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Michelle R. Linch 4/10/13

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by

Michelle R. Linch

Adviser

Lynne Nygaard, PhD

Program in Linguistics

Lynne Nygaard, PhD
Adviser

Laura Namy, PhD
Committee Member

Lisa Dillman, MA
Committee Member

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Lynne Nygaard, PhD
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Abstract

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A basic assumption concerning natural language is that the relationship between sound and meaning is arbitrary. The sounds of language are thought to bear no resemblance to the objects and events to which they refer. However, many examples of non-arbitrary correspondences between sound and meaning have been found across languages, and language users are sensitive to this type of sound symbolism. The goal of the current research was to explore the role of sound symbolism in the applied domain of product labeling. A set of studies examined language users' sensitivity to sound symbolism in product labels and the features of labels, products, and tasks that influence product-label pairings. Across experiments, participants were asked to match printed labels with pictorial representations of products. Pairs of labels and product pictures reflected five dimensions: light/dark, fast/slow, light/warm, small/large, and light/heavy. In Experiments 1 and 2, product labels contrasted in a single vowel, and the task was varied to highlight differences in the labels or in product pictures. In Experiment 3, product labels contained vowel and consonantal sound symbolism. Results showed that participants' sensitivity to sound symbolic correspondences between labels and products varied as a function of the label type. Consistent mappings were made for labels containing multiple sound symbolic segments relative to labels containing a single contrasting segment and primarily for dimensions related to size. These findings suggest that sound symbolic correspondences may highlight relevant object or product dimensions for consumers and could be used to influence product appeal or memorability.

Keywords: sound symbolism, arbitrariness, labeling, cross-modality

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Introduction

One basic assumption concerning language is that the relationship between sound and meaning is arbitrary. The sounds of language are thought to bear no resemblance to the objects, events, or concepts to which they refer (de Saussure, 1959). For example, the English word *dog* and the Spanish word *perro* both refer to the same object, yet appear to have very different sound inventories. This arbitrariness assumption is even considered to be a "universal principle" intrinsic to the nature of language (Greenberg, 1957). The arbitrary nature of language allows for the creation of new word forms without the constraint of similar sound-to-meaning correspondences. Word to referent pairings can be formed from an infinite number of sound combinations. The production of arbitrary sounds in natural language allows speakers to easily learn the vocabulary of their language system because semantically related words are phonemically distinguishable (Gasser, 2004). Gasser presents the example of labeling a cow and a sheep. The probability of confusing these words is less than if they had similar sounding names such as *feb* and *peb*, suggesting that arbitrariness between names increases efficiency in communication.

Despite the arbitrary nature of natural language, numerous instances of non-arbitrary correspondences between the sounds of words and their meanings, or *sound symbolism*, have been found to exist. Sound symbolism occurs when the sound properties of the word resemble a characteristic of the object it represents. Non-arbitrary sound to meaning mappings have been found to exist across languages and language families (Nuckolls, 1999). Additionally, listeners demonstrate a sensitivity to sound symbolic words cross-linguistically, challenging the view that language is exclusively arbitrary (Kunihira, 1971; Nuckolls, 1999).

One variety of sound symbolism is onomatopoeia. Words such as *buzz*, *bang*, and *achoo* reflect the sounds they describe. Although onomatopoeia is a type of sound symbolism based on sound-to-sound correspondence, this type of mapping comprises a limited class of words within any language. In addition, languages recruit different sound segments for onomatopoeia, such as *woof woof* in English, *guau guau* in Spanish, and *ham ham* in Romanian, suggesting that each language has its own onomatopoeic conventions.

Another type of non-arbitrary sound to meaning correspondence is *phonesthemes*. This variety of sound symbolism consists of an assortment of phonemic clusters where each one represents a specific meaning. For instance, in the words *snore*, *snout*, *sniff*, and *sneer, sn-* refers to *nose*. Other examples of English phonesthemes include *gl-* for words relating to light and *sm-* for words dealing with force or contact. However, the phonemic clusters *gl-, sm-* and *sn-* may not refer to these meanings in other languages. Therefore, phonesthemes seem to be language specific such that the sound to meaning correspondences also arise from linguistic convention.

Another type of non-arbitrary sound to meaning correspondences is *mimetics* (Hinton, Nichols, & Ohala, 1994; Imai, Kita, Nagumo, & Okada, 2008; Nuckolls, 1999). These sets of words refer to a unique class of sound symbolism found in many different languages (Hinton, Nichols, & Ohala, 1994; Nuckolls, 1999; Voeltz & Kilian-Hatz, 2001) and refer to motion events in addition to tactile, visual or emotional experiences. Unlike onomatopoeia and phonesthemes, mimetics span a more varied series of semantic domains. For example, in Japanese; *goro* refers to a heavy object rolling and *nurunuru* means "being slimy" (Imai, Kita, Nagumo, & Okada, 2008). Nevertheless, these examples also represent a limited class of words that are not consistent across languages.

This paper focuses on examples of sound symbolism that go beyond these specialized classes of words. This variety of sound symbolism may be more general both within and across languages and is based on direct correlates between specific sounds and meaning dimensions. For example, high front vowels such as /i/ and /ɪ/ correspond to meanings such as pointy, small, and sharp (Kohler 1947; Maurer, Pathman, & Mondloch, 2006; Ramachandran & Hubbard, 2001). This research aims to examine the nature of this type of sound symbolism as it is utilized in natural language. Specifically, this study investigates the extent to which listeners are sensitive to sound symbolic cues that correspond to perceptual characteristics by examining the relationship between sound symbolic labels matched to the characteristics of particular products. Language users' sensitivity to sound symbolic object-label pairings will be evaluated by assessing their ability to match labels containing particular sound characteristics to pictorially represented products.

Object recognition and sound symbolism

Throughout the last century, psycholinguistic research has provided evidence for listener's sensitivity to non-arbitrary sound to meaning mappings. Linguist Edward Sapir (1929) examined English speakers' sensitivity to sound to meaning mappings relating labels to object size. Sapir presented participants with labels such as *mil* and *mal* and asked which word corresponded to a large table and a small table. Listeners consistently labeled the small table as *mil* and the large table as *mal,* demonstrating sensitivity to the sound symbolic properties of these words. Subsequent to Sapir, Köhler (1947) studied listeners' sensitivity to sound to meaning correspondences in the domain of shape. Köhler presented participants with labels such as *maluma* and *takete* and found that people consistently matched *maluma* with round objects and *takete* with pointy objects (Kohler, 1947). Recent investigations reinforce Sapir and Kohler's findings. Maurer, Pathman, and Mondloch (2006) found that English-speaking adults and children associate non-words like *bouba* with round objects and *kiki* with angular objects. These experiments suggest that low vowels, or ones that are produced with the speakers' tongue low in the mouth like /a/ and /u/, correspond to rounded shapes and high front vowels, or ones that are produced with the speakers' tongue high and forward in the mouth such as /i/ and /e/, correspond to angular objects.

Sound symbolism has also been found to facilitate word learning in children and in adults. For instance, in Nygaard, Cook, and Namy (2009), monolingual English speakers were asked to learn the English translations of Japanese antonyms. In the learning phase, participants heard a Japanese word paired with its correct English translation, the English antonym of its correct translation, or an unrelated word. Participants learned the correct translations for the Japanese words in less time and with greater precision than the unrelated pairings. These findings reveal that sound symbolism may provide an advantage in word learning as participants more readily learned Japanese vocabulary when sound symbolic relationships between Japanese antonyms and meanings were preserved than when sound and meaning was unrelated.

Sound symbolism also influences language acquisition in young children. Imai et. al. (2008) demonstrated that two- to three-year-old Japanese children were sensitive to sound symbolism in novel Japanese mimetic words. When they taught three year olds non-sound symbolic novel verbs, the children were not able to generalize verb meanings to novel contexts with different actors performing the same action. However, children were able to generalize meanings across instances when the verbs had a sound symbolic relationship to the action. For example, when children were presented with the novel label, *chokachoka*, they accurately matched it with a visual representation of "fast walking with small steps" when asked to choose between two videos. Availability of sound to meaning mappings appeared to help children determine the word's meaning and generalize that learning to novel contexts. This work suggests that young children are sensitive to sound symbolism and use sound symbolic cues in early word learning. The notion that young children may learn novel sound symbolic words with greater accuracy than non-sound symbolic words supports that they are using cross-modal sensory-perceptual mappings, in this case between auditory and visual motion information.

A follow up study conducted by Kantartzis, Imai, and Kita (2011) examined the sensitivity of English-speaking children to the same novel Japanese sound symbolic verbs. In this study, children were asked to learn both novel sound symbolic and non-sound symbolic verbs and generalization in the use of the novel verbs they learned was assessed. The results showed that the children learned the sound symbolic word to meaning pairings at a faster rate than the random pairings and generalized that learning to novel contexts, just like the Japanese-speaking children. This study illustrates that listeners are sensitive to sound symbolic cues cross-linguistically, as both young Japanese and English speakers were able to learn the sound symbolic labels at a faster rate.

Further evidence for cross-linguistic sound symbolism comes from a study by

Ultan (1978) that examined 136 languages for evidence of diminutive sound symbolism represented by high, front vowels. Results revealed that a wide variety of languages represent size using similar phonological features. Ultan also found that proximity or distance is largely represented by these same attributes cross-linguistically; high, front vowels represent proximal referents and low, back vowels signify distal ones. This research supports the theory that sound symbolic features represent semantic dimensions similarly across languages.

Another example of cross-linguistic sound symbolism is in bird and fish nomenclature. Berlin (1992; 1994; 2005) investigated the non-arbitrary nature of the sounds that constitute fish and bird names in vastly diverse languages. In studying Malay and Huambisa (a language used by the Jívaro people in the Amazon), Berlin (1992) found that names for smaller fish and birds often contain the vowels /i/ and names for larger fish contain the vowels /a/ and /u/. Additionally, bird names often included voiceless stops (e.g., /p/, /t/, /k/) and fish names included nasal consonants (e.g., /n/ and /m/). Berlin found similar patterns in animal names across 24 South American Indian languages. These findings are consistent with previously mentioned evidence supporting the mapping between high, front vowels and smaller objects and low, back vowels with larger objects. This study also provides evidence for cross-linguistic sound symbolism in natural language.

Since language users are sensitive to sound symbolism across languages (e.g., Imai et al., 2008; Nygaard et al., 2009), the same sounds may be used cross-linguistically to represent characteristics that are inherent in objects in our environment (e.g., /a/ and /u/ corresponding to rounder shapes and /i/ and /e/ to angular objects). These same vowel sounds, /i/ and /e/ and /a/ and /u/, have been found to represent size as well. In previous studies, participants demonstrate sensitivity between small objects and high, front vowels and large objects with low, back vowels (Maurer et. al., 2006; Sapir, 1929). Beyond vowels, sound symbolic properties have been shown to exist in consonants as well. Consonants have been shown to correspond to a variety of characteristics such as fast/slow, big/small, and moving/still in addition to round/pointy (Klink, 2000; Mathur et al., 2010; Nuckolls, 1999; Spector & Maurer, 2011). One instance of sound symbolism in natural language is in the word *pointy* itself, as the consonants *p/t/k/b/d/g/,* or o*bstruents* are often associated with sharp, coarse objects, as they are harsher sounds. Upon articulating an obstruent, the air is obstructed in the throat and then suddenly released. The manner of articulation physically mirrors the characteristics obstruents represent: harsh, jagged or fractured (Nielsen & Rendall, 2011; Westbury, 2005).

The relationship among articulation and meaning is demonstrated in a study conducted by Parise and Pavani (2011). After seeing triangles and dodecagons, participants were asked to say *ah* and continue this vocalization until the next question. The results showed that the visual stimuli consistently produced similar vocal responses across participants; participants responded to seeing triangles with a softer /a/ response then dodecagons, which participants were louder in articulating. The results suggest that a specific visual stimulus caused speakers to produce particular sounds, and this response is consistent across speakers. This finding suggests that consistent sound to meaning mapping may arise across languages, because language users would spontaneously produced the same sounds to describe particular objects.

Further evidence suggests that sound symbolism is often recruited when people are asked to name objects. In an experiment by Berlin (2006), participants invented labels in CVCVCV (C = consonant; V = vowel) form for the rounded and pointy objects used in Kohler's (1947) takete-maluma experiment. The participants' invented names demonstrated systematic mappings between sound and object properties. Participants consistently labeled pointed objects with more front vowels and rounded objects with back vowels, suggesting that participants had a tendency to associate certain sounds or phonological features of language with certain visual attributes. Taken together, these results suggest that visual characteristics (e.g., round/pointy, big/small) of objects and events correspond cross-modally with articulations such as /i/, /e/, /a/, /o/, and /u/ and their acoustic consequences. Sound symbolism may serve to connect our sensory perceptual experience with the form of our communication.

Sound symbolism in product naming

Sound-to-meaning correspondences manifest themselves in a number of different ways in modern language. In the domain of product names, studies have examined the relationship between brand names and specific attributes of a product (Klink, 2000; Lowrey, Shrum, & Dubitsk, 2003). Research suggests that speakers of English are sensitive to the correspondences between the sound structure of product labels and characteristics of the products (Abel & Glinert 2008; Klink 2000; Yorkston & Menon 2000). This literature establishes a foundation for the current research, which explores the role of sound symbolism in pictorially presented product-label pairings or preferences.

Abel and Glinert (2008) investigated the effect of sound symbolism in chemotherapy drug names. The authors found that the voiceless consonants /p/, /t/, /k/, /f/, /s/, which are associated with lightness and fastness, were found in chemotherapy drug names reliably more often than in a Standard American English reference database. For example, the name for one brand of hormonal therapy treatments most commonly used by doctors is *Herceptin*. As suggested by the authors, this label contains voiceless consonants, in this case /p/ and /t/, in addition to only high, front vowels, all of which are associated with lightness and fastness. As a result, doctors and patients perceived these drugs to be quicker and less painful, suggesting that sound symbolism within labels relates information about the drugs to the consumer. Thus, the sound symbolic properties of a label allow drug makers and marketers to highlight the perceived efficacy of their products. These findings imply that the sound properties of a label enable companies to describe favorable characteristics of a product with the name as their medium.

Another example of sound symbolism in brand labels comes from an experiment by Yorkston and Menon (2004). In this study, participants were asked to evaluate brand names for ice cream based on the characteristics with which ice cream is associated, such as rich, creamy, and smooth. Overall, participants associated these features with the label *frosh* more often than with the label *frish.* The contrast of sounds /a/ and /ɪ/ and the mappings to particular properties of ice cream suggests that the /ɪ/ from *frish* conveys a less thick or creamy ice cream, whereas the /a/ in *frosh* implies a creamier one. This finding is consistent with previous studies that provide evidence for sensitivity to sound symbolic correspondences and suggests that consumers may develop expectations about a product based on how the label sounds. For example, the label *frish* may not be as effective in highlighting desirable features of ice cream as *frosh* because there would be a divergence between expectations about the product and the form of the linguistic reference.

Klink (2000) investigated the correspondences between sounds in labels and product characteristics across a range of product properties. In Klink's experiment, participants were asked to evaluate the extent to which products reflected certain characteristics. He did this by highlighting a desirable trait within the given product. For example, participants were asked, "*Which ketchup is thicker?*" and then were asked to choose between the two labels (e.g., *Nidax* or *Nodax*) that best conveyed the given attribute. Results demonstrated that participants were more likely to pair a product, such as *soft toilet paper*, with its congruent sound symbolic label, *pem*, than the mismatched label, *dem*. Based on participants' judgments, the "p" sound in *pem* better reflected softness in the product because, in this instance, "p," as opposed to "d" is perceived as a less harsh consonant. Klink's research aligns with previous findings on sound to meaning correspondences, but is applied to the domain of product labels. Furthermore, these results illustrate the implications of sound symbolic brand names for marketers, highlighting that consumers may be sensitive to the relationship between a label and the desired characteristics of the product. Conveying attributes of a product implicitly through the label would be advantageous to marketers by potentially influencing consumer choice.

Despite evidence that language users are sensitive to sound symbolic cues and use them to infer object characteristics from labels, the effect of sound symbolism for naturalistic product-label pairings has yet to be explored. The current study is designed to determine if sound to meaning mappings are used in establishing product-label correspondences across a range of product properties, product types, and in situations when the relevant product dimension has to be inferred. If sound symbolism reflects potential cross modal auditory-visual connections (Spence, 2011), people may more easily associate sound symbolic labels with their matching product properties. Because the specific phonetic structure of the label corresponds to targeted characteristics of the product referent (e.g., small, large, dark, light, fast, slow), participants could use that connection as an additional cue to product preference or for remembering a product name.

The current study evaluated this hypothesis by exploring the role of sound symbolism in product-label pairings. In the first experiment, we chose labels from Klink (2000) that were minimal pairs such as *mig* and *mog*, which varied in only a single vowel segment (see Appendix A) for each pair of products. Sound segments in the labels either matched or mismatched particular characteristics of a given product. Participants completed a task in which they saw a pictorial representation of a product, such as a fast car, paired with either a sound symbolic (e.g., *gerps*) or non-sound symbolically matched label (e.g., *gorps*). The objective of using such a paradigm was to evaluate if participants were sensitive to the sound symbolism in a label-product pairing as they might be in a real-life shopping situation.

The aim of the second experiment was to evaluate whether sensitivity to label-product correspondences would be influenced by task. In this case, participants were presented with two product pictures that varied on a single dimension (e.g., fast and slow car) and chose which of the pictures best corresponded to the given label. The goal was to examine whether participants would be more sensitive to sound symbolic mappings when they had the opportunity to compare product pictures that varied along the relevant dimension.

Finally, in the third experiment, novel labels were created with segmental content that varied in both vowels and consonants. In this experiment, participants saw a novel sound symbolic label and again viewed two pictures of the same product (e.g. choosing between a small flashlight and a large flashlight when presented with *pitip*). The goal was to investigate whether the nature and number of sound symbolic linguistic segments would influence participants' sensitivity to the sound symbolic cues in each novel label and to using them to correctly identify the correct product-label pairing.

The results of this experiment may inform marketing efforts of companies by assessing whether the creation of sound symbolic labels for products enables consumers to more easily remember the names of products and influences their overall shopping preferences and choice behaviors. By using product labels to test sound symbolism, we are extending research on sound symbolism into the applied domain of consumer behavior, providing an example of a modern situation in which English speakers may be swayed as consumers based on the sound symbolic properties of a label.

Experiment 1

The purpose of this experiment was to examine whether listeners would reliably map sound symbolic product labels to their intended pictorial referents. In Klink (2000), participants were presented with two contrasting novel labels for a product and asked which of the two labels best corresponded to the target product (e.g., "Which laptop seems smaller? *Detal* or *Dutal*?"). In the current study, we examined to what extent participants would make similar word-referent mappings when presented with pictorial images of products. Listeners heard a subset of the novel product labels used in Klink (2000) that were reliably mapped to particular product characteristics (e.g., *esab* and *usab* for light and dark beer, respectively). However, in this task listeners completed a forced-choice task that was designed to determine whether the sound symbolic cues identified by Kink (2000) would reliably map onto *pictorial* representations of particular product characteristics. A key aspect of this experiment was to determine if sound symbolic cues would be associated with product features when the presentation of the dimension of interest was in a naturalistic picture format. Given Klink's (2000) findings that participants reliably matched novel labels to their intended product referents, we predicted that participants in the current study would match the product labels with the corresponding product pictures in a forced-choice task.

Method

Participants. Participants were 17 native English-speaking undergraduate students from Emory University who reported no history of speech or hearing disorders. Participants received course credit for their participation.

Stimuli. Verbal stimuli consisted of 20 pairs of novel product labels that represented five dimensions: warmth (warm/light), heaviness (heavy/light), darkness (dark/light), size (big/small), and speed (fast/slow). The verbal stimuli were taken from Klink (2000) and consisted of minimal pairs (i.e., one vowel segment different between members of a pair) that represented the contrast within each dimension. For example, for the size dimension, *lipush* represented a smaller flashlight and *lupush* with a larger flashlight. Previous findings suggest that vowels such as /ɛ/ are associated with smallness, and /u/ with largeness (Sapir 1929). Appendix A shows the 20 pairs of words used in the present study.

For each of the five dimension categories, there are four pairs of product pictures (e.g., light/warm socks, hats, gloves, and shoes). The four picture pairs in each dimension corresponded to specific products and were normed to confirm that each picture represented the intended dimension. In a forced-choice task, participants (n = 24) viewed each picture (e.g., a fast car) and chose which of two written labels (e.g., fast/slow) best corresponded to the target picture. Each participant viewed a total of 287 pictures, with up to five pictures representing each of the two opposite characteristics of each dimension. Of the pictures presented, those for which participants responded with at least 80% consistency were chosen for use. The final picture set consisted of 40 total pictures, one for each of the twenty pairs of product labels (e.g. fast train and slow train). Appendix B includes all the images.

Procedure. The purpose of this experiment was to examine whether participants viewed the labels as sound symbolically corresponding to the pictorial representation of the product. On each trial, participants viewed a product picture (e.g., fast boat) at the top of the computer screen and saw two printed labels below and to the right and left of the product picture. One of the printed labels was chosen, again based on Klink (2000), to match the particular attribute of the product (e.g., fast) and the other label was chosen to match its opposite (e.g., slow). Participants were asked to chose which label (e.g. *nellar* and *nullar* for fast boat and slow boat) best corresponded to the target picture and to indicate their response with a key press. Half of the participants (Condition 1) viewed twenty of the product pictures (one picture from each of the four picture pairs for each of the five dimensions) and the other half viewed the set of pictures with the opposite attributes (Condition 2). The order of the stimuli presentation was randomized, and the horizontal location of the verbal labels (left vs. right) was counterbalanced.

Results and Discussion

To examine the mean proportion of participant responses in matching product labels to their intended pictorial referents, one-sample *t*-tests were used to compare performance to chance. This analysis determined if participants demonstrated sensitivity to sound symbolism in the minimal pair labels by reliably matching the label to the product picture for both dimension and word meaning. Fig. 1 illustrates the mean proportion accuracy by dimension. Participants did not reliably match the dimension pairs dark/light, $t(16)=-.68$, $p=.508$, fast/slow, $t(16)=.59$, $p=.565$, heavy/light $t(16)=.22$, $p=.826$, and warm/light, $t(16)=1.23$, $p=.236$, to the intended sound symbolic label. However, participants performed at significantly below-chance levels in the dimension large/small, $t(16)=-2.28$, $p=.037$, illustrating participants consistency in their responses solely for this dimension, albeit in the opposite direction.

Performance did not significantly differ from chance for individual word meanings within dimension either, with one notable exception. The analysis revealed that participants' performance did not differ from chance for the small stimuli, $t(16)=-.29$, $p=.773$, but did for the large stimuli, $t(16)=-3.50$, $p=.003$, suggesting that the contrasting segmental information across the word pairs was sufficient to highlight sound to meaning mappings for the large product pictures. Again, however, the direction of the mapping was in the opposite direction. Performance for no other individual label-product mapping was significantly above chance. Within the dark/light dimension, participants did not reliably map either the dark, $t(16)=-.32$, $p=.750$, or the light, $t(16)=1.29$, labels to pictures in the matching task. Within the fast/slow and heavy/light dimension, participants did not consistently map fast, $t(16)=-.32$, $p=.750$, slow, $t(16)=1.17$, $p=.260$, heavy $t(16)=.37$, $p=.718$, or light $t(16)=0$, $p=1.000$, labels to pictures at significantly above chance rates. Likewise, within the warm/light dimension, participants did not reliably map warm, $t(16)=.62$, $p=.543$, or light, $t(16)=1.14$, $p=.269$, labels to pictures.

Overall, the results showed that participants did not reliably map the product labels to their intended pictorial referents (M = .50, SD = .12). Performance did not differ reliably from chance for any dimensions but the product-label pairings from the large/small dimension. This finding suggests that in general participants were not sensitive to the sound symbolic differences in the label-product pairings. One reason consistent mappings may not have been made is that in the current task, participants may not have been able to recognize the intended product dimension from the picture stimuli or the presentation of the picture stimuli. Experiment 2 addresses this possibility.

Experiment 2

The results from Experiment 1 suggested that listeners did not reliably map product labels to their intended product referents when presented with contrasting product labels. The purpose of Experiment 2 was to examine the extent to which participants would make more consistent label-product pairings when the dimension of interest was contrasted within picture pairs rather than label pairs. In Experiment 1, participants viewed a single product picture and chose which of two minimally contrasting labels corresponded best with that product. In this experiment, a single product label (e.g., *rinder*) was presented and participants were asked to choose which of two contrasting product pictures (e.g., a fast and slow scooter) best corresponded to the product label. Here, presenting two pictures simultaneously establishes a visual contrast between the dimensions. Unlike the previous experiment where the contrast was between labels, the aim of this procedure was to examine sensitivity to the label product pairings when the dimension of interest was depicted in a more explicit manner.

Participants. Participants were 44 native English-speaking undergraduate students from Emory University who reported no history of speech or hearing disorders. Participants received course credit for their participation.

Stimuli. The product labels and picture stimuli were identical to those used in Experiment 1.

Procedure. For each trial, participants viewed two pictures of the same product that differed only in the characteristic of interest at the left and right at the top of the computer screen. For example, participants viewed a picture of a slow scooter and a fast scooter and then chose which of the two pictures corresponded to the presented product label, which was presented centered below the two pictures. Unlike in Experiment 1, participants in the current experiment saw all of the 40 product pictures and verbal labels across two blocks. In the first block, participants viewed all 20 product picture pairs paired with half of the labels from each dimension and in the second block, participants viewed all 20 product picture pairs again but now paired with their contrasting labels from each dimension.

Performance in the first block was used to investigate participants' initial sensitivity to sound symbolic correspondences between products and labels. Performance in the second block was used to determine if the labels from the first block were employed as a point of reference in mapping the correct product to the label. For example, we examined to what extent there was a relationship between how participants responded when they first viewed pictures of a large and small flashlight with a label in the first block (e.g., *lipush*), and how they responded when they viewed the same pictures with a label's foil in the second block (e.g,. *lupush*). Higher response accuracies in Block 2 would demonstrate that participants were more sensitive to correspondences between the pictures and the labels, after perhaps recognizing the related minimal pairs between Block 1 and Block 2 and using this to inform their decisions.

Results and Discussion

To determine if participants reliably mapped product labels to their intended referents, one-sample *t*-tests were used to compare participants' mean accuracy to chance for each dimension and word meaning. Fig. 2 plots the mean proportion of responses in which participants matched the labels to the intended product picture. Participants reliably mapped labels to the intended referents for the dimension heavy/light, $t(42)=2.51$, $p=.016$. All other dimensions, dark/light, $t(42)=.92$, $p=.364$, fast/slow, $t(42)=.83$, $p=.411$, large/small, $t(42)=.88$, $p=.387$, and warm/light, $t(42)=-.534$, $p=.596$ were not mapped at rates significantly above chance.

Although overall participants responded significantly above chance for the heavy/light dimension, individual labels were not mapped to picture references significantly above chance, heavy, $t(42)=1.39$, $p=.173$, and light, $t(42)=1.97$, $p=.056$. Within the dark/light dimension, participants did not reliably map dark, $t(42)=-.17$, $p=.868$, or light, $t(42)=1.42$, $p=.216$ significantly above chance. The same pattern was found for the dimensions fast/slow and large small. Participants did not perform significantly above chance for fast, $t(42)=.61$, $p=.543$, slow $t(42)=-.1.76$, $p=.086$, large, $t(42)=.298$, $p=.767$, or small, $t(42)=.71$, $p=.482$, labels. Within the warm/light dimension, performance for the warm labels, $t(42)=1.36$, $p=183$, was not significantly different from chance. However, performance for the light labels, $t(42)=-2.26$, $p=.029$, was significantly below chance.

A paired t-test was performed to examine whether participants improved between Block 1 and Block 2. The results show that participants did not utilize the first block in their performance in the second block, as no significant difference between blocks was found, $t(42)= .433$, $p= .667$.

Highlighting the dimension of choice between product pictures did not appear to significantly increase the chances of participants making a sound to meaning mapping. As noted before, the pictures may not have saliently represented the dimension of interest, even when presented side by side, and therefore participants were unable to reliably map them to the sound symbolic label. Another potential problem could have resulted from the characteristics of the labels themselves. Given that the product labels were minimal pairs differing in only one segment, participants may have mapped other sounds within the label onto the dimension of interest because the sound symbolic segment was not particularly salient in this task. Given the minimal differences between contrasting labels, participants may have used other sounds in the labels to cross map meaning onto the visual representation of the product. For example, the label for large flashlight was *lupush*, which may have lead participants to associate /l/ with lightness rather than focusing on the relationship between the vowel /u/ and size.

Experiment 3

The results of Experiments 1 and 2 suggest that overall participants did not reliably map the salient dimensions within the products onto the accurate labels. To examine to what extent this pattern of findings can be attributed to insufficiently salient sound symbolic cues in the product labels, we created novel product labels that differed across intended meanings in both consonant and vowels in order to examine the role of the nature and extent of sound symbolic segmental cues in sensitivity to product-to-label correspondences. The small to absent effects from the previous two experiments may have been due to the minimal contrasts in the sound structure of the product labels. Participants appeared not to recognize that the labels were sound symbolic and may have been influenced by conflicting content from other segments in the product labels. The current experiment evaluates that hypothesis by examining product labels designed to be maximally contrastive sound symbolically.

Participants. Participants were 15 native English-speaking undergraduate students from Emory University who reported no history of speech or hearing disorders. Participants received course credit for their participation.

Stimuli. The previous experiments suggest that participants were not sensitive to the sound symbolism between minimal pairs in the verbal stimuli. In this experiment, we replaced the stimuli from Klink (2000) with novel sound symbolic labels. We designed the stimuli to include consonants and vowels that sound symbolically correspond to each of the five dimensions (Appendix C).

We drew from previous research demonstrating listeners' sensitivity to sound symbolic cues. For example, prior research suggests that people associate high, front vowels with brighter or lighter objects (Newman, 1933; Mondloch et al, 2004). Additionally, for the light/dark dimension, Spector and Maurer (2008), for instance, studied the relationship between color and letters. The authors found that people associated the letter “z” with the color black and the letters “c” and "i" with yellow and white, respectively. For the purpose of this study, “z” is used as a dark sound, as black represents darkness and we used “c” and "i" as light sounds, as yellow and white are lighter colors.

The sound symbolic segments for large and small come from a number of studies. Sapir (1929) found that high, front vowels map onto small referents and low, back vowels to larger ones. Mathur (2010) found that large sounds contained more voiced consonants and fewer closed vowels than small words. Additionally, Thompson and Estes (2011) established that the sounds /m/, /l/, and /w/ were consistently mapped to largeness. We applied these findings in the creation of the new stimuli of both small/large and light/heavy because overall, they both relate to distinguishable differences in perceived size.

Mathur (2010) also reports on sound symbolic consonants cross-linguistic phoneme patterns. He studied the phonemic constructions of ten languages and found consistencies in consonant and vowel representations for fast/slow. The findings showed that slow words contained more sonorant consonants and rounded vowels.

There is little research regarding sound symbolic vowels and consonants for heavy and light. However, Tzur (2006) found that heavy and light are analogous to fast and slow. Therefore, in this experiment, the same vowels and consonants used in creating the stimuli for fast and slow are also used in heavy and light. As stated above, slow words contained more sonorant consonants and rounded vowels.

For the current experiment, high, front vowels were chosen to correspond to light weight, fast, small, light (warmth), and light (darkness) product dimensions. Low back vowels were chosen to correspond with heavy, slow, large, warm, and dark characteristics.

In designing the stimuli, the intention was to minimize the number of candidate phonemic interpretations because all novel items were presented as printed text. For example, there are no labels ending in –es because a word such as *teres* could be interpreted as /tiɹs/, /tɛɹs/, or /tɛɹɛs /. This constraint on stimulus construction was to account for any change in sound symbolic meaning or mapping that may occur if a consonant or vowel is interpreted or read differently than intended. Furthermore, the vowels chosen aimed to create distinct polarizations in place of articulation (e.g. high vs. low vowels) to present a clear sound symbolic message.

Procedure. As in Experiment 2, participants viewed a single printed product label and chose which of two product pictures best corresponded to the presented label. Only the novel word stimuli differed. All other aspects of the experiment were identical to Experiment 2.

Results and Discussion

The mean proportion of responses on which participants chose the product labels to correspond to their intended referents was calculated. Fig. 3 shows the proportion correct responses for each dimension. To assess the extent to which participants consistently mapped product labels to their intended referents, one-sample *t*-tests compared participants' mean accuracy for each dimension and novel label meaning. Participants reliably mapped labels to their intended referents for heavy/light, $t(16)=3.73$, $p=.002$, large/small, $t(16)=3.93$, $p=.001$, and warm/light, $t(16)=4.13$, $p=.001$. Participants' did not exceed chance for light/dark, $t(16)=-.25$, $p=.809$, and fast/slow, $t(16)=-.34$, $p=.739$.

One-sample *t*-tests revealed that individual label accuracies were significantly above chance both for heavy, $t(15)=.3.19$, $p=.006$, and light, $t(15)=2.82$, $p=.013$. Within the large/small dimension, participants' matched labels to the intended pictures significantly above chance for small labels, $t(15)=5.51$, $p>.001$, but not for large labels, $t(15)=1.43$, $p=.173$. Within the warm/light dimension, participants mapped warm, $t(15)=3.50$, $p=.003$, but not light labels, $t(15)=1.00$, $p=.333$, at significantly above chance levels. For the dark/light dimension, participants did not map the dark, $t(15)=-.57$, $p=.580$, or the light, $t(15)=.00$, $p=1.000$, labels consistently above chance. Finally, within the fast/slow dimension, participants did not map fast, $t(15)=-.32$, $p=.750$, or slow, $t(15)=-.81$, $p=.432$, labels at significantly above chance rates.

We ran a paired *t*-test to determine if the increase in sound symbolic cues facilitated the mapping of product-label pairings across blocks. The results show that there was not a significant increase in performance between the Block 1 and Block 2, $t(15)=.19$, $p=.264$. Additionally, an independent *t*-test was conducted to compare the dimension pair means from Experiment 2 and Experiment 3. Fig. 4 illustrates that the only dimension that there was a significant difference between Experiment 2 and Experiment 3 between the dimensions light/heavy, small/large and light/warm.

General Discussion

This study examined the relationship between sound symbolic labels and the consistency with which they are paired with a corresponding product. More specifically, it was of interest to determine if sound symbolic properties of a label would facilitate its pairing with corresponding salient characteristics illustrated in product pictures. To investigate these issues, the consistency of label-product pairings was examined across different types of tasks (Experiments 1 and 2) and across different kinds of labels (Experiments 2 and 3).

In Experiment 1, participants chose between two sound symbolic labels that were minimal pairs differing in only a single segment and asked to match the best label to a pictorial representation of a product. The results showed that participants mapped the product label pairings at chance except for small/large. In Experiment 2, participants were presented with two product pictures and a single label, but also did not show significant results except for light/heavy. Thus, the difference in task across the two experiments did not lead to significant differences in performance. The manipulation of the verbal stimuli in Experiment 3 suggests that increasing sound symbolic cues within the label enabled participants to more readily match the label with the dimension of interest when the dimension reflected size differences between products.

The labels for Experiment 1 and 2 were taken from Klink (2000). Although in Klink's experiment, participants demonstrated sensitivity to sound symbolism in these labels, in the current experiment, overall the participants did not. However, the current experiments differ from Klink's investigation in that the dimension of interest was not explicitly stated. Stating the dimension of interest to participants directly provided them with information that was likely ambiguous in this experiment. Although the pictorial stimuli differed along the relevant dimension, a variety of other visual cues differed across the product pictures. Klink exclusively tested if the labels were sound symbolic by providing relevant dimensions and contrasting labels. However, in this experiment, we tested an arguably more difficult and naturalistic task --- whether participants could recognize correspondences between product names and pictorial representations.

Additionally, the participants viewed the labels rather than hearing them, which raises the possibility of multiple phonemic interpretations among participants. It is possible that the strength of the sound symbolic cues rely on the extent in which they are pronounced either higher in the front of the mouth or lower in the back of the mouth. Therefore, participant pronunciation of the labels may have been a factor in the salience of sound symbolic cues received by that participant. As Experiments 1 & 2 suggest, the properties of the product labels (e.g., printed labels with only one sound symbolic segment) may be important in making the product-label pairings.

In Experiment 3, novel sound symbolic labels that varied in both vowel and consonant segments were constructed, rather than in only one segment as in Klink and the first two experiments. Participants reliably chose the correct label for the light/heavy, large/small, and light/warm dimensions. Performance for the product label-picture mappings for the light/dark and fast/slow dimensions were not significant. The three dimensions that participants paired significantly above chance relate to one another in that they all represent size of an object. For example, light and heavy objects project heaviness based on size; larger objects are perceived to be heavier and lighter objects seem smaller. Similarly, warm objects, at least as instantiated in the current study generally took up more space and were bulkier in order to provide and convey warmth. The pictorial representations of the light objects took up less space and were smaller in comparison.

These results support previous sound symbolism research on specific sound to meaning correspondences. Thompson and Estes (2011) found that /m/, /l/, and /w/ are associated with large size. The reliably above-chance performance for the large/small dimension corroborates their findings. Experiment 3 is also consistent with previous work relating high front vowels to small referents and low back vowels to large referents (Sapir, 1929). For all three of the dimensions that participants found to be consistently sound symbolic, light/heavy, large/small, and light/warm, the results support generalizing high, front vowels to light dimensions and low, back vowels to heavy and warm dimensions.

Although three of the dimensions in the third experiment resulted in consistent mappings between labels and picture referents, two dimensions, light/dark and fast/slow, did not. The pattern of data from Spector and Maurer (2008) relating the letters "i," "z," and "c," to light and dark did not emerge in the current experiment. These letters in the context of our task and label types did not appear to convey sound symbolism for light and dark. One difference between their study and the current experiments may be that Spector and Maurer specifically examined letter to meaning correspondences, whereas these letters were embedded in the context of novel labels in the current experiment. Another possible difference is that our participants may have accessed an auditory phonological form when reading the novel labels. Participants may have pronounced words differently to themselves, thus different sounds could have lead to variable interpretations of the label. Another limitation in applying Spector and Maurer's work in this experiment is that their research explicitly states that people associate "i" with white, "c" with yellow, and "z" with black. In this experiment, "i" and "c" may have been wrongfully overgeneralized to represent light perceptual qualities in a product and "z" with darkness in a product.

Another factor in the visual presentation of the product labels is that these labels were not presented with any additional auditory information, such as prosody. Studies show that if a word is pronounced faster, listeners will interpret the word meaning as implicitly faster than a word said at a slower speed (Shintel and Nusbuam, 2007). Therefore, prosody can imply speed, even if the meaning of the word is unknown. This is relevant to the dimensions fast/slow and dark/light as the participants did not show sensitivity to the sound symbolic labels and these types of dimension may generally be signaled by prosodic rather than segmental cues. If prosody plays a greater factor in the interpretation of fast/slow and dark/light, even more so than the other dimensions, this may explain why product-label pairings were not as consistently matched.

Although the pictorial representations of the products were normed, the perceptual experience for the individual participants may have varied. For example, the speed of a fast boat may have been the intended dimension of interest, but individual participants could have found other features of the product more salient and attempted to match the sounds of the label with those characteristics. Thus, some of the pictures may have been better at highlighting the relevant dimensions than others. One instance is with slow boat; slow is depicted by an older boat rather than an image that implies slow motion. As a result, participants may have identified other characteristic features of the product that also contrasted with the picture that was presented alongside of it. In the case of fast and slow boat, participants could have seen the contrast as new and old boat and paired the label accordingly.

Furthermore, the overall light/dark dimension did not consistently index a specific feature across all products. This supports the possibility that the salient feature in the product picture that was highlighted in the sound symbolic label was not identified as the main feature of the picture pairs as was intended. Therefore, light/dark may not have been a natural, or at least uniform, categorization of these products. For example, in one product, dark and light were defined by the type and color of chocolate. However, in another, when dark and light referred to curtains, the dimension categorization could refer to the color of the curtains or the function of them, such as curtains that do or do not reveal outside light.

As seen in Fig. 2, heavy/light was the only dimension pair for which participants' performance reliably differed from chance in both Experiments 2 and Experiment 3. This finding suggests that English speakers are more sensitive to label-product pairings within the heavy/light dimension. The representation of this dimension also differed from the others in that the product of interest was more loosely defined. For example, a bowling ball and a beach ball represented the product *ball*. This is dissimilar to the product category of *car* in that bowling ball and beach ball could have been seen as more distinctly different than a fast and slow car. As a result, heavy and light products inherently resemble the dimension that we aimed to highlight (e.g., bowling balls are generally considered heavy, but a car is not widely accepted as always being fast.

Moreover, to understand not just why performance for warm/light and fast/slow did not exceed chance, but also why heavy/light, large/small, and warm/light were significantly different from chance, similarities among the three dimensions must be noted. These three dimension pairs all roughly relate to size. Large and small are observable object properties, but heavy and light objects also tend to differ in size, lighter objects being smaller and heavier ones larger. Additionally, warmer products tend to be bigger because they take up more space with thicker or more material. Thus, that heavy/light, large/small, and warm/light converge on the dimension of size may be important in explaining performance for these dimension pairs.

Implications

This research explores sound symbolism outside the traditional realm by applying it to the domain of product names. The present research suggests that language users are sensitive to sound symbolic correspondences between products and labels at least within the domains of light/heavy, large/small, and light/warm. This investigation is pertinent to the field of applied psycholinguistics as sound symbolism in product naming can be used as a marketing strategy to implicitly convey characteristics about a product.

This study differs from previous applied research in that product characteristics were not explicitly named as in Klink (2000), but rather had to be inferred from product pictures. Participants saw pictures of the products and inferred the relevant dimensions by viewing a contrast between labels or pictures. This type of presentation of the stimuli is more likely to relate to a real-life shopping experience because the explicit identification of dimension information is not always named alongside the product label. For example, it would be uncommon for a product package to say, “light purse,” but this quality can be perceived implicitly through the label, should the marketers aim to highlight this quality. This research shows that when people have to make product dimension inferences without the aid of additional verbal information, a single sound symbolic segment may not be enough for listeners to establish a connection between the label and the dimension of interest. Thus, labels consisting of sound symbolic vowels and consonants overall convey meaning at a greater degree, which enables participants to more accurately match related product and label pairs.

The absence of sound symbolism literature connecting cognitive science to real-world applications establishes this study as one of the first in presenting participants with a situation that they would realistically encounter when choosing to buy a product. The labels and the products were presented visually in this study because shoppers generally view products and read labels in a store setting. In this context, shoppers do not receive additional information regarding the characteristics of a product that a company might hope to highlight. This information is presented implicitly, such as through a product's name or packaging.

The presence of sound symbolism in natural language also raises questions about the effect of sound symbolism on memory. Given previous evidence that sound symbolic words are learned more accurately and responded to faster than non-sound symbolic words (Nygaard et al., 2009), one can hypothesize that sound symbolic product words would be recalled significantly better than non-sound symbolic ones. Listeners could use sound symbolic cues within words to accurately associate a previously learned label with a specific referent. Future studies should examine whether sound symbolism also has a facilitative effect on memory for labels.

Furthermore, the relationship between sound and size support previous claims regarding cross modal correspondences for multi-perceptual experiences, such as was presented in this study. Spence (2011) reviews previous research that found relationships between auditory pitch and visual size. For example, people consistently match brightness, smallness, and high-pitched sounds together. This could indicate underlying auditory-visual correspondences, such as between specific sounds and size, as was found in this study. Von Horbostel (1927) states that what is essential in studying the cognitive aspects behind a sensory-perceptual experience are what bring these experiences together. In the present study, the visual contrast in size existed in Experiment 2, but it is when there was an increase in sound symbolic cues that participants reliably mapped product-label pairings. Thus, these findings suggest that the variability in sound symbolic cues is a determining factor in determining if cross-modal correspondences are made. Thus, it is when sound symbolism is a distinctly salient feature within one's auditory-visual experience that cross-modal binding occurs.

Sound symbolism also plays a role in attempting to understand the evolution of language. Sound symbolism in words creates systematicity in language that could have helped speakers find a common ground for communication (Monaghan et al., 2011). The evolutionary argument for sound symbolism supports previously stated arguments within this conclusion, such as cross-modal correspondences. For example, if it is evolutionarily advantageous for high frequency sounds (such as high, front vowels) to be paired with small objects, then it can be hypothesized that the brain is wired to make these connections. The implications of the role on sound symbolism in product-label pairings are that sound symbolic words may have evolved to describe important visual features common to all language users, such as the communication of an object's size. Future work can be done to examine cross-modal correspondences as a mechanism utilized as an evolutionary advantage.

Conclusion

In summary, the present study investigated the role of sound symbolism in product to label pairings. The results demonstrate that there is a sensitivity to sound symbolism for novel product labels for the dimensions heavy/light, large/small and warm/light when language users are asked to match labels to pictorial representations of products. The outcome of this investigation suggests that labels should be completely sound symbolic in order to convey a unified sound to meaning representation and are more accurate when paired with products that represent visually salient features. Overall, these findings not only have implications for market research, but also contribute to a greater understanding of how sound symbolism may have been used as a vehicle for conveying meaning as language evolved.

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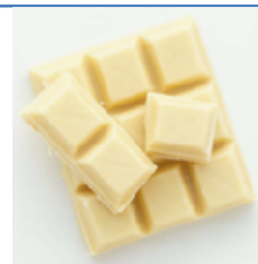
Appendix A: Verbal Stimuli (Exp. 1 & 2)

Dimension Pair	Meaning	Product	Label
fast/slow	fast	train	hilsill
fast/slow	fast	scooter	runder
fast/slow	fast	boat	nellar
fast/slow	fast	car	gorps
fast/slow	slow	train	hosill
fast/slow	slow	scooter	rinder
fast/slow	slow	boat	nullar
fast/slow	slow	car	gerps
warm/light	warm	hats	wudum
warm/light	warm	socks	mig
warm/light	warm	boots	uliy
warm/light	warm	gloves	lerok
warm/light	light	hats	wedum
warm/light	light	socks	mog
warm/light	light	boots	iliy
warm/light	light	gloves	lorok
dark/light	dark	bulb	flumet
dark/light	dark	chocolate	esab
dark/light	dark	curtains	toyag
dark/light	dark	jeans	gidan
dark/light	light	bulb	flimet
dark/light	light	chocolate	usab
dark/light	light	curtains	teyag
dark/light	light	jeans	godan
large/small	large	flashlight	lupush
large/small	large	fridge	geleve
large/small	large	speaker	dutal
large/small	large	table	kifave
large/small	small	flashlight	lipush
large/small	small	fridge	goleve
large/small	small	speaker	detel
large/small	small	table	kofave
heavy/light	light	watch	ikud
heavy/light	light	stroller	fopill
heavy/light	light	ball	keffi
heavy/light	light	purse	umar
heavy/light	heavy	watch	okud
heavy/light	heavy	stroller	fepill
heavy/light	heavy	ball	kuffi
heavy/light	heavy	purse	emar

Appendix B: Visual Stimuli

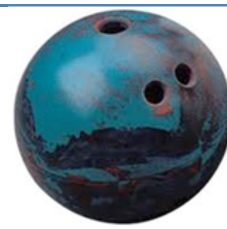
Light/Dark

Dark	Light
	
	
	
	

Fast/Slow

Fast	Slow
	
	
	
	

Light/Heavy

Light	Heavy
	
	
	
	

Small/Large

Small	Large
	
	
	
	

Light/Warm

Light	Warm
	
	
	
	

Appendix C: Verbal Stimuli (Exp. 3)

Dimension Pair	Meaning	Product	Label
fast/slow	fast	scooter	viziv
fast/slow	fast	train	fizas
fast/slow	fast	boat	gifig
fast/slow	fast	car	sibed
fast/slow	slow	train	lomur
fast/slow	slow	car	numar
fast/slow	slow	boat	rolor
fast/slow	slow	scooter	homor
warm/light	warm	socks	dafuf
warm/light	warm	hats	fabuf
warm/light	warm	gloves	sahas
warm/light	warm	boots	burud
warm/light	light	hats	lekim
warm/light	light	gloves	metem
warm/light	light	boots	gizik
warm/light	light	socks	nerir
dark/light	dark	curtains	bumon
dark/light	dark	bulb	zufaz
dark/light	dark	chocolate	bagaz
dark/light	dark	jeans	fuzov
dark/light	light	curtains	diren
dark/light	light	bulb	cimic
dark/light	light	chocolate	mehen
dark/light	light	jeans	hicen
large/small	large	flashlight	mobom
large/small	large	speaker	gogel
large/small	large	table	vodaz
large/small	large	fridge	bodad
large/small	small	flashlight	pitip
large/small	small	speaker	kiket
large/small	small	table	vikez
large/small	small	fridge	pitet
heavy/light	heavy	watch	mudod
heavy/light	heavy	ball	logod
heavy/light	heavy	purse	wubam
heavy/light	heavy	stroller	wuwol
heavy/light	light	watch	nipep
heavy/light	light	ball	fipiv
heavy/light	light	purse	rikas
heavy/light	light	stroller	fifer

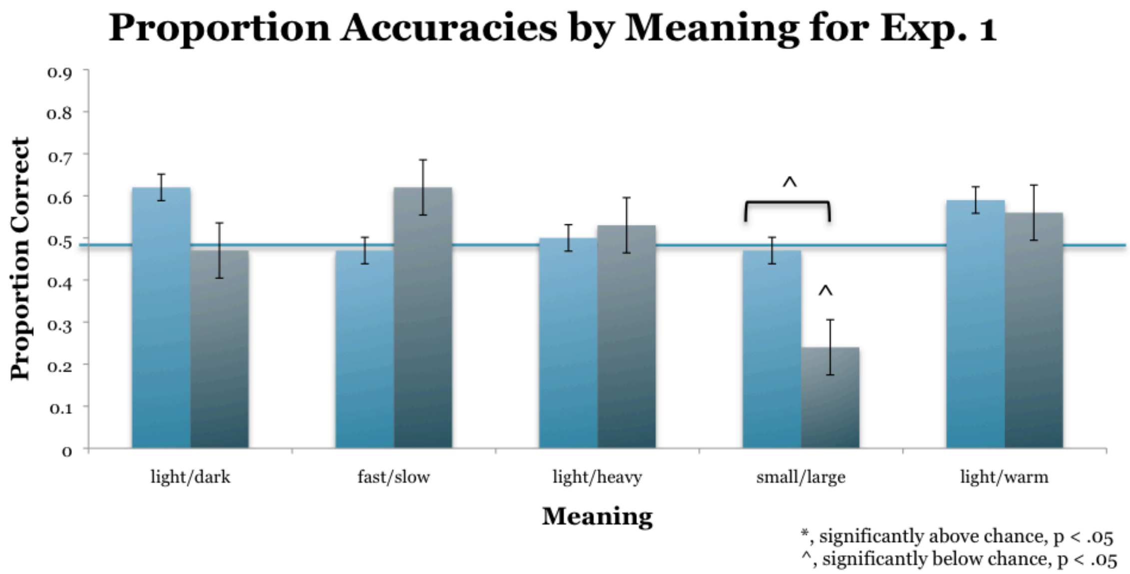


Figure 1: Mean proportion accuracy by meaning for Experiment 1. Significant results were found for large. Standard errors are represented in the figure by the error bars attached to each column.

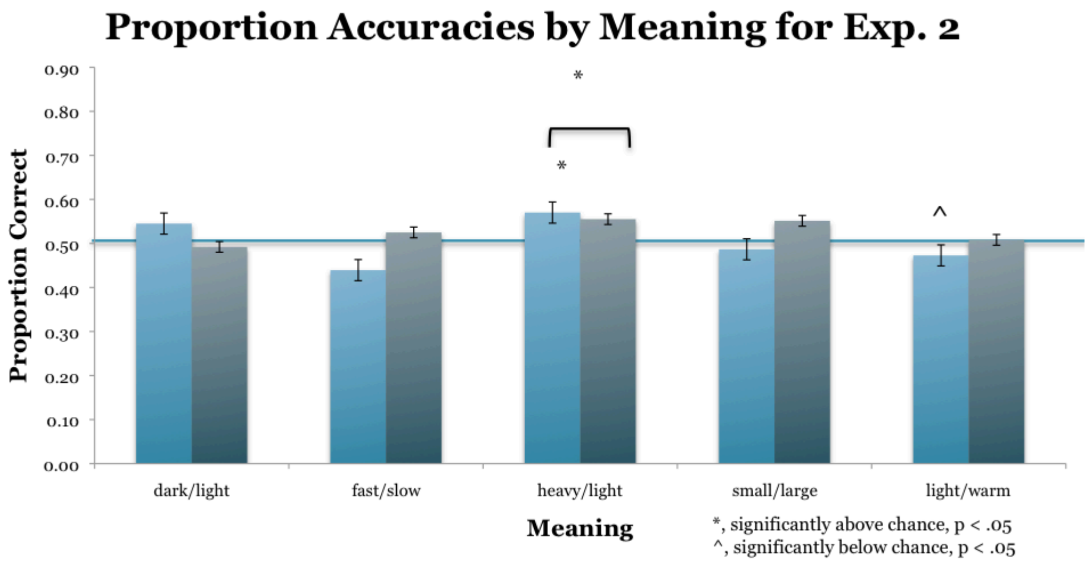


Figure 2: Mean proportion accuracy by meaning for Experiment 2. The light meaning from the light/warm dimension was the only one mapped significantly below chance. Standard errors are represented in the figure by the error bars attached to each column.

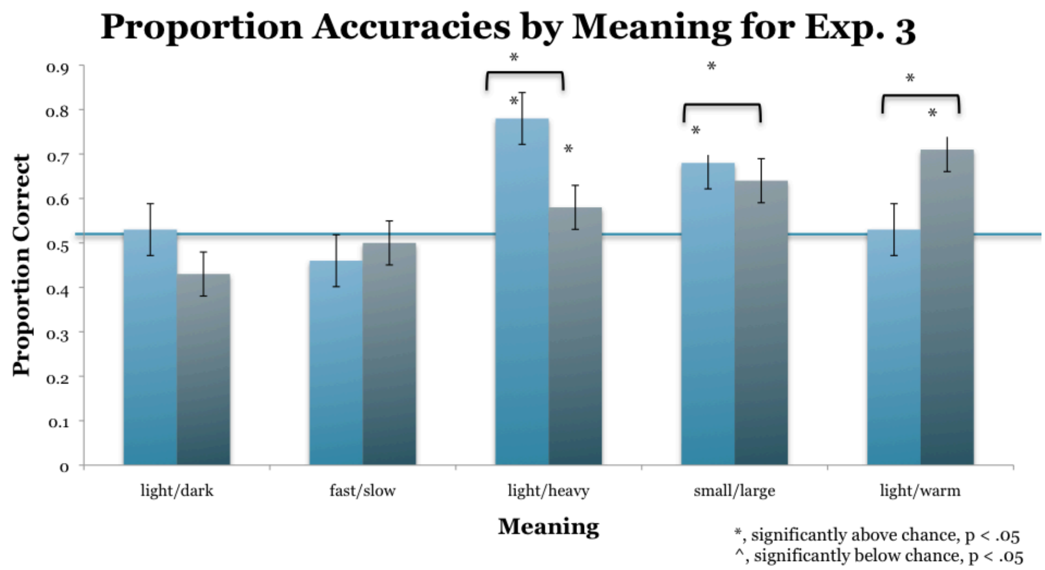


Figure 3: Mean proportion accuracy by meaning for Experiment 3 is reported in this table. Results are significant for the warm, small, and light (weight) meanings. Standard errors are represented in the figure by the error bars attached to each column. Standard errors are represented in the figure by the error bars attached to each column.

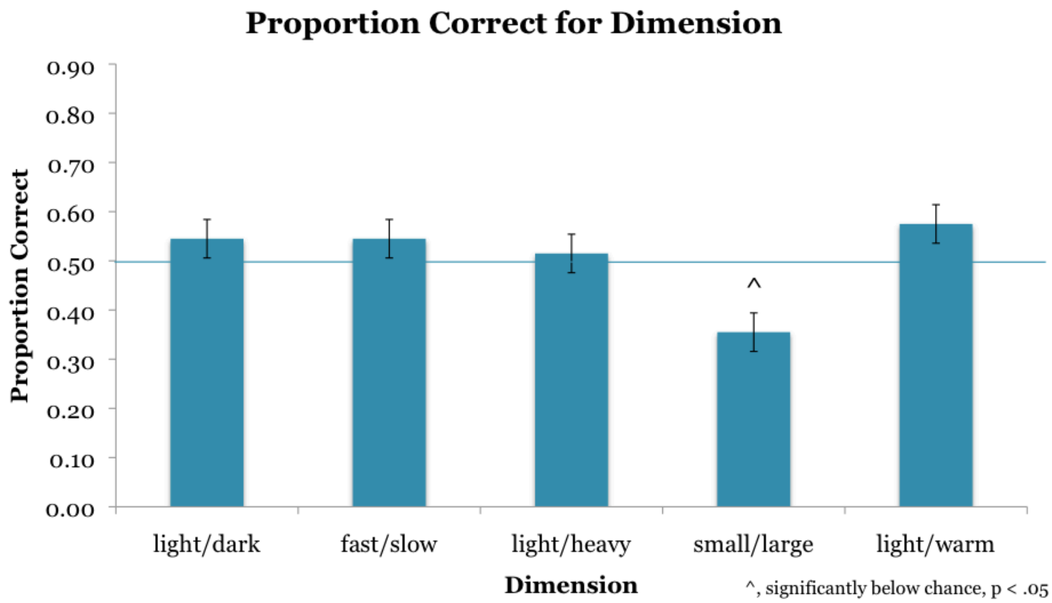


Figure 4: Mean proportion accuracies by dimension for Experiment 1. No significant results were found. Standard errors are represented in the figure by the error bars attached to each column.

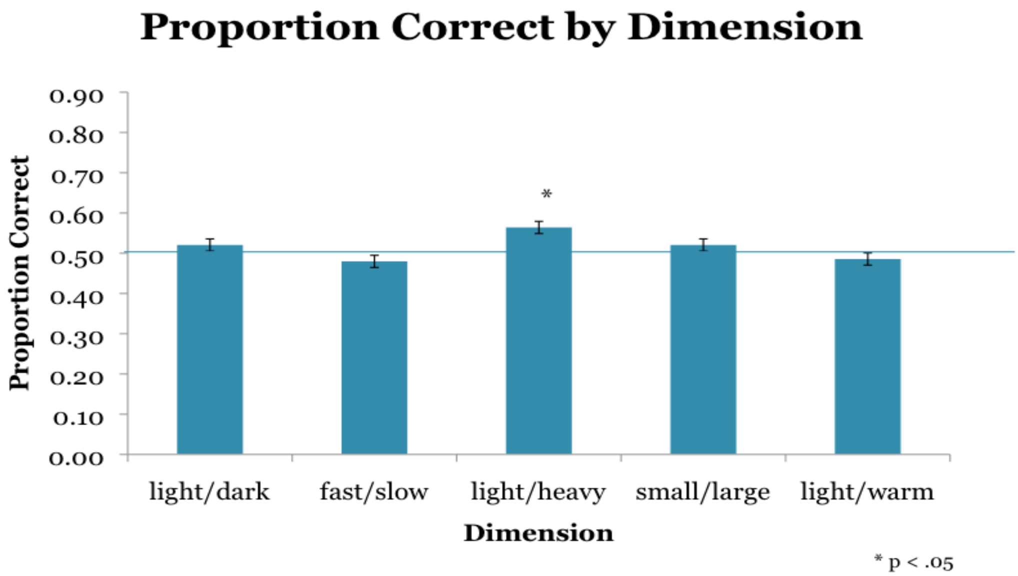


Figure 5: Mean proportion accuracy by dimension for Experiment 2. Significant results were found for the light/heavy dimension. Standard errors are represented in the figure by the error bars attached to each column.

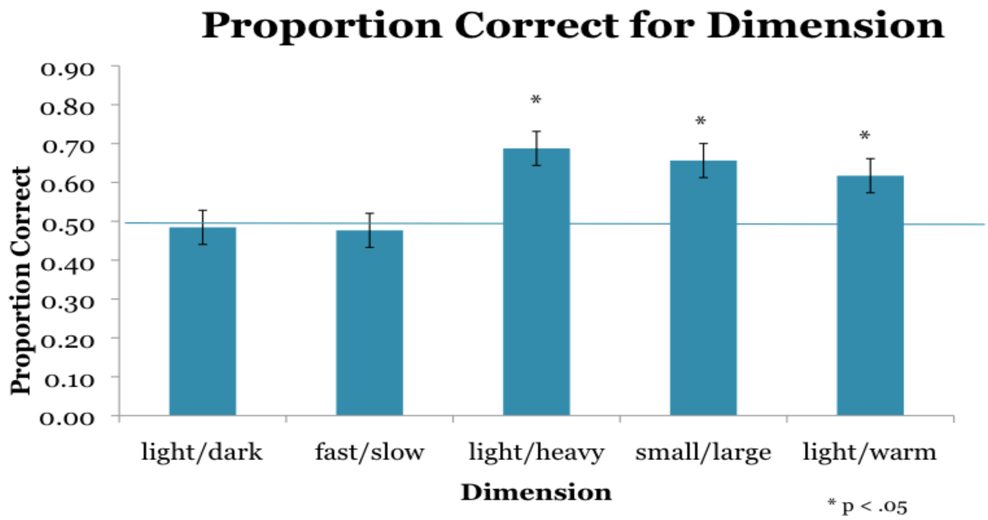


Figure 6: Mean proportion accuracy by dimension for Experiment 3. Significant results were found for dimensions light/heavy, small/large and light/warm. Standard errors are represented in the figure by the error bars attached to each column.

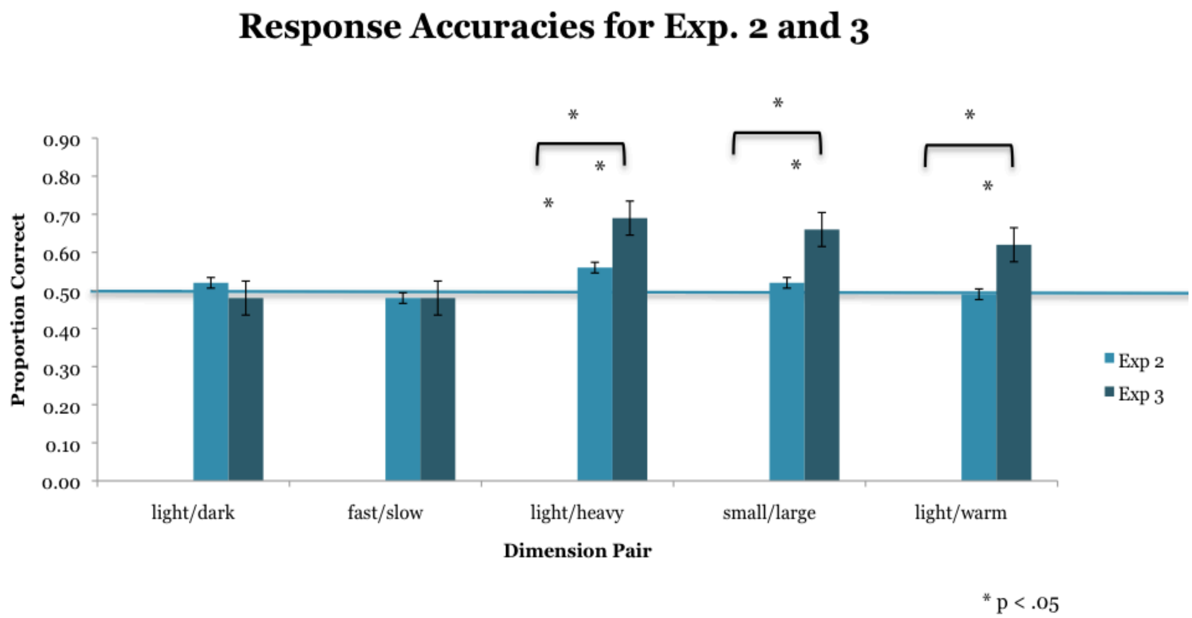


Figure 7: Dimension comparisons of mean proportion accuracies between Exp 2 & 3. Between Experiment 2 and 3 the results for the light/heavy, small/large, and light/warm dimensions are significant. Standard errors are represented in the figure by the error bars attached to each column.