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The Specificity of Sound Symbolic Correspondences in Spoken Language

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The Specificity of Sound Symbolic Correspondences in Spoken Language

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B.A., Columbia University, 2009

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Abstract

The Specificity of Sound Symbolic Correspondences in Spoken Language

By Christina Y. Tzeng

Sound symbolism, or non-arbitrary correspondences between the sound of a word and its meaning, appears to be an inherent property of natural language. Although previous research suggests that listeners are sensitive to sound-to-meaning correspondences, little is known about the specificity of these mappings. The present study investigated whether sound symbolic properties correspond to specific meanings, or whether these properties extend to other semantic dimensions as well. Native English-speaking adults heard sound symbolic foreign words for four dimensional adjective pairs (*big/small, round/pointy, fast/slow, moving/still*), and for each foreign word, chose which of two English antonyms was its correct translation. Choice dimension either matched or mismatched the meaning dimension from which the word was drawn. Participants reliably matched foreign words to their correct meanings, replicating the finding that listeners utilize sound-to-meaning correspondences to infer the meanings of unfamiliar words across unrelated languages. Foreign words were also mapped to related semantic dimensions, suggesting that sound symbolic properties also facilitate word-to-meaning mappings across a range of associated and co-varying dimensions. However, mappings to correct meanings were more consistent than for mismatched dimensions, suggesting overall specificity in sound-to-meaning mappings. That sound symbolic properties elicit agreement regarding meaning within mismatched dimensions may be a product of overlapping semantic features across these dimensions.

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The Specificity of Sound Symbolic Correspondences in Spoken Language

Introduction

The relationship between the sound of a word and its meaning has traditionally been assumed to be arbitrary (de Saussure, 1959; Hockett, 1960; Newmayer, 1993). According to this principle, the sounds that comprise a spoken word do not reflect the properties of the word's referent. For example, the word *tree* bears no resemblance to the object to which it refers. Moreover, the term for any particular object, concept, action, or event varies in phonological structure across different languages (de Saussure, 1959). Despite recent challenges to the absoluteness of this arbitrary assumption, that language consists primarily of non-systematic correspondences between sound and meaning remains a dominant perspective among linguists (Gasser, Sethuraman, & Hockema, 2005; Pinker, 1999).

The arbitrary relationship between sound and meaning is thought to provide language its referential power (Hockett, 1960). In addition to the theoretical accounts by de Saussure (1959) and Hockett (1960), computational simulations of language systems by Gasser (2004) demonstrate that arbitrary mappings between sound and meaning impose fewer constraints on the number of possible sound-to-meaning pairings than do non-arbitrary correspondences. The existence of arbitrary mappings between sound and meaning in language, therefore, facilitates the development of extensive vocabularies (Gasser, 2004; Monaghan & Christiansen, 2006).

Despite the arbitrariness assumption, increasing evidence suggests that sound symbolism, or non-arbitrary correspondences between sound and meaning, exists in natural language. One example is onomatopoeia, or words such *zoom, whirr,* and *buzz*, that resemble the sounds they represent (Bredin, 1996). Another example is phonesthemes, or sound sequences used in groups of words to reflect semantically related meanings (Bergen, 2004; Sereno, 1994). The consonant cluster *gl-*, for instance, is a phonestheme in English that often occurs in words relating to light (e.g. *glimmer, glisten, gleam, glow*) (Bergen, 2004).

Yet another example of sound symbolism is mimetics, or a special class of words that convey sensory, motor, or affective information (Kita, 1997). Like onomatopoetic words, mimetics can refer to events or concepts that involve sound (e.g. *pota,* meaning a small amount of liquid hitting a solid surface; Imai, Kita, Nagumo, & Okada, 2008). However, mimetics can also refer to concepts or events that do not involve any auditory experience (e.g., In Japanese, *kyoro kyoro* means to look around or spin; Hamano, 1998). Although Japanese mimetics are perhaps most widely cited, mimetics exist in African (Hinton, Nichols, & Ohala, 1994; Nuckolls, 1999), Finnish (Mikone, 2001), and South American (Nuckolls, 1999) languages as well.

Although each of these phenomena suggests that the arbitrariness assumption may not be absolute and that non-arbitrary sound-to-meaning correspondences exist in natural language, these types of non-arbitrary sound to meaning correspondences describe a minority of the lexical items of any given language and tend to obey specific within-language conventions (Bergen, 2004; Bredin, 1996, Sereno, 1994).

Beyond these specialized classes of words, there are sound symbolic correspondences that further challenge the principle of arbitrariness in natural language. One set of these non-arbitrary pairings includes correspondences between phonological structure and grammatical class (Cassidy & Kelly, 1991; Farmer, Christiansen, & Monaghan, 2006; Kelly, 1992; Monaghan & Christiansen, 2005; Monaghan, Christiansen, & Chater, 2007; Shi, Werker, & Morgan, 1999). English nouns and verbs, for example, have been shown to differ in lexical stress (Kelly, 1992), length (Cassidy & Kelly, 1991), and vowel type (Sereno & Jongman, 1990). Analyses of Dutch, French, and Japanese in Monaghan et al. (2007) further suggest that although the phonological cues distinguishing grammatical categories vary among languages, each of the examined languages exhibits significant differences in phonological properties between nouns and verbs, thus providing cross-linguistic evidence for non-arbitrary correspondences between phonological structure and grammatical class.

Although these correspondences between phonological structure and grammatical class challenge the principle of arbitrariness in natural language, such pairings do not provide direct evidence for the existence of systematic correspondences between sound and semantics. However, a growing number of studies have reported findings suggesting that there are direct correspondences between the sound of a word and its meaning (Kohler, 1947; Maurer, Pathman, & Mondloch, 2006; Sapir, 1929; Westbury, 2005). For example, Sapir (1929) examined whether listeners exhibit biases in labeling two tables of differing sizes (one small, one large) when given pairs of choices (e.g. *mal* - *mil*) as labels. Results indicate that listeners reliably labeled the small table as *mil* and the large one as *mal*, suggesting that listeners may have naturally biased associations between a word's phonological structure and the size of its referent.

Kohler (1947) and Westbury (2005) found that native English-speaking adults reliably associated non-words, such as *maluma*, with round shapes, and *takete* with angular shapes. Ramachandran and Hubbard (2001) and Maurer et al. (2006) found similar results using non-words, such as *bouba* and *kiki,* as shape labels, with Maurer et al. (2006) extending this finding to demonstrate that 2.5-year-old children also made the same pattern of choices. Thus, these results suggest that there may be non-arbitrary correspondences between sounds and shapes (Maurer et al., 2006). Taken together, these results suggest not only that listeners are sensitive to direct sound-to-meaning correspondences, but also that they utilize correspondences between phonological features and semantics to infer the meanings of unfamiliar words.

Research also indicates that non-arbitrary sound-to-meaning mappings exist cross-linguistically, suggesting that sensitivity to sound symbolic correspondences cannot be entirely attributed to listeners' knowledge of the conventions governing sound-to-meaning mappings within a particular language (Berlin, 1994; Brown, Black, & Horowitz, 1955; Imai et al., 2006; Kunihira, 1971; Weiss, 1966). For example, Berlin (1994) found that native English-speaking adults could classify spoken Huambisa (language spoken in northern Peru) words as either names for fish or names for birds at significantly above chance levels. As in the studies using *bouba/kiki* and *maluma/takete* (Kohler, 1947; Maurer et al., 2006; Westbury, 2005), this pattern of labeling may also reflect a sound-shape correspondence.

In Kunihira (1971), native English-speaking adults reliably matched Japanese antonym pairs to their correct English translations. Further, Brown et al. (1955) found that native English-speaking adults reliably matched Chinese, Czech, Hindi, and Japanese antonym pairs to their correct English translations. Thus, listeners were able to infer correct meanings for words in languages that have unfamiliar phonologies. These findings suggest that non-arbitrary sound-to-meaning mappings exist cross-linguistically, and that listeners' sensitivity to sound symbolic correspondences cannot be explained fully by their knowledge of within-language conventions.

Sound symbolism and word learning

Evidence for listeners' sensitivity to non-arbitrary correspondences between sound and meaning across unrelated languages suggests that sound symbolism may offer a potential language-processing advantage (Namy & Nygaard, 2008). Recent research indicates that sound symbolism may indeed facilitate word learning (Imai et al., 2008; Nygaard, Cook, & Namy, 2009; Parault & Parkinson, 2007; Parault & Schwanenflugel, 2006). Imai et al. (2008) found, for example, that 3-year-old native Japanese-speaking children learned and generalized the meaning of novel sound symbolic verbs more accurately than they did for non-sound symbolic verbs. Kantartzis, Imai, and Kita (in press) found similar results showing that in a novel verb-learning task, children from both Japanese-and English-speaking language backgrounds learned the sound symbolic verbs more accurately than they learned the non-sound symbolic verbs.

Nygaard et al. (2009) examined native English-speaking adults learning the English meanings of Japanese antonym pairs. Listeners heard each Japanese word presented with its correct English translation, its antonym, or a random word. At test, listeners learned the Japanese words more quickly and accurately when they were paired with their correct English meanings than with mismatched meanings. Interestingly, Japanese words that were paired with the English equivalent of their antonym were learned just as quickly and accurately as Japanese words that were paired with their correct meanings, suggesting that sound symbolism facilitates the pairing of words not only with their correct meanings, but also with related meanings. Indeed, Murphy and Andrew (1993) have shown that a word and its antonym are similar conceptually, differing only in one dimension. For example, *big* and *small* have similar meanings, differing only in where along the size continuum each word falls.

Specificity of sound symbolic correspondences

The literature discussed thus far provides evidence for cross-linguistic sensitivity to sound symbolism and its facilitative effects on novel word interpretation and word learning. Little is known, however, about the nature of the mapping between sound and meaning. In particular, it is unclear whether sound symbolic properties correspond to specific meanings or to a range of related meanings or higher-order semantic features. Nygaard et al.'s (2009) finding that Japanese words paired with the English equivalent of their antonym were learned just as quickly and accurately as Japanese words paired with their correct English meanings raises the possibility that sound symbolic properties may correspond not only to specific meanings, but also to semantically related meanings as well.

In addition to Murphy and Andrew's (1993) finding that synonyms and antonyms are conceptually similar, several theoretical accounts claiming that words are conceptually related along certain connotative dimensions (Osgood, 1969; Wurm; 2007) also support the possibility that sound symbolic properties of a word may correspond not only to the word's specific meaning, but also to semantically related dimensions or more global semantic features. Osgood (1969), for example, argues that the meanings of words can be understood in terms of three dimensions: evaluation (good/bad), potency (strong/weak), and activity (fast/slow). According to this semantic-differential model, words that have similar ratings along these three dimensions are considered semantically related.

In the context of understanding the specificity of the mapping between word's phonetic properties and its meaning, theoretical accounts of semantic relatedness, such as those by Osgood (1969) and Wurm (2007) imply that phonetic cues to meaning may facilitate mappings to not only to a word's specific meaning, but also to related meanings. The proposed research addresses two questions concerning the relative specificity of non-arbitrary sound-to-meaning mappings. First, do sound symbolic properties correspond to specific meanings or to more global semantic features, such as word valence, that may cross-cut semantic dimensions? Second, if mappings do generalize beyond specific meanings, what semantic features underlie this generalization?

To address these questions, a corpus of sound symbolic foreign words was developed based on native English speakers' performance on a forced-choice task. Only those words for which at least 80% of participants agreed on a meaning were employed in Experiments 1 and 2 of the current study. To confirm that our auditory stimuli are indeed sound symbolic, Experiment 1 examined whether listeners could correctly infer the meaning of foreign sound symbolic adjectives from 10 unrelated languages. After hearing each of these words, native English-speaking monolinguals chose which of two English antonyms was the correct meaning for the word they heard. If listeners are indeed sensitive to sound symbolic properties of these foreign words and use them to infer meaning, then mappings should occur at above-chance levels, confirming the words' sound symbolic status and listeners' sensitivity to this cross-linguistic sound symbolism.

Using the foreign words from Experiment 1, Experiment 2 then investigated whether listeners would also reliably associate the words' sound symbolic properties with other meanings as well. Listeners completed a task identical to that in Experiment 1 except that the choice dimension either matched or mismatched with the dimension from which the word was drawn. If sound symbolic properties correspond to specific meanings, then mappings in matched conditions should occur at above-chance levels, and mappings in mismatched conditions should occur at chance. Alternatively, if sound symbolic properties correspond not only to specific meanings, but to other dimensions as well, then mappings in both matched and mismatched conditions should occur at significantly above-chance levels. Of particular interest is whether there are systematic relationships among meanings that may inform the semantic basis for generalizing sound symbolic relations across dimensions of meaning.

Experiment 1

The purpose of Experiment 1 was to confirm the sound symbolic status of our multi-language auditory stimuli to be used in Experiment 2. These words had been rated as sound symbolic in a previous experiment during which listeners heard the foreign words and in a forced choice task, chose which of two English antonyms was its correct translation. Separate groups of listeners heard words in each choice dimension (e.g. one group of listeners rated all foreign words meaning *big/small*, another group rated foreign words meaning *round/pointy*, etc.)

Participants in Experiment 1 completed a task similar to the one described above, except that they heard foreign words across *all eight word meanings.* Thus, trial by trial, listeners heard words in different dimensions (e.g. a *big* word, followed by a *fast* word, etc.). If listeners are indeed sensitive to the sound symbolic properties of these words and use them to infer word meaning, then word-to-meaning mappings should still occur at above-chance levels, providing further evidence that these foreign words are indeed sound symbolic.

Methods

Participants

Participants were 40 Emory University undergraduate students. All were native English monolinguals who had no familiarity with any of the languages used in the study and reported no history of speech or hearing disorders. Participants either received course credit (n = 18) or were paid $10 for their participation (n = 22).

Stimuli

The stimuli were selected from a multi-language database in which native speakers of 10 different languages (Albanian, Dutch, Gujarati, Indonesian, Korean, Mandarin, Romanian, Tamil, Turkish, and Yoruba) nominated multiple synonyms for nine dimensional adjective pairs (big/small, round/pointy, fast/slow, moving/still, quiet/loud, good/bad, up/down, near/far, bright/dark). All the synonyms from each language were then digitally recorded by a native speaker of that language, edited into separate files for presentation to listeners, and amplitude normalized using Audacity software (Mazzoni & Dannenberg, 2000). Although the number of synonyms that were generated varied across each meaning and language, native speakers of each language generated at least six synonyms for each word, yielding a set of 1,220 words across the 18 meanings and 10 languages.

To assess whether listeners could correctly infer word meaning from these synonyms, the words from this stimulus set were presented to separate groups of native English-speaking monolinguals (n = 15 for each group) who rated all the nominated synonyms in each word dimension (e.g. one group of listeners rated all synonyms corresponding to *big/small*, another group rated all synonyms corresponding to *round/pointy*, etc.) In a forced-choice task, listeners heard each nominated synonym and chose which of two English meanings was the correct translation for each foreign word. A particular word was considered sound symbolic if it was mapped onto one English translation at least 80% of the time.

The stimuli used in the current experiment were selected from the above stimulus set and consisted of sound symbolic foreign words from four (big/small, round/pointy, fast/slow, moving/still) of the original nine dimensional adjective pairs in the study described above (mean agreement across stimulus items = .85). Chosen dimensions corresponded either to form-related meanings (big/small, round/pointy) or to motion-related meanings (fast/slow, moving/still). Ten sound symbolic words across the 10 languages were chosen from each of the eight meanings, resulting in a total of 80 sound symbolic stimuli words (see Appendix). Of the 80 sound symbolic words used, 35 were reverse mappings such that listeners reliably mapped them to the words' opposite meanings (e.g. a word that means *fast* was reliably chosen to mean *slow*).

Design and Procedure

Each participant heard 80 sound symbolic foreign words (10 words for each of the following meanings: *big, small, round, pointy, fast, slow, moving, still*). In a forced-choice task, each foreign word was paired with its correct choice dimension (big/small, round/pointy, fast/slow, or moving/still). Auditory stimuli were presented over Beyerdynamic DT100 headphones, and stimulus presentation was controlled on a PC computer using E-prime 1.1 (Schneider, Eschman, & Zuccolotto, 2002).

On each trial, participants heard a sound symbolic foreign word and were then presented with two English antonyms in the correct choice dimension side by side on the computer screen. Participants were asked to choose which of the two English antonyms was the correct translation for the word they just heard by pressing one of two designated keys on a button box corresponding to the left and right words on the computer screen. Participants were instructed to pay attention to the sounds of the words and not to the voices of the individual speakers when making their choices. The experiment was self-paced and proceeded to the next trial only after the participant made a choice. Foreign words were presented in random order and the position of each of the two words within a choice dimension was counterbalanced across participants. Upon completion of the 80-trial forced-choice task, participants provided a written response to a question regarding how they were making their decisions during the task.

Results and Discussion

The mean proportion of responses on which participants chose the foreign words to correspond to their correct sound symbolic meanings were calculated. Results from one-sample *t* tests by subject (t_1) and by item (t_2) indicate that all words were mapped onto their correct sound symbolic translations at above-chance levels (see Figure 1), *big*, $t_1(39) = 4.38$, $p < .001$, $t_2(9) = 4.53$, $p < .01$; *small*, $t_1(39) = 8.46$, $p < .001$, $t_2(9) = 4.46$, $p < .01$; *round*, $t_1(39) = 5.84$, $p < .001$, $t_2(9) = 10.36$, $p < .001$; *pointy*, $t_1(39) = 5.02$, $p < .001$, $t_2(9) = 5.61$, $p < .001$; *fast*, $t_1(39) = 4.90$, $p < .001$, $t_2(9) = 4.03$, $p < .01$; *slow*, $t_1(39) = 4.93$, $p < .001$, $t_2(9) = 2.45$, $p = .04$; *moving*, $t_1(39) = 5.31$, $p < .001$, $t_2(9) = 3.95$, $p < .01$; *still*, $t_1(39) = 4.71$, $p < .001$, $t_2(9) = 2.62$, $p =.03$. These results suggest not only that listeners are sensitive to the sound symbolic properties of these words, but also that they use these properties to infer word meaning.

These findings are consistent with those from previous studies that imply listeners' sensitivity to non-arbitrary correspondences between sound and shape (Kohler, 1947; Maurer et al., 2006; Ramachandran & Hubbard, 2001; Westbury, 2005), and sound and size (Sapir, 1929). That listeners also mapped *fast, slow, moving*, and *still* words to their correct sound symbolic meanings suggests that non-arbitrary correspondences between sound and meaning also exist for motion-related dimensions. Further, that these sound symbolic foreign words were selected from 10 unrelated languages suggests that these non-arbitrary relationships between sound and meaning occur cross-linguistically and that sensitivity to these correspondences cannot be attributed to listeners' knowledge of within-language conventions.

Findings from Experiment 1 thus provide further evidence that these 80 foreign words indeed sound symbolic. However, listeners' mappings in Experiment 1 (mean agreement across stimulus items = .65) were less consistent than those in the initial experiment during which separate groups of listeners heard foreign words in each word dimension (mean agreement across the subset of stimuli selected for this study = .85) Although listeners in both experiments reliably mapped foreign words to their correct meanings, it is possible that because listeners in Experiment 1 heard randomly presented foreign words from eight different word meanings, the task in Experiment 1 was more difficult than the one in which listeners heard words in only one choice dimension. Moreover, because listeners in Experiment 1 heard randomly presented foreign words in different dimensions, it may have been more difficult for listeners to use particular sound characteristics that map onto a single dimension to inform their decisions. Thus, lower performance in Experiment 1 may be attributed to the increased task demand of making judgments in different dimensions from one trial to the next. However, that listeners chose the correct meanings for the foreign words they heard at above-chance levels in both experimental conditions provides further evidence of the words' sound symbolic status.

Experiment 2

The results from Experiment 1 indicate that when given a choice between a word's English translation and its antonym, listeners can correctly identify the sound symbolic meaning of unfamiliar foreign words. Thus, sound symbolic properties elicit reliable mappings to correct word meaning when listeners are presented with two potential meanings within the word's semantic dimension. Given theoretical accounts of semantic relatedness among words (Murphy & Andrews, 1993; Osgood, 1969; Wurm, 2007) and Nygaard et al.'s (2009) finding that sound symbolism provides facilitative effects for learning unfamiliar Japanese words as well as their antonyms, it is relevant to consider the extent to which semantic dimensions are related and how this relationship may influence listeners' use of sound symbolic words to infer word meaning. The goal of Experiment 2 was, therefore, to investigate the possibility that sound symbolic properties correspond to a range of related meanings or higher order semantic dimensions (e.g. valence) rather to a single meaning. If sound symbolic properties correspond to specific meanings, then mappings in matched conditions should occur at above-chance levels, and mappings in mismatched conditions should occur at chance. Alternatively, if sound symbolic properties correspond not only to specific meanings, but to other meanings as well, then mappings in both matched and mismatched conditions should occur at significantly above-chance levels.

Methods

Participants

Ninety Emory University undergraduates participated in the experiment for course credit. Participants were native English monolinguals who had no familiarity with any of the languages used in the study and reported no history of speech or hearing disorders. None had participated in Experiment 1.

Stimuli

Stimuli were identical to those used in Experiment 1.

Design

Four between-subject experimental conditions were constructed. Each condition consisted of 80 foreign words (10 words for each of the following meanings: *big, small, round, pointy, fast, slow, moving, still*). As in Experiment 1, response dimensions were big/small, round/pointy, fast/slow, and moving/still. In each condition, one-fourth of the spoken words were paired with the correct choice dimension, and three-fourths of the spoken words were paired with mismatched choice dimensions, with pairings between word meaning and choice dimension rotating through all the permutations of a Latin-square design across the four conditions. Table 1 presents the word and choice dimension pairings across conditions. For example, a participant in Condition 1 heard words meaning *big* or *small* paired with the matching big/small choice dimension and the other words paired with mismatching choice dimensions. *Round* and *pointy* words were paired with a fast/slow choice, *fast* and *slow* words were paired with a moving/still choice, and *moving* and *still* words were paired with a round/pointy choice. Across conditions, word-choice pairings occurred such that each word meaning was paired with each choice dimension, allowing for comparison of listeners' mappings when word and choice dimension matched and when they mismatched.

Procedure

Participants completed a forced-choice task similar to that in Experiment 1. Participants heard 80 sound symbolic foreign words and were shown two English antonyms presented side by side on the computer screen. After hearing each foreign word once, participants chose which of the two English antonyms (matched or mismatched with word dimension) was the correct translation for the word they just heard by pressing one of two designated keys on a button box corresponding to the left and right words on the computer screen. Foreign words were presented in random order and the position of each of the two words within a choice dimension was counterbalanced across participants. All other aspects of the experimental procedure were identical to those in Experiment 1.

Results and Discussion

Across the four experimental conditions, each of the eight word meanings was paired with each of the four choice dimensions, allowing comparison of participants' responses when word and choice dimension matched and when word and choice dimension mismatched. Fig. 2a-d present the mean proportion of responses on which listeners chose the foreign words to mean one endpoint for each of the four choice dimensions (big, round, fast, and moving). Fig. 2a shows proportion "big" responses to each of the eight foreign word meanings. Results from one-sample *t* tests by subject and by item showed that, as expected, when foreign words were paired with a big/small choice, listeners were able to accurately map foreign words meaning *big* and *small* to their correct choices at above chance levels, *big,* $t_1(24) = 3.72$, $p = .001$, $t_2(9) = 3.47$, $p = .007$; s*mall,* $t_1(24) = -3.72$, $p = .001$, $t_2(9) = -4.17$, $p = .002$. Comparisons to chance for the mismatched words revealed that listeners also reliably chose *moving* words to mean *big,* $t_1(18) = 4.24$, $p < .001$. Listeners responded at chance for all other mismatched words.

Fig. 2b shows proportion "round" responses to each of the eight foreign word meanings. When foreign words were paired with a round/pointy choice, listeners reliably mapped *round* and *pointy* words to their correct choices, *round,* $t_1(21) = 4.79$, $p < .001$, $t_2(9) = 8.74$, $p < .001$; *pointy*, $t_1(21) = -4.53$, $p < .001$, $t_2(9) = -7.23$, $p < .001$. Listeners also judged *slow* words to mean round, $t_1(23) = 2.50$, $p = .020$. In addition, *fast* and *moving* words were chosen at significantly below chance levels to mean round (i.e. participants selected "pointy" at above-chance rates), $t_1(23) = -4.10$, $p < .001$, $t_2(9) = -4.90$, $p = .001$; *moving,* $t_1(24) = -2.16$, $p = .041$.

Fig. 2c shows proportion "fast" responses to each foreign word meaning. When words were paired with a fast/slow choice, listeners reliably mapped *fast* and *slow* words to their correct choices, *fast*, $t_1(18) = 4.14$, $p = .001$, $t_2(9) = 6.87$, $p < .001$; *slow,* $t_1(18) = -3.06$, $p = .007$. *Pointy* and *moving* words were also chosen at significantly above chance levels to mean fast, *pointy,* $t_1(24) = 2.35$, $p = .028$; *moving,* $t_1(21) = 4.79$, $p < .001$, $t_2(9) = 3.54$, $p = .006$. *Round* and *still* words were chosen at significantly below chance levels to mean fast (i.e. participants selected "slow" at above-chance rates), *round,* $t_1(24) = -2.89$, $p = .008$, $t_2(9) = -2.55$, $p = .031$, *still,* $t_1(21) = -3.16$, $p = .005$.

Lastly, Fig. 2d shows proportion "moving" responses to each foreign word meaning. When foreign words were presented with a moving/still choice, listeners reliably mapped moving and still words to their correct meanings, *moving,* $t_1(23) = 5.41$, $p < .001$, $t_2(9) = 5.62$, $p < .001$; *still*, $t_1(23) = -6.63$, $p < .001$, $t_2(9) = -3.89$, $p = .004$. In addition, *big, pointy,* and *fast* words were chosen at significantly above chance levels to mean moving, *big,* $t_1(21) = 2.47$, $p = .022$; *pointy*, $t_1(18) = 4.71$, $p < .001$, $t_2(9) = 4.55$, $p = .001$; *fast*, $t_1(24) = 2.16$, $p = .041$. *Small* and *round* words were chosen at significantly below chance levels to mean moving (i.e. participants selected "still" at above-chance rates), s*mall,* $t_1(21) = -.422$, $p < .001$, $t_2(9) = -3.42$, $p = .008$; *round*, $t_1(18) = -3.32$, $p = .004$.

Table 2 presents the reliable mappings made by listeners. Taken together, these results indicate that listeners made some reliable cross-dimensional mappings, suggesting that sound symbolic properties may correspond not only with specific meanings, but also with related semantic dimensions as well. Cross-dimensional mappings were not equally distributed across different word-choice dimension pairings, however. For example, whereas listeners reliably mapped four word meanings (*moving, big, pointy, fast*) onto a "moving" choice, listeners only reliably mapped one word meaning (*small*) onto a "small" choice, suggesting that the eight word meanings are differentially associated with the choice dimensions, with certain word meanings tracking more choice dimensions than others.

Specificity

To assess whether participants were more likely to map the foreign words to their specific meanings than to other mismatched meanings, the mean proportion of responses on which participants chose one of the choice dimension endpoints (big, round, fast, and moving) when presented with each of the eight word meanings was calculated for matched and mismatched pairings. Within each choice dimension, the mean proportion of times one word meaning was chosen to mean a particular choice dimension endpoint was subtracted from the proportion of times the word's antonym was chosen to mean that same dimension endpoint (e.g. absolute value of the difference between the mean proportion of "big" responses to a *big* word and the mean proportion of "big" responses to a *small* word). These Antonym Difference Scores were calculated separately for each pairing of word and choice dimension to measure the extent to which responses were differentiated within each word dimension. Fig. 3 shows Antonym Difference Scores for each choice dimension, with a larger Antonym Difference Score indicating that listeners were better able to differentiate between the two meaning choices within a particular choice dimension. Antonym Difference Scores greater than zero indicate differentiation between meanings in a single choice dimension, with greater differentiation between meanings for matched than for mismatched dimensions suggesting specificity in mappings.

To evaluate whether Antonym Difference Scores in each choice dimension were significantly greater when word and choice dimension matched than when they mismatched, a 2 x 4 ANOVA with Match Status (Matched vs. Mismatched) and Matched Dimension (big/small, round/pointy, fast/slow, moving/still) as within-subjects factors was conducted. The ANOVA revealed a main effect of Match Status, $F(1,86) = 29.53$, $p < .001$, *partial* $\eta^2 = .256$ and no significant interaction, indicating that across choice dimensions, Antonym Difference Scores were significantly greater when word and choice dimension matched than when they mismatched. Thus, although there was some evidence of cross-dimension mapping, there appears to be semantic specificity in the mapping between sound symbolic foreign words and their meanings.

Valence

To determine whether the pattern of cross-dimensional mappings could be accounted for by an underlying semantic similarity across dimensions, word valence was determined from ratings by a separate group of participants (n = 16) who rated the extent to which each of the eight English word meanings was associated with being positive and negative on a Likert-type scale with 1 meaning not at all positive/negative and 7 meaning extremely positive/negative. Ratings showed that *big, round, fast*, and *moving* words were rated as more positive and less negative than *small, pointy, slow,* and *still* words. Based on these ratings, we classified *big, round, fast*, and *moving* words as positive, and *small, pointy, slow,* and *still* words as negative. To assess whether this valence-based classification accounted for the cross-mappings observed, a 2 x 4 ANOVA was conducted with Word Valence (positive and negative) and Word Dimension (big/small, round/pointy, fast/slow, moving/still) as within-subjects factors, and proportion *positive* (i.e. big, round, fast, and moving) responses as the dependent measure.

Fig. 4 presents the proportion of positive responses for positive and negative words in each word dimension. The ANOVA revealed a main effect of Word Valence, $F(1,86) = 32.91$, $p < .001$, *partial* $\eta^2 = .264$. However, this main effect was mediated by a significant interaction between Word Valence and Word Dimension, $F(2.58, 229.81) = 7.74$, $p < .001$, *partial* $\eta^2 = .080$, suggesting that the extent to which positively valenced words were mapped onto positive choices varied by word dimension. Follow-up analyses of simple effects indicated a significant effect of Word Valence for *big/small* words ($t(89) = 6.13$, $p < .001$), and *moving/still* words ($t(89) = 5.14$, $p < .001$), but not for *round/pointy* and *fast/slow* words.

If listeners were primarily employing valence to make their responses for cross-dimensional mappings, then the proportion of times that positive and negative words were mapped onto positive choices should be similar across the four word dimensions.

That there were significant differences across word dimensions suggests that additional factors beyond valence must be considered for explaining the pattern of generalization in listeners' word-to-meaning mappings. For example, listeners reliably mapped both *pointy* words (negatively valenced) and *moving* words (positively valenced) onto a "fast" choice, demonstrating that word valence cannot fully account for the pattern of cross-dimensional mappings.

General Discussion

The purpose of the current study was to examine the nature of the relationship between sound and meaning in sound symbolic foreign words. In particular, the aim of the study was to clarify the specificity of the correspondence between sound symbolic properties and their semantic correlates. In Experiment 1, listeners reliably chose the correct meaning for unfamiliar spoken words when given a choice between the words' sound symbolic meanings and their antonyms, suggesting not only that sound symbolic properties exist in dimensional adjectives across multiple unrelated languages, but also that listeners are sensitive to the sound symbolic properties of these words and use them to infer specific word meaning within a semantic dimension. In Experiment 2, foreign words were paired with choice dimensions that either matched or mismatched with word dimension. As expected, listeners reliably chose the foreign words to correspond to their correct meanings when word and choice dimension matched. However, listeners also made some reliable word-to-meaning mappings when word and choice dimension mismatched, suggesting that the sound symbolic properties of these foreign words correspond not only to specific meanings, but also to a range of meanings, with cross-dimensional mappings unequally distributed across different word-choice dimension pairings. Nonetheless, overall specificity in listeners' mappings was indicated by the finding that responses within a particular word dimension were significantly more differentiated when word and choice dimension matched than when they mismatched.

These results are consistent with other empirical findings that listeners are indeed sensitive to non-arbitrary correspondences to sound and meaning and use them to infer the meaning of unfamiliar foreign words (Berlin, 1994; Imai et al., 2008; Nygaard et al., 2009; Yoshida & Smith, 2003). Although previous studies have demonstrated cross-linguistic sensitivity to sound symbolism, results of the current study extend these findings to demonstrate consistent mappings between sound symbolic words and their meanings across 10 unrelated languages with dissimilar phonologies, thus confirming that listeners' sensitivity to sound symbolic correspondences cannot be solely attributed to knowledge of conventionalized sound-to-meaning mappings in any particular language. Further, the findings of the current study imply that in addition to non-arbitrary correspondences between sound and shape (Kohler, 1947; Maurer et al., 2006; Ramachandran & Hubbard, 2001; Westbury, 2005), and sound and size (Sapir, 1929), listeners are also sensitive to sound symbolic mappings between sound and motion-related dimensions.

Sound symbolism and organization of semantic space

Given that listeners made reliable word-to-meaning mappings not only when word and choice dimension matched, but also when they mismatched, the findings of the current study also provide evidence that clarifies the relationship between sound and meaning in sound symbolic words.

Reliable cross-dimensional mappings between word and meaning implies shared semantic features among words that elicited similar patterns of responses. One candidate semantic feature that may underlie listeners' cross-dimensional mappings is word valence. Considered an important factor in the interpretation of word meaning (Corrigan, 2007; Osgood, 1969), word valence could have affected listeners' responses such that words sharing similar valence ratings could have had similar patterns of mappings. For example, the more positively valenced words in each dimension (*big, round, fast, moving*) could have been consistently been mapped onto the more positive choice dimension endpoints. However, our results indicate that there were significant differences across word dimensions in the proportion of times that positive and negative words were mapped onto positive choices suggesting that beyond valence, additional factors should be considered for explaining the pattern of generalization in listeners' cross-dimensional mappings.

One possibility is that words sharing similar patterns of mappings may have similar values along particular semantic dimensions share particular higher order semantic features, or occupy similar regions of semantic space. Osgood's (1969) semantic differential model, for example, claims that words rated similarly along the dimensions of evaluation (good/bad), potency (strong/weak), and activity (fast/slow) are semantically related. Derived from participants' judgments of the similarity between pairs of words, these ratings were analyzed using multidimensional scaling methods, producing a series of orthogonal vectors that explained the variance in participants' responses (Osgood, 1969; 1976). Further, in an auditory lexical decision task, Wurm, Vakoch, and Seaman (2004) demonstrated that participants' response times to nouns varied as a function of Osgood's three dimensions, suggesting that semantic relatedness effects occur early in lexical processing. That listeners in Experiment 2 of the current study reliably chose *big*, *pointy,* and *fast* words to mean "moving," therefore, may imply that these words, or referents that have big, pointy, and fast as features, have similar values for evaluation, potency, and/or activity. This will be an important direction for future research.

Another source of semantic relatedness that could have influenced listeners' cross-semantic responses is that words with similar patterns of mappings may share certain perceptual and functional features (De Deyne, Peirsman, & Storms, 2009; McRae, Cree, Seidenberg, & McNorgan, 2005; McRae, de Sa, & Seidenberg, 1997). It is possible that the words in the current study which were reliably mapped to a particular dimension endpoint share certain perceptual features or have co-occurring features. That slow objects may often be round, for instance, could have influenced listeners to map both word meanings to a round choice.

A related possibility is that the foreign word meanings tend to co-occur in natural language. The Latent Semantic Analysis (LSA) (Landauer & Dumais, 1997) and the Hyperspace Analogue to Language (HAL) (Burgess & Lund, 1996) theories are two models of linguistic meaning which posit that word meaning is represented by vectors connecting features in space. LSA considers the reoccurrence of words across semantically related texts, and HAL considers word-word co-occurrences within a corpus of text. For both models, semantic similarity is determined by the strength and distance between vectors. The semantic similarity predicted by such models has been shown to facilitate lexical processing. In a visual lexical decision task, Lund, Burgess, and Atchley (1995) found that participants' response latencies were significantly shorter when primes preceded a semantically similar or associated word than when they preceded an unrelated word, suggesting that the semantic vectors in high-dimensional semantic space models correspond to participants' conceptualization of semantic relatedness and facilitate their processing of target words followed by semantically similar primes. In Experiment 2 of the current study, *pointy*, *moving*, and *fast* words were all mapped to pointy, moving, and fast choices. In an LSA matrix comparison of these three words (http://www.lsa.colorado.edu), *fast* is more similar to *moving* (.47) than to *pointy* (.06), suggesting that although linguistic co-occurrence may contribute to listeners' cross-dimension mappings, it cannot fully account for the pattern of generalization in sound-to-meaning mappings.

Yet another possibility is that words sharing similar patterns of mappings may have similar magnitude representations. Magnitude is often conceptualized in terms of quantitative, bipolar dimensions (Holyoak, 1978; Smith & Sera, 1992). A particular level of loudness, for example, can be conceptualized as a measureable quantity, namely one of more or less sound. As dimensional adjectives, the words used in the current study can likewise be construed as labels for measurable quantities. *Big* and *small* are measures of size, *round* and *pointy*, measures of angularity, and *fast*, *slow*, *moving*, and *still* as measures of speed. Words with similar patterns of sound-to-meaning mappings may then have similar quantities of 'more' or 'less' in their respective dimensions.

These possibilities imply that the words which elicited similar patterns of responses share certain semantic features. However, it is possible that it is *not* the shared semantic features that elicit cross-dimensional mappings, but that the same sound structures are recruited for multiple meanings in natural language because context constrains meaning. According to this account, cross-dimensional mappings may occur among semantically *unrelated* words and meanings to minimize contextual confusion. That *moving* words were chosen to mean "big" would then be attributed to these words' supposed semantic distinctiveness.

Mechanisms underlying sensitivity to sound symbolism

One proposed mechanism for listeners' sensitivity to sound symbolic words implicates the role of embodied theories of language processing. Embodied theories of meaning posit that exposure to linguistic units, such as words, allows the listener to simulate relevant aspects of experience that are associated with the words' referents (Barsalou, 2003; Gibbs, 2001; Glenberg & Robertson, 2002; Zwaan, 2004). A semantic judgment task by Setic and Domijan (2007) provides one example of this phenomenon. In this study, participants responded more quickly to words for flying animals when they were presented at the top of a visual display than when they were presented at the bottom, whereas words for non-flying animals were responded to more quickly when they were presented at the bottom of the display than when they were presented at the top. These results suggest that representations of perceptual experiences are reactivated during lexical processing and thus facilitate the comprehension of spoken words (Setic & Domijan, 2007). Auditory presentation of the sound symbolic words in the current study could have activated representations of perceptual experiences associated with them, such as those of a speaker's lips uttering the words (Ramachandran & Hubbard, 2001). Thus, given that sound symbolic words may activate embodied representations of experiences that are associated them, it is possible that perceptual experiences associated with the words affected listener's judgments about what the sound symbolic words mean.

A second potential mechanism underlying listeners' sensitivity to sound symbolic words implies cross-modal activation between visual and auditory cortices (Ramachandran & Hubbard, 2001). According to this claim, representations of spoken words map non-arbitrarily onto representations of the visual features of the word or the speakers' lip, tongue, and vocal tract movements when uttering the word. In Kovic, Plunkett, and Westermann (2010), participants learned to label novel objects as *mots* and *riffs* in either a congruent condition, in which rounded objects were labeled as *mots*, or an incongruent condition, in which angular objects were labeled as *mots*. At test, participants decided whether object-label pairs were matched or mismatched. ERP results indicated significant differences in brain-wave responses between congruent and incongruent conditions such that stimuli in the congruent condition, but not the incongruent condition, elicited early, negatively peaking waves, implying earlier and faster integration of auditory-visual information in response to sound symbolic words. Thus, an interaction between the auditory and visual cortices may affect listeners' responses to non-arbitrary pairings between sound and meaning.

The current findings provide evidence that sound symbolic properties exist in dimensional adjectives across multiple unrelated languages. Listeners are not only sensitive to the sound symbolic properties of these words, but also use them to infer word meaning. Further, although overall specificity was found for listeners' sound-to-meaning mappings, listeners also made some reliable word-to-meaning mappings when word and choice dimension mismatched, suggesting that the sound symbolic properties of these foreign words correspond to multiple meanings.

One concern is the extent to which this pattern of reliable cross- dimensional mapping can be attributed to the structure of the task. Given that the task involved a two-alternative forced choice between two antonyms within a particular semantic dimension, it is possible that listeners' choices reflected decisions made under constrained circumstances unlikely to occur in a natural linguistic setting. A task requiring listeners to make a choice between words in two or more dimensions may further clarify the relationship between sound symbolic properties and their semantic correlates.

Another concern is that given our participants were all native English-speaking monolinguals, it is possible that listeners' choices were affected by their knowledge of English language conventions. Listeners could have associated the foreign sound symbolic words with similar-sounding English words before making their responses, thereby basing their choices on the sounds of elicited English words, not on the acoustic and phonetic properties of the foreign words they heard. That listeners commonly reported the foreign words' similarity to English words as a basis for making their decisions suggests that this is a possibility. However, given that the sound symbolic words employed cross-cut 10 unrelated languages with different phonologies, it is unlikely that the pattern of responses in the current study were due exclusively to within-language conventions. Further, additional studies have found that both Japanese- and English-speaking children are sensitive to the sound symbolic properties in Japanese mimetic words (Imai et al., 2008; Kantartzis et al., in press), indicating cross-cultural sensitivity to sound symbolism. Maurer et al. (2006) found sensitivity to sound symbolic words in 2.5-year-old children, suggesting that this sensitivity emerges before achieving fluency in a particular language. Future studies should examine listeners' sensitivity to sound symbolic correspondences in native speakers of additional languages and ages to further inform the role of within-language conventions.

The current study investigated the specificity of the correspondence between sound symbolic properties and meaning. Results demonstrated that native English-speaking monolinguals are sensitive to the sound symbolic properties of sound symbolic foreign words in 10 unrelated languages and that they use these properties to reliably infer correct word meaning. Although overall specificity was found in listeners' responses, sound symbolic properties facilitated word-to-meaning mappings within a range of associated semantic dimensions, suggesting that overlapping semantic features among these dimensions may influence listeners' processing of sound symbolic words. Taken together, these findings imply a complex relationship between spoken words and their meanings that encourages a reconceptualization of the absoluteness of the arbitrariness assumption and the functional significance of sound symbolic words in natural language.

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Table 1

Experiment 2: Word and choice dimension pairings across conditions

	Choice Dimensions			
Foreign Words	Condition 1	Condition 2	Condition 3	Condition 4
big small	**big/small**	moving/still	round/pointy	fast/slow
round pointy	fast/slow	**round/pointy**	moving/still	big/small
fast slow	moving/still	big/small	**fast/slow**	round/pointy
moving still	round/pointy	fast/slow	big/small	**moving/still**

Table 2

Experiment 2: Reliable mappings

Choices	Big	Small	Round	Pointy	Fast	Slow	Moving	Still
Foreign word meanings reliably mapped to each choice	big moving	small	round slow	pointy fast moving	fast pointy moving	slow round still	moving big pointy fast	still small round

Figure captions

Figure 1. Experiment 1: Proportion agreement for each of the eight word meanings

Figure 2a. Experiment 2: Proportion Big responses for each word meaning

Figure 2b. Experiment 2: Proportion Round responses for each word meaning

Figure 2c. Experiment 2: Proportion Fast responses for each word meaning

Figure 2d. Experiment 2: Proportion Moving responses for each word meaning

Figure 3. Experiment 2: Antonym Difference Scores for each choice dimension as a function of whether word-choice dimension matched or mismatched

Figure 4. Experiment 2: Proportion positive responses for positive and negative words in each word dimension

Figure 1

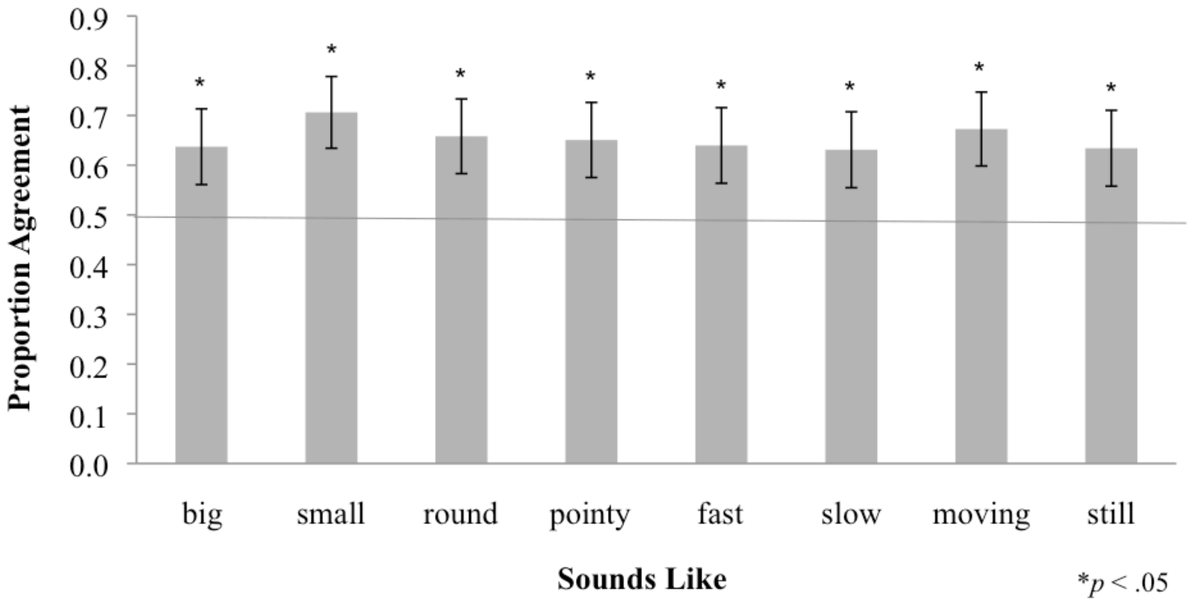

0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Proportion Agreement
*
big
small
round
pointy
fast
slow
moving
still
Sounds Like
*p < .05

Figure 2a

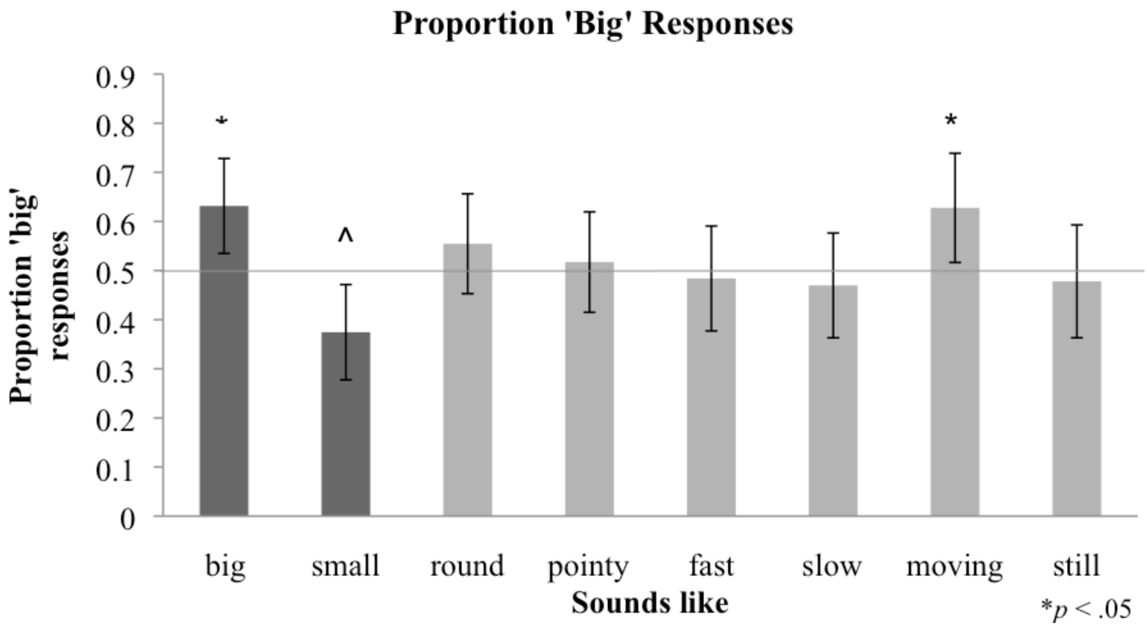

Proportion 'Big' Responses
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Proportion 'big' responses
*
^
*
big
small
round
pointy
fast
slow
moving
still
Sounds like
*p < .05

Figure 2b

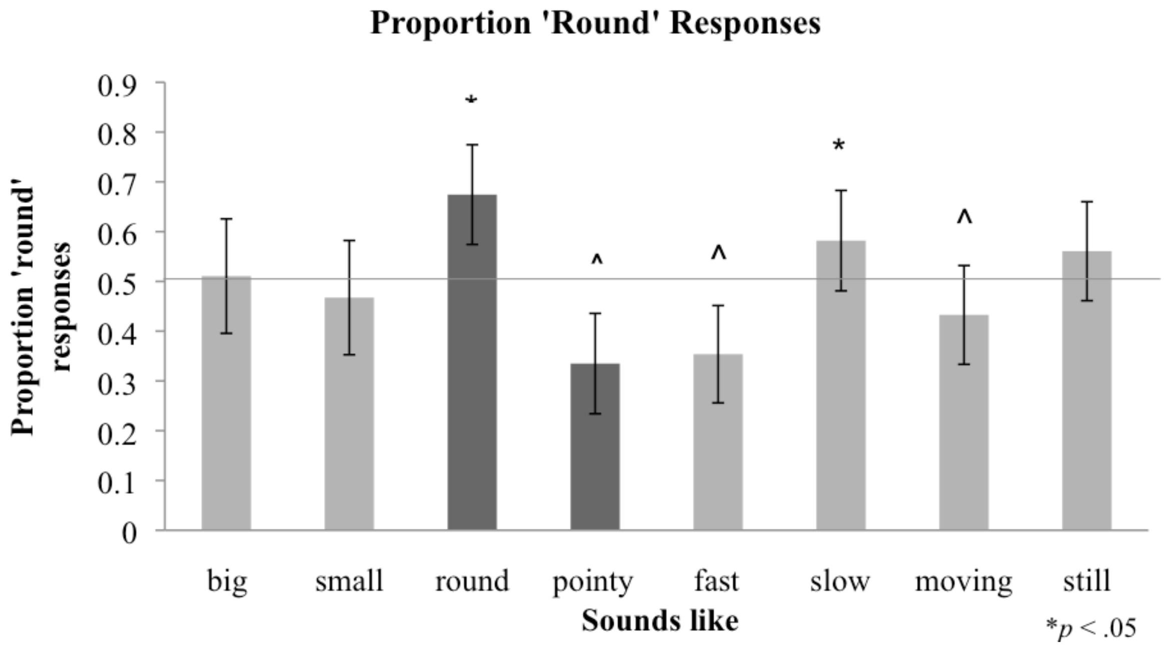

Proportion 'Round' Responses
Proportion 'round' responses
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
*
*
^
^
^
big
small
round
pointy
fast
slow
moving
still
Sounds like
*p < .05

Figure 2c

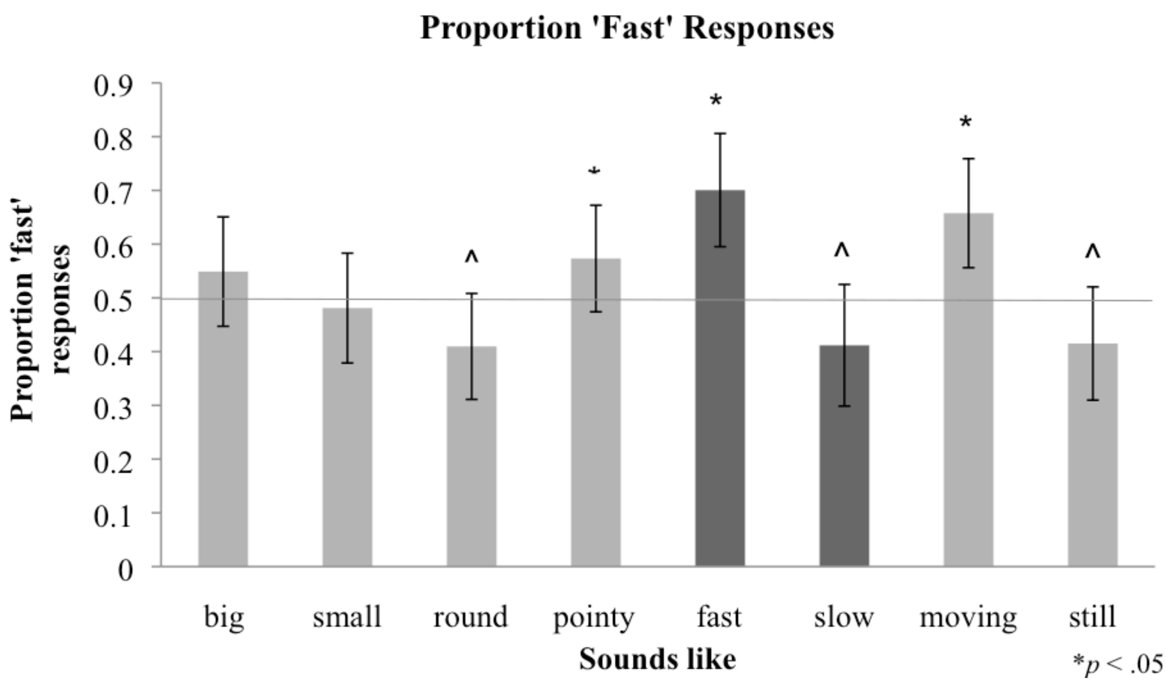

Proportion 'Fast' Responses
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Proportion 'fast' responses
*
*
^
^
^
big
small
round
pointy
fast
slow
moving
still
Sounds like
*p < .05

Figure 2d

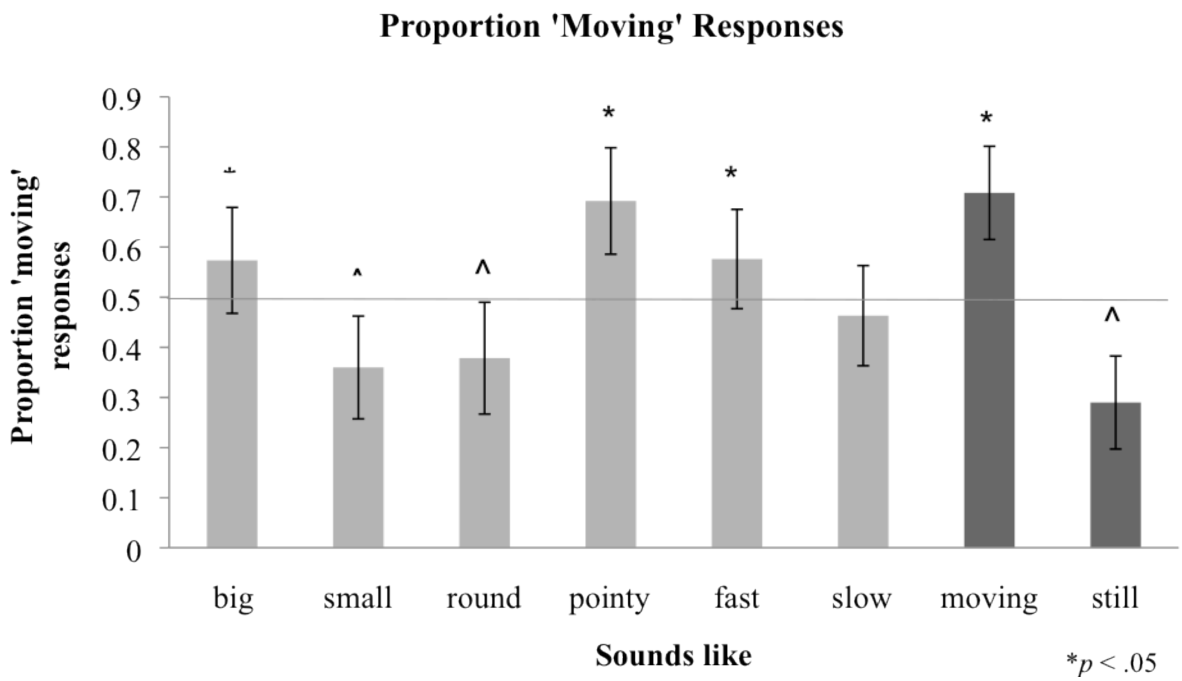

Proportion 'Moving' Responses
Proportion 'moving' responses
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
*
*
*
^
^
^
big
small
round
pointy
fast
slow
moving
still
Sounds like
*p < .05

Figure 3

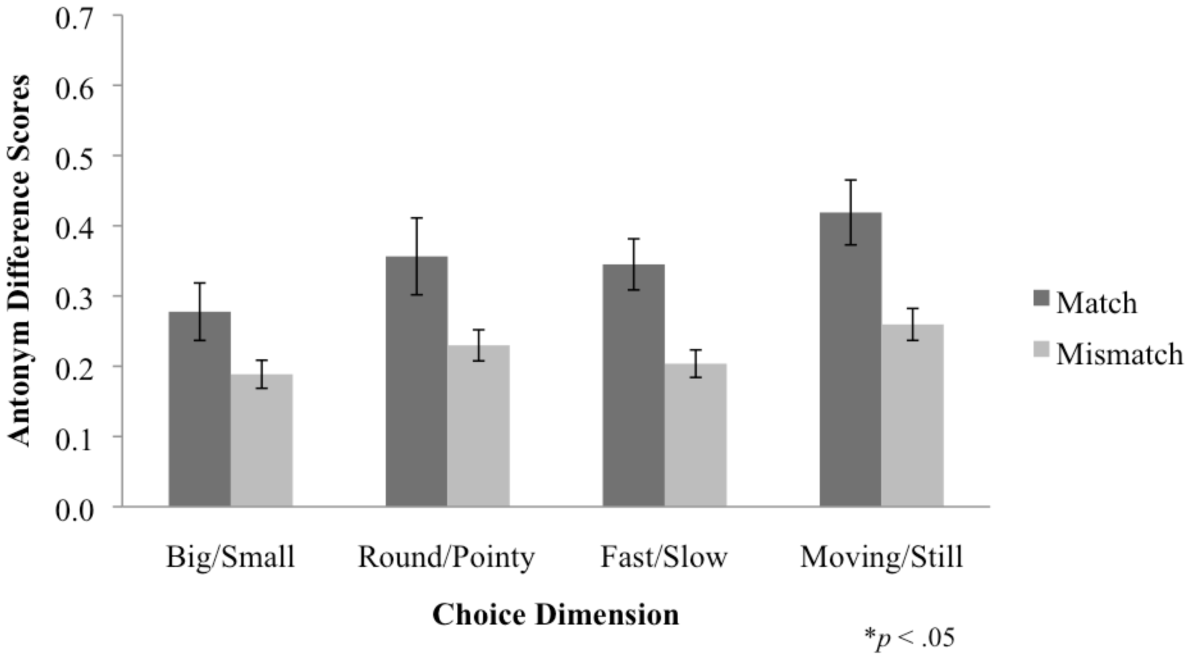
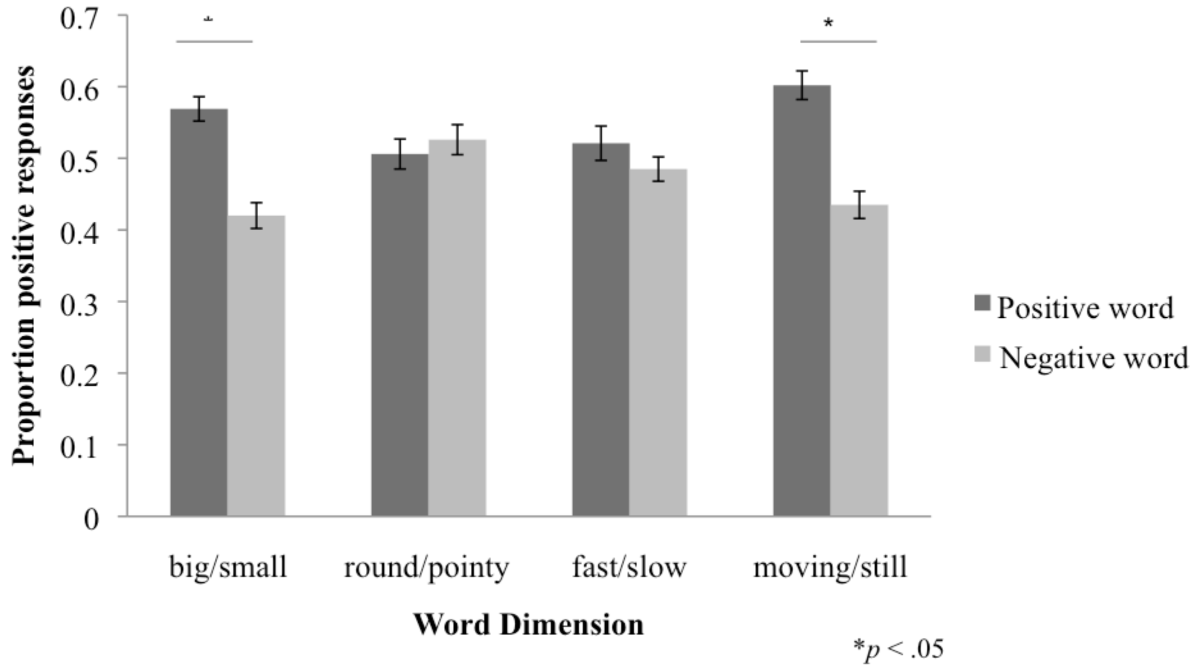

0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Antonym Difference Scores
Match
Mismatch
Big/Small
Round/Pointy
Fast/Slow
Moving/Still
Choice Dimension
*p < .05

Figure 4


0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Proportion positive responses
*
*
Positive word
Negative word
big/small
round/pointy
fast/slow
moving/still
Word Dimension
*p < .05

Appendix

Word	**Sounds Like**	**Actual Meaning**	**Language**
bamba	big	big	Yoruba
booku	big	big	Yoruba
buyuk	big	big	Turkish
ghanda	big	big	Gujarati
hen xiao	big	small	Mandarin
koskocaman	big	big	Turkish
raksasa	big	big	Indonesian
ta gun	big	small	Korean
urias	big	big	Romanian
zada	big	big	Gujarati
flink	small	big	Dutch
iri	small	big	Turkish
nanu	small	small	Gujarati
periya	small	big	Tamil
peru	small	big	Tamil
scurt	small	small	Romanian
sempit	small	small	Indonesian
shou	small	small	Mandarin
ufak	small	small	Turkish
xia xiao	small	small	Mandarin
ajubaju	pointy	round	Gujarati
berbentuk lingkaran	pointy	round	Indonesian
bergerigi	pointy	pointy	Indonesian
dhembezuar	pointy	pointy	Albanian
ding zi ban	pointy	pointy	Mandarin
geu jo ka da	pointy	pointy	Korean

kesici	pointy	pointy	Turkish
mprehte	pointy	pointy	Albanian
on yong hi da	pointy	round	Korean
tun gu tru ma da	pointy	round	Korean
bombat	round	round	Romanian
bulat	round	round	Indonesian
bute	round	round	Albanian
gbun	round	pointy	Yoruba
goad	round	round	Gujarati
lun	round	round	Mandarin
maje	round	pointy	Albanian
mu	round	pointy	Yoruba
urunta	round	round	Tamil
yuan	round	round	Mandarin
acele	fast	fast	Turkish
ager	fast	fast	Romanian
athiteeveram	fast	fast	Tamil
atik	fast	fast	Turkish
cepat	fast	fast	Indonesian
grabit	fast	fast	Romanian
man tun tun	fast	slow	Mandarin
sipsak	fast	fast	Turkish
thamathamaka	fast	slow	Tamil
veraivu	fast	fast	Tamil
aasu	slow	fast	Tamil
dheere	slow	slow	Gujarati
domol	slow	slow	Romanian
gjalle	slow	fast	Albanian
laju	slow	fast	Indonesian

na len	slow	fast	Korean
pa lun	slow	fast	Korean
snel	slow	fast	Dutch
uzun suren	slow	slow	Turkish
yara	slow	fast	Yoruba
achaivillatha	moving	still	Tamil
bergesas-gesas	moving	moving	Indonesian
berjalan	moving	moving	Indonesian
calisan	moving	moving	Turkish
hareketli	moving	moving	Turkish
inmarmurit	moving	still	Romanian
nilaiyana	moving	still	Tamil
palevizshem	moving	still	Albanian
pu dong sa se i da	moving	still	Korean
um ji gi he ga nun	moving	moving	Korean
asai	still	moving	Tamil
chaltu	still	moving	Gujarati
fo	still	moving	Yoruba
gerak	still	moving	Indonesian
katham	still	moving	Tamil
notr	still	still	Turkish
sare	still	moving	Yoruba
stheer	still	still	Gujarati
teu da	still	moving	Korean
yi dong	still	moving	Mandarin