), 131–144. https://doi.org/10.2307/462806

Bremner, A. J., Caparos, S., Davidoff, J., de Fockert, J., Linnell, K. J., & Spence, C. (2013). "Bouba" and "Kiki" in Namibia? A remote culture make similar shape-sound matches, but different shape-taste matches to Westerners. *Cognition*, *126*(2), 165–172. https://doi.org/10.1016/j.cognition.2012.09.007

Calhoun, S., Warren, P., Mills, J., & Agnew, J. (2024). Socialising the Frequency Code: Effects of gender and age on iconic associations of pitch. *The Journal of the Acoustical Society of America*, *156*(5), 3183–3203. https://doi.org/10.1121/10.0034354

Carcassi, G., Aidala, C. A., & Barbour, J. (2021). Variability as a better characterization of Shannon entropy. *European Journal of Physics*, *42*(4), 045102. https://doi.org/10.1088/1361-6404/abe361

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). Lawrence Erlbaum Associates, Publishers.

Coulter, K. S., & Coulter, R. A. (2010). Small sounds, big deals: Sound symbolism effects in pricing. *Journal of Consumer Research*, *37*(2), 315–328. https://doi.org/10.1086/651241

Cuskley, C. (2013). Mappings between linguistic sound and motion. *PJOS*, *5*(1), 39–62. https://doi.org/10.37693/pjos.2013.5.9651

Ćwiek, A., Fuchs, S., Draxler, C., Asu, E. L., Dediu, D., Hiovain, K., … Winter, B. (2022). The bouba/kiki effect is robust across cultures and writing systems. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *377*(1841), 20200390. https://doi.org/10.1098/rstb.2020.0390

Dean, I., Harper, N. S., & McAlpine, D. (2005). Neural population coding of sound level adapts to stimulus statistics. *Nature Neuroscience*, *8*(12), 1684–1689. https://doi.org/10.1038/nn1541

Dingemanse, M., Blasi, D. E., Lupyan, G., Christiansen, M. H., & Monaghan, P. (2015). Arbitrariness, iconicity, and systematicity in language. *Trends in Cognitive Sciences*, *19*(10), 603–615. https://doi.org/10.1016/j.tics.2015.07.013

Dingemanse, M., Perlman, M., & Perniss, P. (2020). Construals of iconicity: experimental approaches to form–meaning resemblances in language. *Language and Cognition*, *12*(1), 1–14. https://doi.org/10.1017/langcog.2019.48

Dingemanse, M., Schuerman, W., Reinisch, E., Tufvesson, S., & Mitterer, H. (2016). What sound symbolism can and cannot do: Testing the iconicity of ideophones from five languages. *Language*, *92*(2), e117–e133. https://doi.org/10.1353/lan.2016.0034

Erben Johansson, N., Anikin, A., Carling, G., & Holmer, A. (2020). The typology of sound symbolism: Defining macro-concepts via their semantic and phonetic features. *Linguistic Typology*, *24*(2), 253–310. https://doi.org/10.1515/lingty-2020-2034

Erosheva, E. A., Grant, S., Chen, M. C., Lindner, M. D., Nakamura, R. K., & Lee, C. J. (2020). NIH peer review: Criterion scores completely account for racial disparities in overall impact scores. *Science Advances*, *6*(23), eaaz4868. https://doi.org/10.1126/sciadv.aaz4868

Firth, J. R. (1964/1930). *The Tongues of Men, and Speech*. Oxford: Oxford University Press.

Fónagy, I. (1961). Communication in Poetry. *Word*, *17*, 194–201. https://doi.org/10.1080/00437956.1961.11659754

Fort, M., Lammertink, I., Peperkamp, S., Guevara-Rukoz, A., Fikkert, P., & Tsuji, S. (2018). Symbouki: a meta-analysis on the emergence of sound symbolism in early language acquisition. *Developmental Science*, *21*(5), e12659. https://doi.org/10.1111/desc.12659

Friston, K. (2010). The free-energy principle: a unified brain theory? *Nature Reviews Neuroscience*, *11*(2), 127–138. https://doi.org/10.1038/nrn2787

Garofolo, J. S., Lamel, L. F., Fisher, W. M., Fiscus, J. G., & Pallett, D. S. (1993). *TIMIT Acoustic-Phonetic Continuous Speech Corpus LDC93S1*. Philadelphia: Linguistic Data Consortium. Retrieved October 06, 2023, from https://catalog.ldc.upenn.edu/LDC93s1

Genette, G. (1995). *Mimiologics* (T.E. Morgan, Trans.). University of Nebraska, Lincoln. (Original work published 1976).

Gutiérrez, E. D., Levy, R., & Bergen, B. (2016). Finding non-arbitrary form-meaning systematicity using string-metric learning for kernel regression. In *Proceedings of the 54th Annual Meeting of the Association for Computational Linguistics* (Volume 1: Long Papers, pp. 2379–2388). https://doi.org/10.18653/v1/P16-1225

Hedges, L. V. (2007). Effect sizes in cluster-randomized designs. *Journal of Educational and Behavioral Statistics*, *32*, 341–370.

Hinton, L., Nichols, J., & Ohala, J. J. (Eds.). (2006). *Sound symbolism*. Cambridge University Press.

Hollis, G., & Westbury, C. (2016). The principals of meaning: Extracting semantic dimensions from co-occurrence models of semantics. *Psychonomic Bulletin & Review*, *23*, 1744–1756. https://doi.org/10.3758/s13423-016-1053-2

Holmes, J. R. (2010). ‘Inside a Song’: Tolkien’s Phonaesthetics. In B. L. Eden (Ed.), *Middle-Earth minstrel: Essays on music in Tolkien* (pp. 26–46). Jefferson, NC; London: McFarland & Company, Inc., Publishers.

Howell, D. C. (2013) *Statistical methods for psychologists* (8th ed.). International Edition. Wadsworth: Belmont, CA.

Hunter-Smith, S. (2007). *Understanding without Babblefish: Reviewing the Evidence for Universal Sound Symbolism in Natural Languages*. Bachelor’s Thesis, Swarthmore College, PA. Retrieved from https://www.swarthmore.edu/sites/default/files/assets/documents/linguistics/2007_hunter-smith_sarah.pdf

Imai, M., & Kita, S. (2014). The sound symbolism bootstrapping hypothesis for language acquisition and language evolution. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *369*(1651), 20130298. https://doi.org/10.1098/rstb.2013.0298

Imai, M., Kita, S., Nagumo, M., & Okada, H. (2008). Sound symbolism facilitates early verb learning. *Cognition*, *109*(1), 54–65. https://doi.org/10.1016/j.cognition.2008.07.015

Imai, M., Miyazaki, M., Yeung, H. H., Hidaka, S., Kantartzis, K., Okada, H., & Kita, S. (2015). Sound symbolism facilitates word learning in 14-month-olds. *PLoS One*, *10*(2), e0116494. https://doi.org/10.1371/journal.pone.0116494

Isomura, T., Kotani, K., Jimbo, Y., & Friston, K. (2022). Experimental validation of the free-energy principle with in vitro neural networks. *bioRxiv*, *2022*, 10. https://doi.org/10.1101/2022.10.03.510742

Jakobson, R. (1971/1966). Quest for the Essence of Language. In *Selected Writings II* (pp. 345–359). Paris: Mouton. https://doi.org/10.1515/9783110873269.345

Jakobson, R. (1981). *Poetry of Grammar and Grammar of Poetry*. Mouton de Gruyter. https://doi.org/10.1515/9783110802122

Jakobson, R., & Waugh, L. (1979). *Sound shape of language*. London: Bloomington.

Jin, H. (2024). *Conversions between partial eta squared and Cohen’s d*. GitHub.io. Retrieved from https://haiyangjin.github.io/2020/05/eta2d/.

Johnson, K. (2012). *Acoustic and auditory phonetics*. Hoboken, NJ: Wiley-Blackwell.

Kantartzis, K., Imai, M., & Kita, S. (2011). Japanese sound-symbolism facilitates word learning in English-speaking children. *Cognitive Science*, *35*(3), 575–586. https://doi.org/10.1111/j.1551-6709.2010.01169.x

Kawahara, S. (2021). *Phonetic bases of sound symbolism: a review*. Preprint. PsyArXiv. https://doi.org/10.31234/osf.io/fzvsu

Kawahara, S., & Moore, J. (2018). Exploring sound symbolic knowledge of English speakers using Pokémon character names. Ms Keio University and Sophia University.

Kawahara, S., Shinohara, K., & Grady, J. (2015). Iconic inferences about personality. *Iconicity in Language and Literature* (ILL), *57*. https://doi.org/10.1075/ill.14.03kaw

Kitada, R., Kwon, J., Doizaki, R., Nakagawa, E., Tanigawa, T., Kajimoto, H., … Sakamoto, M. (2021). Brain networks underlying the processing of sound symbolism related to softness perception. *Scientific Reports*, *11*(1), 7399. https://doi.org/10.1038/s41598-021-86328-6

Klink, R. R. (2000). Creating brand names with meaning: The use of sound symbolism. *Marketing Letters*, *11*, 5–20. https://doi.org/10.1023/A:1008184423824

Klink, R. R. (2003). Creating meaningful brands: The relationship between brand name and brand mark. *Marketing Letters*, *14*, 143–157. https://doi.org/10.1023/A:1027476132607

Klink, R. R., & Wu, L. (2017). Creating ethical brands: The role of brand name on consumer perceived ethicality. *Marketing Letters*, *28*, 411–422. https://doi.org/10.1007/s11002-017-9424-7

Knoeferle, K., Li, J., Maggioni, E., & Spence, C. (2017). What drives sound symbolism? Different acoustic cues underlie sound-size and sound-shape mappings. *Scientific Reports*, *7*(1), 5562. https://doi.org/10.1038/s41598-017-05965-y

Köhler, W. (1929). *Gestalt psychology*. NY: Liveright.

Lenth, R. V. (2006). *Java Applets for Power and Sample Size* [Computer software]. Retrieved December 11, 2024, from http://www.stat.uiowa.edu/~rlenth/Power

Lenth, R. V. (2024). *Emmeans: Estimated Marginal Means, aka Least-Squares Means*. R package version 1.10.5-0900003. Retrieved from https://rvlenth.github.io/emmeans/, https://rvlenth.github.io/emmeans/.

Li, S. Y., Yang, M., Li, C. C., & Cai, P. (2008). Analysis of heart rate variability based on singular value decomposition entropy. *Journal of Shanghai University* (English Edition), *12*(5), 433–437. https://doi.org/10.1007/s11741-008-0511-3

Liddell, S., & Scott, R. (1996). *A Greek-English Lexicon*. Oxford: Clarendon Press.

Lockwood, G., & Dingemanse, M. (2015). Iconicity in the lab: A review of behavioral, developmental, and neuroimaging research into sound-symbolism. *Frontiers in Psychology*, *6*, 1246. https://doi.org/10.3389/fpsyg.2015.01246

Maglio, S. J., Rabaglia, C. D., Feder, M. A., Krehm, M., & Trope, Y. (2014). Vowel sounds in words affect mental construal and shift preferences for targets. *Journal of Experimental Psychology: General*, *143*(3), 1082. https://doi.org/10.1037/a0035543

Magnus, M. (1997). *Bibliography of phonosemantics*. Retrieved from http://www.trismegistos.com/MagicalLetterPage/Bibliography.html

Magnus, M. (2001). *What's in a Word? Studies in Phonosemantics*. Trondheim, Norway: University of Trondheim. Retrieved March 07, 2023, from https://www.trismegistos.com/Dissertation/dissertation.pdf.

Malhotra, N. K. (1981). A scale to measure self-concepts, person concepts, and product concepts. *Journal of Marketing Research*, *18*, 456–464. https://doi.org/10.1177/002224378101800407

Mark, W. L., & Wilson, D. B. (2001). *Practical meta-analysis* (Vol. 49). Thousand Oaks, CA: Sage Publications.

Maurer, D., Pathman, T., & Mondloch, C. J. (2006). The shape of boubas: Sound-shape correspondences in toddlers and adults. *Developmental Science*, *9*(3), 316–322. https://doi.org/10.1111/j.1467-7687.2006.00495.x

McCormick, K., Kim, J., List, S. M., & Nygaard, L. C. (2015, July). Sound to Meaning Mappings in the Bouba-Kiki Effect. *CogSci*, *2015*, 1565–1570.

Miyazaki, M., Hidaka, S., Imai, M., Yeung, H. H., Kantartzis, K., Okada, H., & Kita, S. (2013). *The facilitatory role of sound symbolism in infant word learning*. Cognitive Science Society.

Monaghan, P., & Fletcher, M. (2019). Do sound symbolism effects for written words relate to individual phonemes or to phoneme features? *Language and Cognition*, *11*(2), 235–255. https://doi.org/10.1017/langcog.2019.20

Monaghan, P., Mattock, K., & Walker, P. (2012). The role of sound symbolism in language learning. Journal of experimental psychology: *Learning, Memory, and Cognition*, *38*(5), 1152. https://doi.org/10.1037/a0027747

Monaghan, P., Shillcock, R. C., Christiansen, M. H., & Kirby, S. (2014). How arbitrary is language?. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *369*(1651). https://doi.org/10.1098/rstb.2013.0299

Motamedi, Y., Little, H., Nielsen, A., & Sulik, J. (2019). The iconicity toolbox: empirical approaches to measuring iconicity. *Language and Cognition*, *11*(2), 188–207. https://doi.org/10.1017/langcog.2019.14

Nielsen, A. K., & Dingemanse, M. (2021). Iconicity in word learning and beyond: A critical review. *Language and Speech*, *64*(1), 52–72. https://doi.org/10.1177/0023830920914339

Nielsen, A. K., & Rendall, D. (2011). The sound of round: evaluating the sound-symbolic role of consonants in the classic Takete-Maluma phenomenon. *Canadian Journal of Experimental Psychology*, *65*(2), 115. https://doi.org/10.1037/a0022268

Nielsen, A. K., & Rendall, D. (2012). The source and magnitude of sound-symbolic biases in processing artificial word material and their implications for language learning and transmission. *Language and Cognition*, *4*(2), 115–125. https://doi.org/10.1515/langcog-2012-0007

Nielsen, A. K., & Rendall, D. (2013). Parsing the role of consonants versus vowels in the classic Takete-Maluma phenomenon. *Canadian Journal of Experimental Psychology*, *67*(2), 153. https://doi.org/10.1037/a0030553

Ögel, İ. Y., & Bayraktaroğlu, G. (2020). Sound Symbolism in Marketing: An Integrative Review of Marketing Studies into Sound Symbolism. *International Journal of Economic & Administrative Studies*, *26*, 1–18. https://doi.org/10.18092/ulikidince.573615

Ohala, J. (1983). The phonological end justifies any means. In S. Hattori & K. Inoue (Eds.), *Proceedings of the 13th International Congress of Linguists* (pp. 232–243). Sanseido, Tokyo.

Ohala, J. (1984). An ethological perspective on common cross-language utilization of f0 of voice. *Phonetica*, *41*, 1–16. https://doi.org/10.1159/000261706

Ohala, J. (1994). The frequency code underlies the sound symbolic use of voice pitch. In L. Hinton, J. Nichols & J. Ohala (Eds.), *Sound symbolism* (pp. 325–347). Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511751806.022

Ohala, J. J., & Eukel, B. W. (1987). Explaining the intrinsic pitch of vowels. In R. Channon & L. Shockey (Eds.), *In honour of Ilse Lehiste* (pp. 207–215). Dordrecht: Foris. https://doi.org/10.1515/9783110886078.207

Osgood, C. E., Suci, S. J., & Tannenbaum, P. H. (1957). *The Measurement of Meaning*. Urbana, IL: University of Illinois Press.

Parault, S. J., & Schwanenflugel, P. J. (2006). Sound-symbolism: A piece in the puzzle of word learning. *Journal of Psycholinguistic Research*, *35*, 329–351. https://doi.org/10.1007/s10936-006-9018-7

Parr, T., Pezzulo, G., & Friston, K. J. (2022). *Active inference: the free energy principle in mind, brain, and behavior*. MIT Press. https://doi.org/10.7551/mitpress/12441.001.0001

Peirce, C. S. (1955). Logic as Semiotic: The Theory of Signs. In J. Buchler (Ed.), *Philosophical Writings of Peirce* (pp. 98–119). New York: Dover Publications Inc.

Perniss, P., Thompson, R. L., & Vigliocco, G. (2010). Iconicity as a general property of language: evidence from spoken and signed languages. *Frontiers in Psychology*, *1*, 227. https://doi.org/10.3389/fpsyg.2010.00227

Plato, C., & Hamilton, E. C. H (Eds.). (1961). *The collected dialogues* (pp. 421–476). Princeton, NJ: Princeton University Press. https://doi.org/10.1515/9781400835867-017

Pogacar, R., Plant, E., Rosulek, L. F., & Kouril, M. (2015). Sounds good: Phonetic sound patterns in top brand names. *Marketing Letters*, *26*, 549–563. https://doi.org/10.1007/s11002-014-9288-z

Popova, S. N., & Magsumov, A. R. (2021). Sound symbolism as a phonetic phenomenon and a means of artistic expression. *Вопросы прикладной лингвистики*, *41*, 8–26.

Preziosi, M. A., & Coane, J. H. (2017). Remembering that big things sound big: Sound symbolism and associative memory. *Cognitive Research: Principles and Implications*, *2*(1), 1–21. https://doi.org/10.1186/s41235-016-0047-y

Ramachandran, V. S., & Hubbard, E. M. (2001). Synaesthesia—a window into perception, thought and language. *Journal of Consciousness Studies*, *8*(12), 3–34.

Robbins, S. (2013). Beauty in Language: Tolkien's Phonology and Phonaesthetics as a Source of Creativity and Inspiration for the Lord of the Rings. *Žmogus ir žodis*, *15*(1), 183–191.

Rosenthal, R. (1994) Parametric measures of effect size. In H. Cooper & L.V. Hedges (Eds.), *The handbook of research synthesis*. New York: Russell Sage Foundation.

Saji, N., Akita, K., Kantartzis, K., Kita, S., & Imai, M. (2019). Cross-linguistically shared and language-specific sound symbolism in novel words elicited by locomotion videos in Japanese and English. *PLOS ONE*, *14*(7), e0218707. https://doi.org/10.1371/journal.pone.0218707

Sanchez-Meca, J., Chacon-Moscoco, S., & Marin-Martinez, F. (2003). Effect-size indices for dichotomized outcomes in meta-analysis. *Psychological Methods*, *8*(4), 448–467. https://doi.org/10.1037/1082-989x.8.4.448

Sapir, E. (1929). A study in sound symbolism. *Journal of Experimental Psychology*, *12*(3), 225. https://doi.org/10.1037/h0070931

Saussure F. de. (1966 [1916]). *Course in general linguistics*. New York, NY: McGraw-Hill.

Schmidtke, D. S., Conrad, M., & Jacobs, A. M. (2014). Phonological iconicity. *Frontiers in Psychology*, *5*, 80. https://doi.org/10.3389/fpsyg.2014.00080

Shannon, C. E. (1948). A mathematical theory of communication. *The Bell System Technical Journal*, *27*(3), 379–423. https://doi.org/10.1002/j.1538-7305.1948.tb01338.x

Shinohara, K., & Kawahara, S. (2010, August). A cross-linguistic study of sound symbolism: The images of size. In *Annual meeting of the berkeley linguistics society* (pp. 396–410). https://doi.org/10.3765/bls.v36i1.3926

Shinohara, K., Kawahara, S., & Tanaka, H. (2020). Visual and Proprioceptive Perceptions Evoke Motion-Sound Symbolism: Different Acceleration Profiles Are Associated With Different Types of Consonants. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.589797

Shinohara, K., Uno, R., & Tobishima, T. (2023). *Does Japanese have language-specific sound symbolism*? A comparison with English and French. ICLC-16 Conference Presentation. Retrieved July 28, 2023, from https://iclc16.phil.hhu.de/wp-content/uploads/2023/04/ICLC16_paper_75.pdf

Shrum, L. J., Lowrey, T. M., Luna, D., Lerman, D. B., & Liu, M. (2012). Sound symbolism effects across languages: Implications for global brand names. *International Journal of Research in Marketin*g, *29*(3), 275–279. https://doi.org/10.1016/j.ijresmar.2012.03.002

Sidhu, D. M., Deschamps, K., Bourdage, J. S., & Pexman, P. M. (2019). Does the name say it all? Investigating phoneme-personality sound symbolism in first names. *Journal of Experimental Psychology: General*, *148*(9), 1595. https://doi.org/10.1037/xge0000662

Sidhu, D. M., & Pexman, P. M. (2018). Five mechanisms of sound symbolic association. *Psychonomic Bulletin & Review*, *25*, 1619–1643. https://doi.org/10.3758/s13423-017-1361-1

Sidhu, D. M., Vigliocco, G., & Pexman, P. M. (2022). Higher order factors of sound symbolism. *Journal of Memory and Language*, *125*, 104323. https://doi.org/10.1016/j.jml.2022.104323

Simner, J., Cuskley, C., & Kirby, S. (2010). What sound does that taste? Cross-modal mappings across gustation and audition. *Perception*, *39*(4), 553–569. https://doi.org/10.1068/p6591

Spence, C. (2012). Managing sensory expectations concerning products and brands: Capitalizing on the potential of sound and shape symbolism. *Journal of Consumer Psychology*, *22*(1), 37–54. https://doi.org/10.1016/j.jcps.2011.09.004

Stevens, S. S. (1957). On the psychophysical law. *Psychological Review*, *64*, 153–181. https://doi.org/10.1037/h0046162

Styles, S. J., & Gawne, L. (2017). When does maluma/takete fail? Two key failures and a meta-analysis suggest that phonology and phonotactics matter. *i-Perception*, *8*(4). https://doi.org/10.1177/2041669517724807

Svantesson, J. O. (2017). Sound symbolism: the role of word sound in meaning. *Wiley Interdisciplinary Reviews: Cognitive Science*, *8*(5), e1441. https://doi.org/10.1002/wcs.1441

Tarte, R. D., & Barritt, L. S. (1971). Sound symbolism in adult native speakers of English: Three studies. *Language and Speech*, *14*(2), 158–168. https://doi.org/10.1177/002383097101400206

Thompson, A. L., Van Hoey, T., & Do, Y. (2021). Articulatory features of phonemes pattern to iconic meanings:

evidence from cross-linguistic ideophones. *Cognitive Linguistics*, *32*(4), 563–608. https://doi.org/10.1515/cog-2020-0055

Thompson, P. D., & Estes, Z. (2011). Sound symbolic naming of novel objects is a graded function. *The Quarterly Journal of Experimental Psychology*, *64*(12), 2392–2404. https://doi.org/10.1080/17470218.2011.605898

Trofimova, I. (2014). Observer bias: An interaction of temperament traits with biases in the semantic perception of lexical material. *PloS One*, *9*. https://doi.org/10.1371/journal.pone.0085677

Tsur, R. (1992). *What Makes Sound Patterns Expressive: The Poetic Mode of Speech-Perception*. Durham N, C.: Duke UP. https://doi.org/10.2307/j.ctv1131366

Vallat, R. (2022). Antropy. *Python Package Index (PyPI).* Python Software Foundation. Retrieved June 10, 2023, from https://pypi.org/project/antropy/

Van Lancker, D., & Cummings, J. L. (1999). Expletives: Neurolinguistic and neurobehavioral perspectives on swearing. *Brain Research Reviews*, *31*. https://doi.org/10.1016/S0165-0173(99)00060-0

Walker, P., & Parameswaran, C. R. (2019). Cross-sensory correspondences in language: Vowel sounds can symbolize the felt heaviness of objects. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *45*(2), 246–252. https://doi.org/10.1037/xlm0000583

Waugh, L. (1980). The Poetic Function and the Nature of Language. *Poetry Today*, *2*, 57–82. https://doi.org/10.2307/1772352

Westbury, C., Hollis, G., Sidhu, D. M., & Pexman, P. M. (2018). Weighing up the evidence for sound symbolism: Distributional properties predict cue strength. *Journal of Memory and Language*, *99*, 122–150. https://doi.org/10.1016/j.jml.2017.09.006

Wickens, D. D., & Lindberg, M. A. (1975). A test of four proposed new dimensions of semantic space. *Bulletin of the Psychonomic Society*, *6*, 381–382. https://doi.org/10.3758/BF03333208

Winter, B., Lupyan, G., Perry, L. K., Dingemanse, M., & Perlman, M. (2023). Iconicity ratings for 14,000+ English words. *Behavior Research Methods*, 1–16. https://doi.org/10.3758/s13428-023-02112-6

Winter, B., Oh, G. E., Hübscher, I., Idemaru, K., Brown, L., Prieto, P., & Grawunder, S. (2021). Rethinking the frequency code: a meta-analytic review of the role of acoustic body size in communicative phenomena. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *376*(1840). https://doi.org/10.1098/rstb.2020.0400

Wong, K. W. Y., & Kang, Y. (2019). Sound symbolism of gender in Cantonese first names. *Proceedings of ICPhS*, *19*, 2129–2133.

Wu, L., Klink, R. R., & Guo, J. (2013). Creating gender brand personality with brand names: The effects of sound symbolism. *Journal of Marketing Theory and Practice*, *21*(3), 319–330. https://doi.org/10.2753/MTP1069-6679210306

Yorkston, E., & Menon, G. (2004). A sound idea: Phonetic effects of brand names on consumer judgments. *Journal of Consumer Research*, *31*(1), 43–51. https://doi.org/10.1086/383422

Copyrights