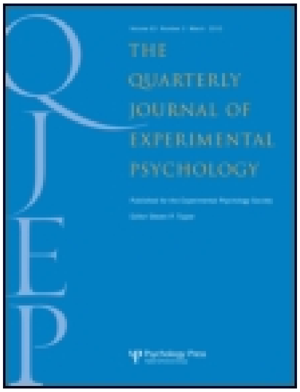

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Sound symbolic naming of novel objects is a graded function

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Sound symbolic naming of novel objects is a graded function

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Although linguistic traditions of the last century assumed that there is no link between sound and meaning (i.e., arbitrariness), recent research has established a nonarbitrary relation between sound and meaning (i.e., sound symbolism). For example, some sounds (e.g., /u/ as in *took*) suggest bigness whereas others (e.g., /i/ as in *tiny*) suggest smallness. We tested whether sound symbolism only marks contrasts (e.g., small versus big things) or whether it marks object properties in a graded manner (e.g., small, medium, and large things). In two experiments, participants viewed novel objects (i.e., greebles) of varying size and chose the most appropriate name for each object from a list of visually or auditorily presented nonwords that varied incrementally in the number of "large" and "small" phonemes. For instance, "wodolo" contains all large-sounding phonemes, whereas "kitete" contains all small-sounding phonemes. Participants' choices revealed a graded relationship between sound and size: The size of the object linearly predicted the number of large-sounding phonemes in its preferred name. That is, small, medium, and large objects elicited names with increasing numbers of large-sounding phonemes. The results are discussed in relation to cross-modal processing, gesture, and vocal pitch.

Keywords: Sound symbolism; Cross-modal processing; Iconism; Naming; Phonetic symbolism; Statistical language learning.

Do the sounds of an object name, such as "balloon", reflect the physical properties of the object, such as its shape and size? This question has been debated since ancient times, and its answer has fundamental implications for our understanding not only of current languages, but also of how language evolved in the first place. Plato, in his Socratic dialogue *Cratylus*, delineated two extreme positions on the relation between words and their referents (Magnus, 2000). According to a "traditionalist" position, there is no relation between sound and meaning (i.e., names are *arbitrary*). In contrast, a "naturalist" position supposes that words reflect the properties of their referents (i.e., names are *sound symbolic*). Although many recent studies indicate that names do indeed convey information about their referents' properties, methodological limitations

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common among those studies have so far constrained theoretical progress. Specifically, it remains unclear whether object names simply mark physical contrasts (e.g., small versus large), or whether they convey more finite gradations of those properties (e.g., small, medium, large). This issue is theoretically important in that evidence of a contrastive effect or a graded effect would implicate different evolutionary origins of sound symbolism and possibly different roles that sound symbolism may play in the evolution of language. We therefore tested whether object names merely contrast small from large objects, or whether people are sensitive to degrees of largeness in object names. After providing a brief history of research on sound symbolism, we then describe two alternative explanations of its occurrence, and we discuss why the prior research is unable to adjudicate between these possible explanations.

Evidence of sound symbolism

Following Saussure's declaration that "the sign is arbitrary" (1959, p. 67), both major linguistics traditions of the 20th century (i.e., "structuralism" of Boaz and Sapir, and "generativism" of Chomsky) assumed that there is, and must be, a separation between meaning and linguistic form. Consequently, early evidence of sound symbolism was generally downplayed or outright ignored (Magnus, 2000; Nuckolls, 1999). An example is onomatopoeia, where a word is based on direct imitation (e.g., "knock"). Saussure argued that the link here is not meaningful, as all words, including these, are subject to linguistic conventions. This, he notes, explains why different languages have dissimilar onomatopoeic words for the same thing, such as "cock-a-doodle-doo" in English and "kikeriki" in German.

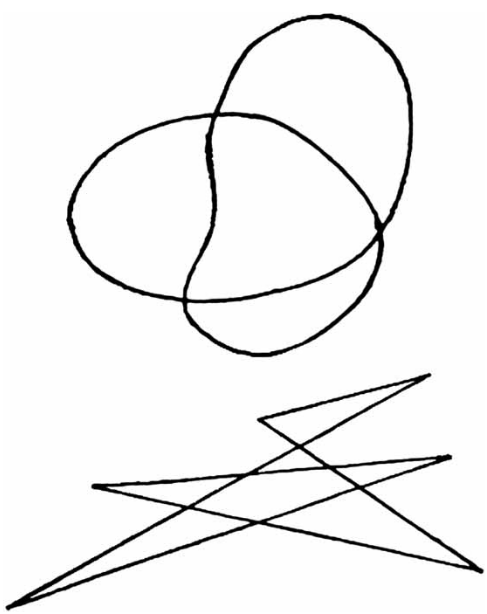

Figure 1. Maluma *(top) and* takete *(bottom), from Köhler (1947).*

However, there is mounting evidence of systematic pairings of sound and meaning in language (Nygaard, Cook, & Namy, 2009). Köhler (1947) provided an early example of such sound symbolism. He showed participants two abstract line drawings, one pointy and one curved, and asked them to decide which object is *maluma* and which is *takete* (see Figure 1). Overwhelmingly, participants matched *takete* with the pointy object and *maluma* with the curved object. Variants of this experiment have been performed successfully many times. For example, Sapir (1929) asked participants to imagine two objects that differed only in size, and subsequently asked them whether the larger object should be called *mil* or *mal*. He found that participants tended to assign the name with the back-most vowel (in this case, *mal*) to the larger object. As he put it, "certain vowels . . . 'sound bigger' than others" (1929, p. 235). More recent demonstrations of sound symbolism have used better experimental controls and more subtle methods. For instance, Kovic, Plunkett, and Westermann (2010) used a categorization task to measure sound symbolism behaviourally with response times and neurophysiologically with electroencephalography (EEG). They found that the match between the shape of an object and the roundness suggested by the sound of its name affected both response times and EEG waveforms. So in sum, despite a historical tendency to ignore or reject sound symbolism, there is now incontrovertible evidence of its occurrence in language.

Explanations of sound symbolism

By a statistical version of sound symbolism, the relation between names and their referents is initially arbitrary, but with time that relation may become symbolic. That is, a given language begins with arbitrary pairings of sound and meaning, but it then evolves some phonetic systematicity. For instance, back vowels (e.g., /u/, as in "book") might initially be used to refer to objects of various sizes, but over time they may nevertheless become more common among large objects than among small objects. If so, this would constitute sound symbolism in that object names would convey information about the physical properties of their referents, and hence the relation between name and referent is nonarbitrary. However, there is no inherent connection between the name and the object. Rather, the relationship is simply statistical; these markings are only symbolic in that the phonemes are not randomly distributed among the words of the language. This explanation thus attributes sound symbolism to comparison (Berlin, 2006): Where semantic contrasts occur, they may come to be marked by phonetic contrasts. Indeed, some evidence supports this contrastive explanation. For example, Brackbill and Little (1957) presented antonymic word pairs from two different languages, and they asked participants to guess which words have the same meanings. They found that "where meaning contrasts are not as great, correct guessing becomes much more difficult" (Brackbill & Little, 1957, p. 318). Brown and Nuttall similarly concluded that "antonyms evolve toward phonetic contrasts appropriate to their semantic contrast" (1959, p. 444). The pressure to create such markings may extend past semantic contrasts to also include grammatical categories. Farmer, Christiansen, and Monaghan (2006) found there to be phonological differences between English nouns and verbs. They manipulated sound–category congruence—for example, presenting a noun that has typical or atypical noun phonemes, speeding and slowing participants' reaction times (for a review of similar congruence paradigms, see Marks, 2004).

Alternatively, a cross-modal version of sound symbolism asserts that naming is directly motivated by the properties of the referent. That is, sound symbolism arises from the systematic matching of spoken sounds to physical properties in the visual or other modalities (Kovic et al., 2010; Maurer, Pathman, & Mondloch, 2006; Ramachandran & Hubbard, 2001). Such cross-modal processing occurs when "the presentation of a stimulus in one sensory modality can be shown to exert an influence on our perception of, or ability to respond to, the stimuli presented in another sensory modality" (Spence, Senkowski, & Roder, 2009, p. 107). In the case of sound symbolism, the matching of auditory and visual modalities could emerge from a mimetic (gestural) system, a frequency (pitch) system, or both. Mimetic theories view symbolic sounds as speech gestures, whereby the mouth and vocal tract are used to produce a vocal "gesture" that mimics the physical properties of an object (Berlin, 1994). Frequency theories view symbolic sounds as signals of physical properties such as the dominance and size of the speaker (Berlin, 1994; Ohala, 1994). In terms of object naming, a symbolic connection is made via mouth shape (gesture) and/or sound pitch (frequency). For instance, the rounded mouth and low frequency typically used to pronounce /o/ may be directly symbolic of the roundness and largeness of the referent (Berlin, 2006). Note that this does not appear to be simple onomatopoeia, whereby a small thing is named with high-pitched phonemes because it makes high-pitched sounds. Rather, there is a connection between pitch and object size even when the objects are silent, as evidenced in the link between the size of fish and the pitch of sounds in their names (Berlin, 1994) and the congruence effect of pitch when judging the size of grey discs (Gallace & Spence, 2006). Thus, it is the size rather than the sound of the object that appears to influence naming.

Although the occurrence of sound symbolism is now well established, few studies have attempted to discriminate between these statistical and cross-modal versions. To date, the only extant approach to investigating these different hypotheses has been cross-language comparisons. If language evolved without sound symbolism, and sound symbolism emerged only later in the development of a given language (i.e., the statistical version), then sound symbolism should vary considerably across languages. Alternatively, if sound symbolism reflects a direct relation between name and referent (i.e., the cross-modal version), then sound symbolism for at least some domains should be universal or at least relatively constant across languages. That is, if sound symbolism is based in perception rather than language-specific contrast, then many of these symbolic sounds should be common across languages. Unfortunately, the evidence is mixed. On one hand, considerable variance in sound symbolism is observed across natural languages (Taylor & Taylor, 1965). Indeed, in some languages, sound symbolic markings are flipped, such as front vowels marking smallness in English but largeness in Bahnar (Diffloth, 1994). But on the other hand, there appear to be more similarities in sound symbolism across languages than one would expect by chance alone (Berlin, 2006; Maurer et al., 2006; Nuckolls, 1999). The ambiguity of the evidence may reflect the imprecision of the theoretical predictions as well as the correlational nature of the research methodology.

We propose new theoretical predictions that allow an experimental test of these alternative explanations of sound symbolism. By the contrastive explanation, sound symbolism only marks the opposite values of the given physical property, such as small and large. By the cross-modal explanation, however, sound symbolism may mark degrees of the given physical property, such as small, medium, and large. Just as physical properties like size are continuous, so too are gesture and frequency. For example, a midsized object could be indicated by a moderate hand or mouth gesture rather than a subtle or extensive gesture, and it could be indicated by a midrange pitch rather than a high or low pitch. Thus, the contrastive explanation predicts a categorical function whereby sound symbolism marks only small and large objects, but the cross-modal explanation predicts a graded function whereby sound symbolism differentiates medium from small and large objects. As described next, prior studies are not capable of discriminating between these predictions (nor were they designed to do so). We therefore report two experiments that directly tested these predictions.

Methodological limitations of prior studies

Many early works in sound symbolism suffered from a variety of confounds (Taylor & Taylor, 1965; Westbury, 2005), most strikingly, strong demand characteristics. In the example of Sapir's (1929) *mil/mal*, participants were asked to imagine two objects that only differ in size, and the chosen names have only one contrast, i.e., /i/ versus /a/. Participants in this task are almost certainly aware of the two manipulations (i.e., object size and vowel), and there is a strong implicit demand for participants to confirm the experimenter's hypothesis. Additionally, many of the nonwords that were used as stimuli in prior studies may have been somewhat meaningful to participants. For example, *mil* is quite similar to *milli-*, a common prefix meaning "one thousandth", and *mal* is a common prefix meaning "bad or evil".

Although recent sound symbolism research is more refined, much of it uses pairwise presentation of alternative names. Critically, this pairwise nature does not allow one to discriminate the contrastive version of sound symbolism from the cross-modal version. For instance, Berlin (1994) examined sound symbolism by presenting pairs of names for birds and fish in the Huambisan language, asking American students to guess which name referred to a bird (or to a fish). The students' guesses were indeed more accurate than chance, thus indicating the presence of sound symbolism. Maurer et al. (2006) tested participants' naming of rounded and spiky shapes using a small set of pairwise choices. Both preschool children and university students showed strong preferences in matching certain sounds with specific shapes, such as using /k/ and /t/ to mark "sharp" objects. Even among studies with more items and more subtle methods, the stimuli tend to be dichotomous, such as round versus pointy shapes (Kovic et al., 2010; Westbury, 2005) and small versus large figures (O'Boyle & Tarte, 1980). Unfortunately, these experiments are unable to determine whether sound symbolism is graded or whether it only marks opposite properties. As explained above, resolving this issue may provide evidence to sound symbolism's origin and function (i.e., contrastive versus cross-modal).

The current research

We report two experiments that test whether sound symbolism for size is categorical or graded. We presented a series of novel figures (i.e., greebles) that varied in size, along with several nonwords that varied in the number of small-sounding and large-sounding phonemes, and we asked American and British undergraduates to choose the name that goes best with the given object. In contrast to most prior studies, the current experiments included many trials per participant and several possible names per trial. This methodology should increase reliability while decreasing demand characteristics. More importantly, the nature of the relationship between the size of the object and the proportion of small- or large-sounding phonemes in its preferred name will reveal whether the presumed sound symbolism is categorical or graded. The cross-modal version of sound symbolism uniquely predicts that small, medium, and large objects should be named with increasing numbers of large-sounding phonemes. We first tested this prediction with American undergraduates using written object name choices in Experiment 1, and for generality we presented British undergraduates with auditorily presented object name choices in Experiment 2.

EXPERIMENT 1

Participants viewed novel objects (greebles) in one of five sizes. To provide relative size information, the greebles were embedded in a pastoral scene (see Figure 2). Each greeble was accompanied by a visually presented list of five possible names, which were nonwords that varied in the number of small- and large-sounding phonemes. Participants chose the name that was "most appropriate" for the given object. If sound symbolism is graded, then the size of the object should linearly predict the number of large-sounding phonemes in its preferred name.

Method

Participants

Forty-seven undergraduates at the University of Georgia participated for course credit.

Materials

Twenty greebles were randomly selected from stimulus images provided courtesy of Michael J. Tarr (n.d.), Center for the Neural Basis of Cognition and Department of Psychology, Carnegie Melon Unviersity, http://www.tarrlab.org. The greebles were manipulated to appear in five sizes: The original greeble (100%) was shrunk to 66, 50, 33, and 10% sizes. Because presenting the greebles in isolation would render their relative size ambiguous, we used the GNU Image Manipulation Program (The Gnu Image Manipulation Program Development Team, 2010) to embed the greebles in scenes that would suggest that the greebles were of differing size, not of differing distance to the viewer. They were placed in a pastoral scene with a cow acting as a reference for size and distance (see Figure 2). All greebles appeared in the same position and at the same picture depth as the cow. The cow's size was roughly that of the 50% greeble.

One hundred nonwords of CVCVCV (C = consonant, V = vowel) form were constructed. The nonwords consisted of varying numbers of large- and small-sounding letters, which correspond to phonemes that have been found in prior research to have size associations for "large" (a, u, o; m, l, w, b, d, g) and "small" (i, e; t, k) (e.g., Berlin, 2006; Maurer et al., 2006; Newman, 1933; Taylor & Taylor, 1962). Nonwords were constructed as randomly as possible within the constraints, while minimizing similarities to real words. They were semirandomly sorted into 20 sets of five items, so that each set contained nonwords with five different numbers of large-sounding (or small-sounding) letters. An example of a nonword set is *wodolo* (6 "large"/ 0 "small"), *tibudo* (4/2), *kuloti* (3/3), *bitiku* (2/4), and *kitete* (0/6). Although presented here in descending order, in the actual experiment the nonwords appeared in random order.

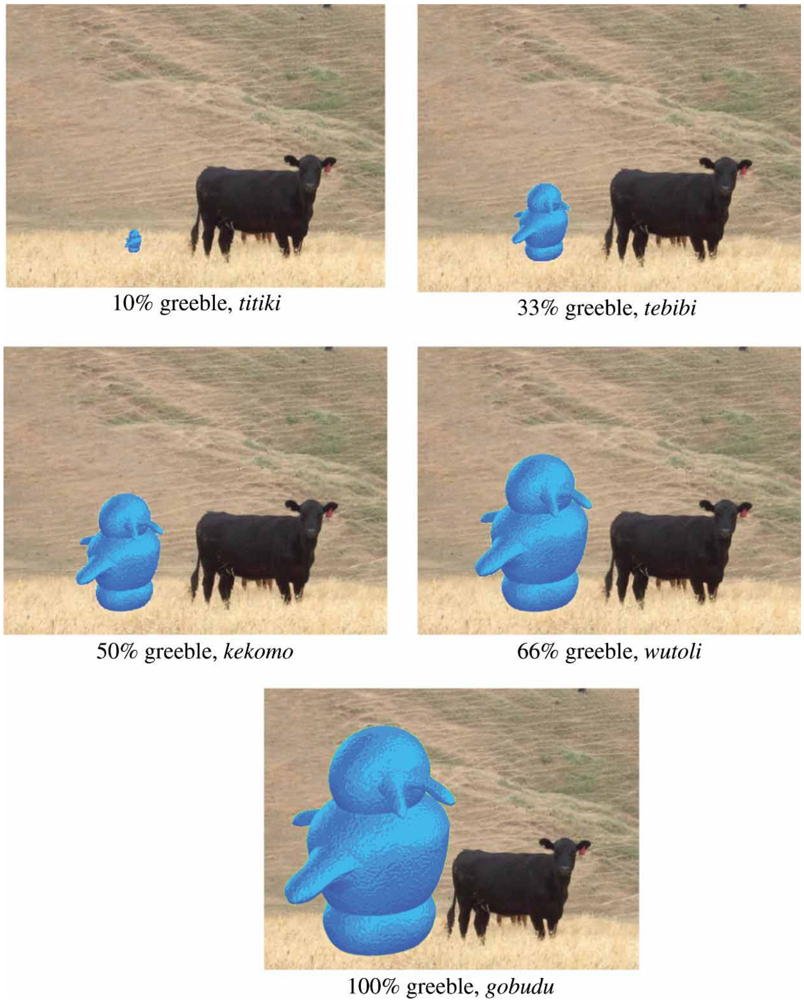

Figure 2. *Experiment 1: Examples of stimuli with name matching size of greeble. To view a colour version of this figure, please see the online issue of the Journal.*

Procedure

Each participant completed 100[1] trials, which appeared in random order. On each trial, a greeble of 10, 33, 50, 67, or 100% size appeared embedded in the background scene above five possible names corresponding to five levels of large-sounding letters. Participants were instructed to choose the most appropriate name for each greeble by pressing the key corresponding to the chosen response option (name 1, 2, 3, 4, or 5). Each greeble was randomly paired with a nonword set that remained constant for each of the greeble's five presentations (once in each of the five sizes).

Results and discussion

Recall that each nonword name contained between zero and six large-sounding letters. Thus, the dependent measure was the number of large-sounding

[1] Participants responded to 100 items but due to programmer error, three greeble sets (15 items) were removed from analyses.

letters in the chosen name on each trial. We calculated for each participant the mean number of large-sounding letters of the chosen name for each of the five object sizes. As illustrated in Figure 3, the size of the object linearly predicted the number of large-sounding letters in its preferred name. This relationship was confirmed via repeated measures analysis of variance (ANOVA), $F(1.83, 84.336) = 73.587$, $p < .001$, partial $\eta^2 = .615$, with significant differences between each successive object size (all $p < .01$ by paired t test).

These results suggest that participants used phonemic composition of names in a graded way to denote size. However, given the visual presentation of the names, participants might have chosen names based on visual cues from the graphemes rather than on the sounds of the names. Upon analysis, a strong correlation was found between number of large phonemes in a word and the word's width in pixels, $r(98) = .743$, $p < .001$. It is difficult to judge to what extent the width of the possible names affected participants' choices. Although it has been debated in the literature (e.g., Atzet & Gerard, 1965; Taylor & Taylor, 1965), the question of whether auditory and visual presentation methods lead to substantially different results remains unclear. Though we feel that this relationship between phoneme and grapheme size is unlikely to fully explain Experiment 1's results, we nevertheless conducted an additional experiment with spoken rather than written names. Critically, the spoken names were matched for duration across conditions.

EXPERIMENT 2

Method

Participants

Nineteen undergraduates at the University of Warwick participated for course credit. Twelve of these participants identified themselves as native speakers of English.

Materials

Participants listened to auditory stimuli on headphones. The volume of the headphones was approximately the same for each participant and was determined by the experimenter. Participants were instructed to inform the researcher if there were any problems, including those with the level of the audio, and none chose to do so.

Auditory stimuli consisted of recordings of 42 nonwords spoken in a "standard" British accent by a male. Each nonword consisted of two CV clusters with an overall phonemic inventory of voiceless ("small") and voiced ("large") stops (/p/, /t/, /k/ and /b/, /d/, /g/) and front ("small") and back ("large") close vowels (/i/, /e/ and /u/, /o/; Berlin, 2006; Newman, 1933). Clusters consisted of "large" and "small" CV pairs—for example, [ki] "kee", [bo] "boh",—such that a "large" name had two "large" clusters, a "medium" name had one "large" cluster, and so on. The 42 names were sorted randomly into 14 sets of choices, such that each had three levels of "large" clusters (e.g., all "large", half "large", zero "large"). The presentation order of the words was balanced. A one-way ANOVA on the duration of names (mean duration = 590 ms) found no significant difference between levels of "phonetic size", $F(3, 38) = 0.925$, $p > .40$, thus indicating that the small, medium, and large names were matched for utterance length. Each of a trial's three name choices was denoted on the screen by a grey circle, measuring 46 pixels in diameter.

Visual presentation of greebles was also simplified, though still very similar to that in Experiment 1. Fourteen greebles were randomly chosen from the Tarrlab greeble set and manipulated using the GNU Image Manipulation Program to convert the images to greyscale, resize them into small (mean = 94×53 pixels), medium (mean = 293×171 pixels), and large (mean = 491×287 pixels) sizes, and add them to a greyscale scene with an abstract human form (292×147 pixels) as reference. The medium-sized greeble was approximately the same height as the human figure. The location of the greeble relative to the human (left or right) was counterbalanced.

The visual and auditory stimuli were presented via Microsoft PowerPoint, with participants marking their naming choices using pen and

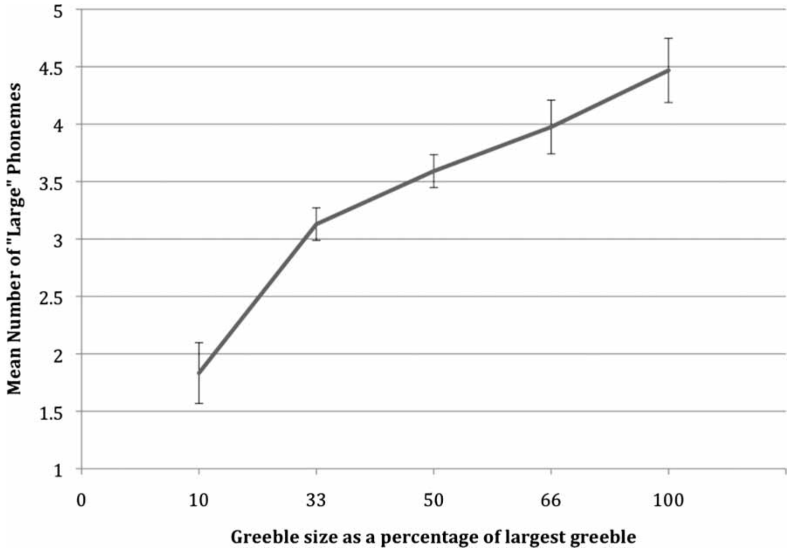

Figure 3. *Experiment 1: Mean number of letters referring to "large" phonemes in the naming of different size of greebles. Error bars represent 95% confidence intervals.*

paper. Each of the 14 greebles was presented in each of its three sizes accompanied by the same set of name choices each time. Since this method does not lend itself to true randomization, two presentation lists were created using the Random.org website (Haahr, 2010). Figure 4 shows an example of a presentation slide with a medium-sized greeble.

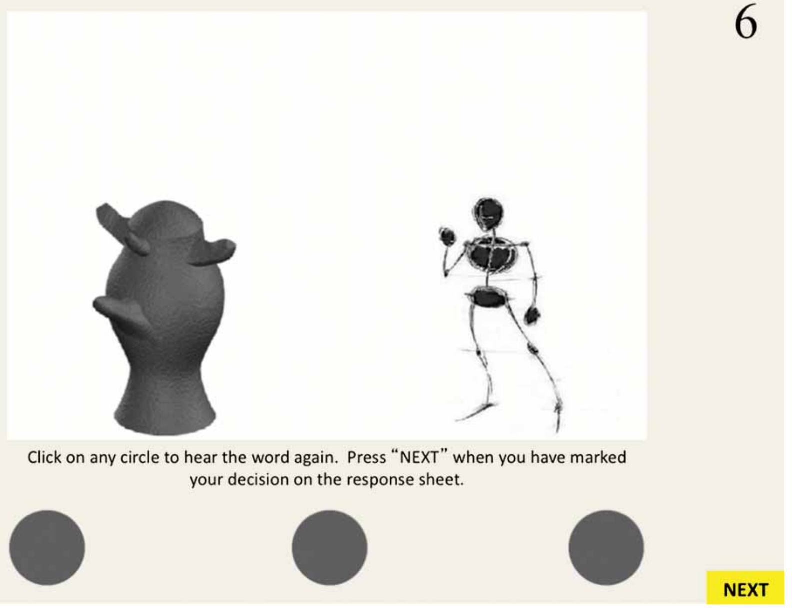

Figure 4. *Experiment 2: Example of visual stimuli. Participants heard a prospective name each time a grey circle appeared.*

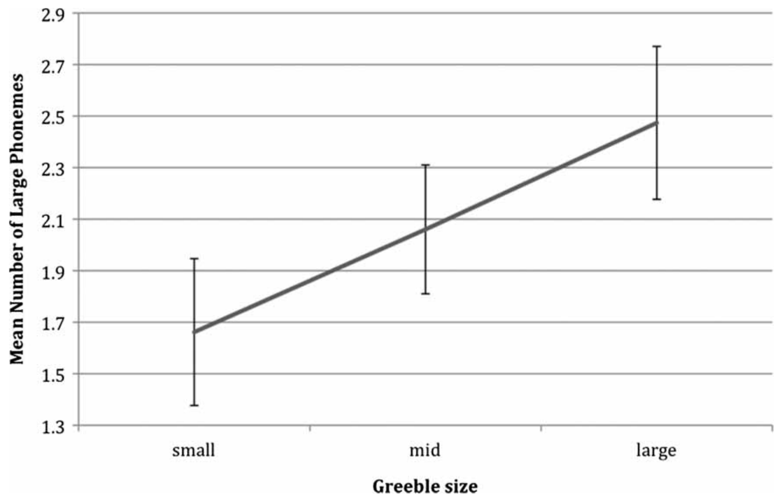

Figure 5. *Experiment 2: Mean number of letters referring to "large" phonemes in the naming of different size of greebles. Error bars represent 95% confidence intervals.*

Procedure

Each participant completed 42 trials at his or her own pace. PowerPoint slides began with a presentation of the greeble/human scene. Two seconds later, the first grey circle marker appeared, and the first possible name was presented auditorily via headphones. Two seconds after the onset of the first name and circle, the second name and circle were presented, and so on until all three circles and names had been presented. Two seconds after the third set began, a box reminding the participant of the instructions and a button allowing the participant to move to the next trial appeared. Participants were encouraged to mouse click on each circle to hear the names again. Upon making a decision, participants had been instructed to clearly mark the grey circle on their response sheets that corresponded with their choices and to press the button marked "NEXT" to move to the next item.

Results and discussion

Each nonword name contained zero, two, or four "large" phonemes, and hence the mean number of "large" phonemes in the chosen names for each greeble served as the dependent measure. As illustrated in Figure 5, the size of the object being named linearly predicted the number of "large" phonemes in its preferred name. A repeated measures ANOVA showed this to be reliable, $F(1, 15) = 11.779$, $p < .01$, partial $\eta^2 = .404$. All post hoc comparisons of size were significant at the $p < .02$ level. Recall that over one third of participants (7 of 19) did not speak English as their native language, though they did have sufficient knowledge of English to study in the UK. We therefore examined whether the native and the non-native English speakers responded similarly by conducting an analysis that included as an additional factor whether the participant was a native English speaker. This factor had no main effect on name choices, $F(1, 15) = 0.202$, $p > .65$, nor did it interact with greeble size, $F(2, 30) = 0.007$, $p > .99$. Thus, native and non-native English speakers exhibited similar naming preferences, and hence the results were not attributable to either participant group alone.

GENERAL DISCUSSION

The present study examined whether phonetic symbolism conveys the size of objects in a graded (i.e., with incrementally more large-sounding letters for increasingly larger objects) or dichotomous manner (i.e., marking only very large and very small objects). The results indicate that phonetic symbolism marks size in a graded manner: Participants reliably preferred names for novel objects that matched the size of each object, including an intermediate number of large-sounding letters for medium-sized objects. As the size of the greeble increased, so too did the number of large-sounding letters in its preferred name. In Experiment 1, participants reliably discriminated between five different levels of phonetic "size". For instance, participants preferred to name a 33% sized object with about three large-sounding letters (e.g., *kuloti*) and a 67% sized object with about four large-sounding letters (e.g., *tibudo*; see Figure 3). Similarly, participants in Experiment 2 chose to name medium-sized objects ($M = 2.06$) with names that were, in terms of number of large phonemes, almost exactly half way in between large ($M = 2.47$) and small ($M = 1.66$) objects.

The results are predicted by the theory that sound symbolism is the combination of gesture and the frequency code (Berlin, 2006) and originates in cross-modal processing (Maurer et al., 2006; Ramachandran & Hubbard, 2001). As the size of the novel object increased incrementally, participants increased the proportion of letters that pointed to phonemes of lower frequency (e.g., back vowels, like /u/ and /o/) and less intensity (e.g., voiced stops, like /b/ and /d/; Berlin, 2006). Object names were presented visually in Experiment 1 and aurally in Experiment 2, and the relationship between size of object and number of large phonemes was highly significant, as were pairwise comparisons between each of the object sizes. This use of sounds is "naturally biased" (Maurer et al., 2006, p. 320), such that the properties of the object (i.e., size) were matched to the phoneme in a meaningful way by participants. Put another way, the phonemes that participants used to mark for size were motivated directly by the properties of the object, thereby supporting the cross-modal explanation of sound symbolism. The preferred names were not simply based on a linguistic contrast between large and small things. Such a contrastive explanation predicts that sound symbolism is categorical, marking only small and large objects. As clearly evident in Figures 3 and 5, however, participants systematically preferred medium-sounding names for mid-sized objects.

These results provide evidence of graded sound symbolism for size, but our conclusions are subject to both empirical and theoretical limitations. Empirically, the present experiments do not indicate whether such graded sound symbolism would generalize to other attributes of objects, such as their shape or motion. Although it seems unlikely that size is the only attribute marked in a graded way, firm conclusions about other attributes will require further research. Domains such as dominance, shape, and motion also appear to be naturally conveyed via frequency and gesture (Berlin, 2006; Ohala, 1982) and, as such, would also be likely to be marked in a graded way. Theoretically, it is important to note that these results should not be taken as evidence that the statistical account of sound symbolism is incorrect. The contrastive explanation of sound symbolism, which is based on statistical learning, fails to explain the present results. But contrastive sound symbolism could nevertheless occur with other attributes such as shape or motion. For example, a speaker of a language could become sensitive to an overrepresentation of front vowels in the words he knows for fast things. When faced with a novel instance of a fast item and asked to name it, he would be likely to name it following the conventions of his language (in this case, with front vowels; Saffran, 2003). More generally, the statistical and cross-modal explanations of sound symbolism need not be mutually exclusive. Sound symbolism could emerge from cross-modal mapping in some domains, giving rise to the sorts of gradations shown in the present experiments, and could additionally emerge from statistical learning and contrastive marking in other domains or at different points in the evolution of a language.

The results of these experiments could suggest that the differing of phonemic markings between experiments (subjective sound symbolism) and corpus studies (objective sound symbolism), as noted by Taylor and Taylor (1965), come from two competing forces. The first is seen in the current experiment—the use of more general cognitive faculties to create names. This results in graded naming via sound symbolism, possibly arising from crossing of sensory modalities (via vocal gesture and frequency code). As we intuitively pitch our voices lower and use outspread arms to suggest large size, we have a natural bias to mark objects of larger sizes with lower toned and open-mouth speech sounds. The second force can be seen at work in natural languages (Berlin, 2006) and may come from selection pressure put on words themselves. As Jespersen puts it, "sound symbolism . . . makes some words more fit to survive and gives them considerable help in their struggle for existence" (1922, p. 408). This could result in categories of words that are not originally marked becoming marked over time—for example, broad grammatical categories (Farmer et al., 2006). Additionally, this pressure could lead to sound symbolic marking for properties like size, shape, and motion being initially graded, but as the need to maximize phonemic usability increases, only names for the ends of the spectra continuing to be marked. Unlike what Brown and Nuttall (1959) envisioned, however, marking for physical properties would come from the initial naming, eventually losing through lexical competition all marking save those at the ends of the continua.

Such a scenario is supported by recent work suggesting a need for both sound symbolism and arbitrariness within a language. Sound symbolism's primary benefit appears to be its facilitation of learning language (Maurer et al., 2006). For example, learning words from a novel language occurs more quickly and with less error when they have sound symbolic mappings (Nygaard et al., 2009). Additionally, children are able to linguistically split actor from action more readily when the sounds of the verbs are symbolic of the action (Imai, Kita, Nagumo, & Okada, 2008).

Although sound symbolism may ease initial language learning, it appears to become a hindrance after that. For example, while sound symbolic marking can facilitate learning of broader categories, it may lead to confusion about category membership (Gasser, 2004). Categories are learned more quickly when they are marked phonetically, with both human and model learners (Christiansen, 2010). However, although initial word individuation task performance is better when sound assignment is symbolic, accuracy for words with arbitrarily assigned sounds quickly catches up (Christiansen, 2010). When a referent's context is added, performance is better when an arbitrary system is used (due to less intracategory confusion; Christiansen, 2010). Additionally, due to the restrictions that sound symbolic marking places on phonetic systems, widespread use of sound symbolism would lead to either a severe restriction of concepts that can be expressed by a language or the necessity of adding a large number of phonemes to the language (Gasser, 2004). It appears that sound symbolism is useful initially—that is, in language development (Maurer et al., 2006) and possibly language evolution (Berlin, 2006; Nygaard et al., 2009)—but is ultimately too constricting for continued, widespread use (Gasser, 2004). As such, the initial bias to use sound symbolism within a natural language may wane over time within a language, thereby facilitating flexibility and ease of use.

However, since the mechanisms underlying sound symbolism are based in general cognition (not language), speakers of a mostly arbitrary language may continue to use sound symbolism when faced with tasks that involve unknown elements and fewer linguistic constraints—for example, creating names for novel objects that will be easy to remember and for others to learn. In these cases, speakers are able to gain the advantages of sound symbolism (e.g., learnability), but due to the novelty of the situations, they can separate the new words from the rest of their vocabulary, thus lessening sound symbolism's disadvantages (e.g., category confusion; Gasser, 2004).

Much of the prior research on sound symbolism has used very limited stimulus samples (i.e., as few as two words or objects) in methodologies with transparent experimenter expectations (e.g., pairwise matching of names to objects). In contrast, we used a large stimulus sample. In Experiment 1, participants named 20 novel objects, each of which was presented in five different sizes, using 42 nonwords. In Experiment 2, participants named 14 novel objects, each appearing in three sizes, using 42 nonwords. The present experiments thus contribute to a growing number of recent studies that have demonstrated reliable sound symbolism in tasks that are less susceptible to demand characteristics (Nygaard et al., 2009; Westbury, 2005). The present study also demonstrates for the first time that, rather than crudely dichotomizing graded dimensions of objects (e.g., small and large), sound symbolism reliably conveys relatively fine distinctions along those graded dimensions (e.g., very small, somewhat small, medium, somewhat large, very large). Evidently, sound symbolism is even more subtle, yet more powerful, than previously known.

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