Cross-Sensory Correspondences in Language: Vowel Sounds can Symbolise the Felt Heaviness of Objects

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Abstract

In sound symbolism, a word's sound induces expectations about the nature of a salient aspect of the word's referent. Walker (2016a) proposed that cross-sensory correspondences can be the source of these expectations and the present study assessed three implications flowing from this proposal. First, sound symbolism will embrace a wide range of referent features, including heaviness. Second, any feature of a word's sound able to symbolise one aspect of the word's referent will also be able to symbolise corresponding aspects of the referent (e.g., a sound feature symbolising visual pointiness will also symbolise lightness in weight). Third, sound symbolism will be independent of the sensory modality through which a word's referent is encoded (e.g., whether heaviness is felt or seen). Adults judged which of two contrasting novel words was most appropriate as a name for the heavier or lighter of two otherwise identical hidden novel objects they were holding in their hands. The alternative words contrasted in their vowels and/or consonants, one or both of which were known to symbolise visual pointiness. Though the plosive or continuant nature of the consonants did not influence the judged appropriateness of a word to symbolise the heaviness of its referent, back/open vowels, compared to front/close vowels, were judged to symbolise felt heaviness. The symbolic potential of back/open vowels to represent felt heaviness, predicted on the basis of their symbolism of visual roundedness, supports the proposal that cross-sensory correspondences contribute to sound symbolism.

Keywords: sound symbolism, cross-sensory correspondences, vowel quality, felt heaviness

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Research on symbolism in language has focused on size and pointiness as visual features that can be symbolised by the sounds of words (for recent reviews see Blasi, Wichmann, Hammarstrom, Stadler & Christiansen, 2016; Chen, Huang, Woods & Spence, 2016; Monaghan, Shillcock, Christiansen & Kirby, 2014; Perniss, Thompson & Vigliocco, 2010). However, the sounds of words can symbolise a wider range of referent features, including contrasts in *elevation, brightness, thickness, heaviness*, and *speed* (see Cuskley & Kirby, 2013; Fischer-Jorgensen, 1978; Klink, 2000; Newman, 1933; Walker, 2016a). Cuskley (2013) has shown, for example, how the acoustic features on which front vowels contrast with back vowels (e.g, *kiki* versus *kuku*) are able to symbolise contrasting values for visual speed, with front vowels symbolising faster speed.

Different acoustic features of word sounds appear to contribute differentially to the symbolism of different referent features. For example, the greater abruptness in the changing amplitude of the sound of a word (i.e., the pointiness of a word's amplitude envelope, cf. Rhodes, 1994) that incorporate plosives (stops) as consonants, rather than continuants, is well positioned to symbolise the visual pointiness of a referent object (e.g., Monaghan, Mattock & Walker, 2012; Nielsen & Rendall, 2011).[1] Similarly, with regard to vowel sounds, Knoeferle, Li, Maggioni and Spence (2017) report that the acoustic frequencies of the first (F1) and second (F2) formants in combination symbolise visual size, while the frequency of F2 alone symbolises visual pointiness (with the frequency of the third formant, F3, seeming to have relatively little symbolic potential). The fact that Knoeferle et al. observed F1 and F2 to interact in their symbolism of size concurs with the belief that it is the difference in the

[1] It is also worth noting that the frequencies of the first two formants are generally higher in plosives than in continuants, something that provides an additional, though less transparent, basis for the symbolism of visual pointiness (see Ladefoged, 2001).

frequency of the first two formants within a vowel sound (i.e., F2-F1), rather than either alone, that best supports size symbolism (see Cuskley & Kirby, 2013, *p.* 885). It also concurs with the common practice of contrasting the sounds of front/close vowels against the sounds of back/open vowels[2] to explore size symbolism (e.g., Sapir, 1929; Newman, 1933). The contrasting vocal articulation of these vowels is known to underpin the F2-F1 difference (where a bigger difference occurs in front/close vowels), largely on the basis of variations in F2. The salience of the interaction between F1 and F2 also concurs with Ohala's (1994) 'frequency hypothesis' concerning how animals alter the acoustic frequencies in their vocalisations to provide misleading information about their own size.

Reflecting on the contrasting sets of qualities symbolised by front versus back vowels in Danish adjectives, Fischer-Jorgensen (1978) comments: *'The qualities high, bright, thin, light and small, as against low, dark, thick, heavy, and big, generally go together. This means that phonetic symbolism cannot be explained independently of the general phenomenon of synesthesia.'* (*op. cit.,* p. 87). With all of these named qualities having a role in cross-sensory correspondences, this comment resonates with Walker's (2016a) proposal that correspondences (sometimes referred to as *weak synaesthesia,* see Martino & Marks, 2001) are able to provide a basis for sound symbolism and, indeed, are able to explain the symbolism of a wider range of referent features than is normally recognized in discussions of

[2] It is not the absolute positioning of vowels contrasting on the front-back and close-open dimensions that determines their classification as being front/close or back/open, but rather their positioning relative to each other (see Newman, 1933, for evidence that the sound symbolism of size, for example, is not confined to extreme contrasts in the nature of vowels). For example, though the vowel /æ/, as in *mat*, is commonly labelled a centre-front and open vowel, it is less a front and open vowel than the vowels / i /, as in *me,* and /I/ as in *Kim,* and so in comparison to these is classified as a relatively back/open vowel. In terms of the F2-F1 difference, front/close vowels tend to have a bigger F2-F1 difference than back/open vowels.

sound symbolism.

Beginning by acknowledging that size, pointiness, elevation, brightness, thickness, and heaviness are all feature *dimensions*, the functional aspects of cross-sensory correspondences most pertinent to sound symbolism are as follows (see Walker, 2016a;b for reviews). Cross-sensory feature dimensions are arranged in parallel, with the small, pointy, high, bright, thin and light-in-weight ends of the dimensions being aligned with each other. Associations linking stimulus features across different sensory domains arise from the cross-activation (crosstalk) of features located at corresponding positions on their respective dimensions (higher pitch sounds with brighter visual stimuli). The systematic nature of these associations, wherein progressively more extreme values on one dimension link to progressively more extreme values on another dimension, is what the term *correspondence* (as opposed to *association*) is intended to capture. At the highest functional level, the feature dimensions underpinning correspondences are conceptual and modality-independent in nature. Their conceptual nature allows feature values to be expressed as abstracted aspects of stimuli, such as their status as the brighter, smaller, or higher stimulus in a context-defined set of stimuli. Their modality-independent nature is consistent with their conceptual basis. For example, it is the amodal concepts of elevation and size that are aligned, rather than specifically auditory pitch and visual size. Because the aligned dimensions are modality-independent in nature, the same cross-sensory feature associations (correspondences) are observed whichever stimulus feature is used to probe them (e.g., whether this involves visual stimuli contrasting in brightness, aromas contrasting in heaviness, or haptic objects contrasting in pointiness) and through whichever sensory channel a stimulus feature is encoded (e.g., whether pointiness is seen, heard, or touched).

With these various aspects to their functional organisation, cross-sensory correspondences are able to serve as a source of expectations regarding what will be

experienced when additional sensory channels are brought to bear on a stimulus. For example, based on the correspondences between pointiness, brightness, and elevation, touching an object that feels relatively pointy in its form will induce expectations that it will also be relatively bright and will make relatively high pitch sounds. Similarly, hearing a relatively high pitch sound will induce expectations of brightness, thinness, and lightness in weight when other sensory modalities become involved in exploring the source of the sound. It is the notion of correspondences giving rise to expectations based on the co-occurrence of different features (i.e., the features that feel as though they 'generally go together,' see Fischer-Jorgensen, 1978, above) that allows them to support sound symbolism: The sound of a word induces expectations regarding what experiences will accompany the word, including the features possessed by the word's referent, and when these expectations are met the word feels appropriate for its referent (i.e., it symbolises its referent).

Several implications flow from Walker's (2016a) proposal that cross-sensory correspondences are able to support sound symbolism. A first implication is that the wider range of features capable of being symbolised will embrace all the features involved in cross-sensory correspondences, including heaviness. A second implication is that whatever acoustic features serve to symbolise one cross-sensory quality of a word's referent, such as its smallness or its pointiness, they will also symbolise corresponding qualities of the referent.[3]

[3] It is not being claimed that an acoustic feature will inevitably be seen to symbolise all corresponding aspects of a word's referent with equal strength, only that the acoustic feature will have the potential to symbolise all of these aspects and, crucially, will not be able to symbolise any contradictory aspects (e.g., an acoustic feature, such as high fundemantal frequency, that is able to symbolise greater elevation in space, will also be able to symbolise thinness, but not thickness, because higher pitch and thinness are corresponding features) (see Dolscheid, Shayan, Majid & Casasanto, 2013, for evidence of this). Though in any one situation evidence for all the different instances of symbolism relating to a single acoustic feature might not be apparent, under at least some circumstances the acoustic feature will be

For example, the acoustic features symbolising smallness and pointiness will also symbolise increasing brightness of colour, greater speed of movement, and relative lightness in weight, because the latter features correspond with smallness and pointiness, and so are expected to co-occur with them (see Walker & Walker, 2012, for discussion of the correspondence between smallness and brightness, and Walker, 2016b, for discussion of correspondences more generally).[4] This would explain why Maurer, Pathman & Mondloch (2006) and Monaghan et al. (2012) were able to use the contrast in the sounds of front/close and back/open vowels to symbolise differences in visual pointiness, even though this contrast in sound is normally thought of as symbolising differences in size. Finally, a third implication follows from the notion that the same pattern of cross-sensory correspondences embraces all modalities of sensory encoding, and so will be observed regardless of the modality through which correspondences are probed (see Walker, 2016b). Therefore, not only will sound symbolism extend to additional referent features, it will also extend to situations in which

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observed to symbolise each and every corresponding aspect of a word's referent (again, see Dolscheid et al., 2013, for evidence supporting this).

[4] Two possible mechanisms are not being distinguished here. The first is that individual acoustic features link directly to, and are therefore able to symbolize, each and every corresponding cross-sensory feature of a word's referent. Thus, for example, if an acoustic feature, such as F2-F1, links directly with relative smallness, it will also link directly with relative brightness of colour, greater speed of movement, and relative lightness in weight. The second is that individual acoustic features link directly to only one cross-sensory feature of a word's referent (e.g., size), but that cross-sensory associations involving this referent feature (e.g., the association between size and brightness) provide indirect (mediated) links to other cross-sensory referent features (e.g., F2-F1 with brightness). Walker and his colleagues normally refer to the latter possibility in their accounts of cross-sensory correspondences. Evidence indicating that distinct acoustic features of a word's sound contribute differentially to the symbolism of different referent features also favour this possibility. It is feasible, however, that both mechanisms combine, in varying proportions, to determine the manner in which the same acoustic feature supports the sound symbolism of different referent features.

these features are encoded through sensory modalities other than vision (e.g., where heaviness is experienced as the felt heaviness of an object that is hidden from view). The present study assesses all three implications of Walker's (2016a) proposal.

The felt heaviness of objects

Heaviness is a feature dimension entering into correspondence with other cross-sensory features, with lighter in weight aligning itself with higher in pitch, higher in space, brighter, thinner, sharper, smaller and faster (Tarte, 1982; Walker & Smith, 1984; Walker, Walker & Francis, 2012). There are indications also that heaviness can be symbolised by the sounds of words in a manner that reflects these alignments. Thus, words in the form of new brand names are able to symbolise contrasting levels of heaviness according to whether they incorporate front/close or back/open vowels (see Klink, 2000; Lowry & Shrum, 2007), with front/close vowels symbolising lightness in weight and back/open vowels symbolising heaviness (consistent with known cross-sensory correspondences). Similarly, Japanese words incorporating voiced consonants (e.g., *gorogoro*) symbolise relative heaviness compared to words with voiceless consonants (e.g., *korokoro*) (see Imai, Kita, Nagumo, & Okada, 2008), something that is consistent with voiceless consonants containing acoustic elements with higher frequencies than those appearing in voiced consonants (see, Ladefoged, 2001).

Such evidence for heaviness being involved in cross-sensory correspondences, and for its symbolic representation in the sounds of words, is indirect, coming as it does from studies in which heaviness is not perceived directly, but instead is judged as a quality likely to be possessed by objects possessing certain other (i.e., corresponding) qualities. For example, bigger visual objects are judged to be heavier than otherwise identical but smaller objects (Walker, Walker & Francis, 2012; Walker & Smith, 1985), as are curved geometric shapes compared to their size-matched equivalents (Walker, Walker & Francis, 2012), and darker

colored balls compared to otherwise identical but brighter balls (Walker, Francis & Walker, 2010; Walker, 2012). A more direct test of the proposed involvement of heaviness in cross-sensory correspondences, and in the sound symbolism these support, would involve manipulating heaviness as a sensory-perceptual experience, as when hidden objects varying in weight are hefted. Being more direct, this is preferable to exploring heaviness by asking people to comment on the weights of imagined instances of objects from familiar categories, such as athletic shoes, vacuum cleaners, and motor vehicles (see Klink, 2000; Lowry & Shrum, 2007).

Walker, Scallon and Francis (2016) manipulated heaviness in this way, asking English speaking adults to lift objects that were identical except in their mass. The objects were never seen (they were always hidden under a thick cloth) and participants were asked to indicate how bright or dark they thought each one to be, and how high or low in pitch the sound it created would be were it to come to life and make a simple vocalisation. Participants conveyed their judgements by selecting one of a range of nine achromatic colours (varying from white to black), or one of a range of musical notes generated on a small electronic keyboard (the nine white keys running upward from middle C on a Casio SA-47H5 Mini Keys Keyboard).

The results confirmed the previously observed correspondences between judgments of the darkness of objects and their heaviness (Walker, Francis & Walker, 2010; Walker, 2012), and judgements of the pitch of a sound and its heaviness (Tarte, 1982; Walker & Smith, 1984; Walker, Walker & Francis, 2012). Because cross-sensory correspondences are understood to apply equally to non-linguistic and linguistic stimuli, this result bodes well for any attempt to demonstrate that the symbolic potential of word sounds can extend to heaviness, and will do so in a manner predicted by sound symbolism having its basis in correspondences (Implication 1). It is also worthwhile to ask if those aspects of the sounds of

words that are capable of symbolising visual size and visual pointiness (i.e., the sound features distinguishing front/close and back/open vowels and those distinguishing plosive and continuant consonants) are also capable of symbolising the heaviness of objects. In particular, will the acoustic features symbolising greater size and less pointiness (i.e., back/open vowels and continuants) also serve to symbolise greater heaviness because this is how these cross-sensory features align with each other in cross-sensory correspondences, and on which basis all three features are expected to co-occur? (Implication 2). Finally, will this be the case when heaviness is experienced as the felt heaviness of a lifted novel object that remains hidden from view? (Implication 3).

The current experiment investigates these issues. Participants are presented with pairs of novel words that contrast by containing either both front and close vowels or both back and open vowels, or by containing plosive or continuant consonants. They are asked to judge which word seems most appropriate as a name for the heavier/lighter of the two otherwise identical novel objects being held in their hands. With the objects being hidden from view throughout the study, felt heaviness is targeted directly. Novel words with back/open vowels and/or continuant consonants were expected to be judged most appropriate as names for the heavier of the two objects (just as they are judged most appropriate for bigger and rounder objects), and novel words with front/close vowels and/or plosive consonants were expected to be judged most appropriate as names for the lighter of the two objects (just as they are judged most appropriate for smaller and pointier objects).

Method

Materials

Objects. Two solid cylinders were created from thin-walled (approx. 1mm) aluminium tubing filled with evenly distributed fragments of lead mixed in builder's expanding foam. The ends of the cylinders were smoothed with a fine layer of epoxy resin,

after which the cylinders were painted matt grey. The two cylinders were identical in size, each with a diameter of 4 cm and a height of 4 cm. The weights of the two cylinders were manipulated by varying the proportion of lead and builder's foam with which they were evenly filled. One cylinder weighed 44 gm, the other weighed 190 gm.

These two objects were part of a larger set of similar objects created for the previous study by Walker, Scallon and Francis (2016), where it was confirmed that the 190 gm object was expected to make relatively low pitch sounds (significantly lower than both the middle note in the range of notes made available and the pitch associated with the lighter object). By contrast, the 44 gm object was expected to make relatively high pitch sounds (significantly higher than the middle note in the range available).

Novel word pairings. Five pairs of contrasting novel words were used as names for the objects. The first pair, *kipi* and *moma*, were taken from Imai et al. (2015), who had ascertained that, from a set of 17 similar non-words, these two were the ones most strongly linked to pointy and curved novel visual shapes, respectively.[5] This pair of words contrast in both the nature of their consonants (*kipi* incorporating plosive consonants, *moma* incorporating continuant consonants) and the nature of their vowels (*kipi* incorporating front/close vowels, and *moma* incorporating back/open vowels), and it remains uncertain if one or both of these contrasts was symbolising visual pointiness. On the basis of previous work, however, both the consonants and the vowels of *kipi* and *moma* predict their appropriateness as names for pointy and rounded shapes, respectively (e.g., Monaghan, Mattock & Walker, 2012). These two novel words were used here in a *pretest,* with the expectation that the predicted sound symbolism would be observed (i.e., *kipi* would be judged appropriate as a name for the 44 gm object, and *moma* as a name for the heavier 190

[5] As noted already, it is theoretically significant that Imai et al. (2015) chose these words on the basis of their association with contrasting levels of pointiness and without knowing anything about their potential association with heaviness.

gm object). Four other pairs of novel words were then derived from this first pair so that the separate contribution to sound symbolism of both the contrasting nature of the vowels and the contrasting nature of the consonants could be assessed. To isolate a contribution from the vowel contrast, two pairs of novel words (*kipi* vs. *kopa* and *mimi* vs. *moma*), incorporating the same vowel contrast as *kipi* vs. *moma*, were matched for their consonants, with one pair adopting the consonants from *kipi*, and the other pair adopting the consonants from *moma* (referred to as the *vowel contrast test*). To isolate a contribution from the consonant contrast, a further two pairs of novel words (*kipi* vs. *mimi* and *kopa* vs. *moma*), incorporating the same consonant contrast as *kipi* vs. *moma*, were matched in the nature of their vowels, with one pair adopting the vowels from *kipi*, and the other pair adopting the vowels from *moma* (referred to as the *consonant contrast test*).

Imai et al. (2015) did not indicate how the vowels in their two novel words, *kipi* and *moma,* were pronounced, only how they were spelt, and so it is unclear just what the sounds of the words were (i.e., what their constituent phonemes were). To be clear about the sounds of the vowels as they were instantiated in the present study, multiple recordings (three of each novel word) were made of the experimenter (CR) speaking each word. These recordings were later transcribed by a trained phonetician[6] as follows: *kipi* = k/ɪ/p/i̇/ (i.e., ki as in *Kim*, pi as in *pea*); *kopa* = k/ɔ/p/æ/ (i.e., ko as in *caught,* pa as in *pat*); *mimi* = m/i̇/m/i̇/ (i.e., both mi as in *me*); and, *moma* = m/ɔ/m/æ/ (i.e., mo as in *caught*, ma as in *mat*). We see, therefore, that for those pairs of novel words differing only in their vowels (*kip*i vs. *kopa* and *mimi* vs. *moma*), the difference involves a contrast between front/close vowels and back/open vowels. That is, whereas i̇ and ɪ are definitely (absolutely) both front and close, ɔ and æ are

[6] The authors are grateful to Dr Sam Kirkham, of the Department of Linguistics and English Language, Lancaster University, for transcribing the recordings.

both relatively more back and open, despite them commonly being labelled as centre-front + open, and back + open-centre vowels, respectively. As mentioned in Footnote 2, if we view these issues in terms of the F2-F1 difference, then the contrast is between vowels with a relatively big F2-F1 difference (here i and ɪ) and vowels with a smaller F2-F1 difference (here ɔ and æ).

Participants

Eighty-four Sunway University students (based in Kuala Lumpur) participated in the study after being approached in various social and learning settings. All participants were fluent in English, though not necessarily as their first language. Twenty students (11 females, 9 males, mean age = 23.60 years, *SD* = 1.98) completed the preliminary test, where they had to indicate which of the two objects was a *kipi,* and which was a *moma*. Two additional groups of sixteen students each took part in the vowel contrast test, where they had to assign *kipi* and *kopa* (10 females, 6 males, mean age = 20.38 years, *SD* = 2.0) or *mimi* and *moma* (11 females, 5 males, mean age = 20.38 years, *SD* = 1.71) to the two objects. Finally, two further groups of sixteen students each took part in the consonant contrast test where they had to assign either *kipi* and *mimi* (15 females, 1 male, mean age = 20.63 years, *SD* = 1.09) or *kopa* and *moma* (10 females, 6 males, mean age = 21.13 years, *SD* = 1.31) to the two objects.

Procedure

Participants were presented with two identical drawstring bags made from heavy denim (30 cm wide by 26 cm deep) into each of which they could place one of their hands. Each bag contained one of the two cylindrical objects, and participants were instructed to put their two hands into different bags and to lift and hold the object inside each. They were then told that the objects were, for example, a *kipi* and a *moma*, without saying which was which, and asked to decide which of the two objects was a *kipi* and which was a *moma*. They indicated their choice both verbally and with an accompanying gesture. In a fully

counterbalanced between-participants design, whether the lighter object was presented to a participant's left or right hand was counterbalanced, along with the temporal order in which the two names were introduced. The whole procedure took approximately 5 minutes. Participants were not compensated for taking part in the study. The study was granted ethical approval by the Research Ethics Committee of Lancaster University.

Results

Pretest. Sixteen of the 20 participants (80%) assigned the novel names to the two objects in line with predictions. That is, they judged that *kipi* is most appropriate as a name for the lighter object, and *moma* is most appropriate as a name for the heavier object. On a 2-tailed binomial test, this outcome deviates significantly, $p = .012$, from what is expected in the absence of any sound symbolism.

Vowel Contrast Test. Twenty six of the 32 participants (81%) assigned the novel names to the two objects in line with predictions. That is, they judged that *kipi* and *mimi* are most appropriate as names for the lighter object, and *kopa* and *moma* are most appropriate as names for the heavier object. On a 2-tailed binomial test, this outcome deviates significantly, $p = .0005$, from what is expected in the absence of any sound symbolism.

Consonant Contrast Test. Only eleven of the 32 participants (34%) assigned the novel names to the two objects in line with predictions. Instead, the majority of participants ($n = 21$) judged *kipi* and *kopa* to be most appropriate as names for the heavier object, and *mimi* and *moma* to be most appropriate as names for the lighter object. On a 2-tailed binomial test, this outcome does not deviate significantly from what is expected in the absence of any sound symbolism, $p = .11$. In any case, of course, the result is in a direction running counter to the predicted symbolism.

Discussion

The present study provides evidence that the same vowels that symbolise less pointiness also serve to symbolise greater heaviness. When participants judged which of two novel words contrasting in the nature of their vowel sounds was most appropriate as a name for the heavier/lighter of two otherwise identical objects, their responses confirmed the predicted form of sound symbolism. Specifically, the novel words *kopa* and *moma,* with their back/open vowels, were judged to be most appropriate as names for the heavier object, whereas the novel words *kipi* and *mimi,* with their front/close vowels, were judged to be most appropriate as names for the lighter object. Because back/open vowels are known to symbolise largeness and roundedness, their symbolic representation of heaviness, rather than lightness, agrees with the manner in which all three features align with each other as cross-sensory correspondences.[7]

When participants judged which of two novel words contrasting in the plosive or continuant nature of their consonants was most appropriate as a name for the heavier/lighter of two otherwise identical objects, there was no evidence for the sound symbolic representation of heaviness. The novel words *mimi* and *moma* were not judged significantly more appropriate as names for the heavier object compared to the novel words *kipi* and *kopa*. As with null results in general, it is not clear what to conclude from this.[8] It is possible that

[7] The transition from front/close to back/open vowels is thought to mirror a reducing difference in the frequencies of their first and second formants (i.e., the F2-F1 difference). This reducing difference arises from a combination of a relatively large reduction in F2 and a modest rise in F1. It is possible, therefore, that the sound symbolism observed in the present study is solely attributable to the contrast in F2 (i.e., vowel backness) between front/close and back/open vowels, or to the contrast in F1 (i.e., vowel height). Further studies are planned to assess the relative influence of F1 and F2 alone, separately from any effect of the difference between them.

[8] Had the consonant contrast supported the reverse of the predicted form of sound symbolism (i.e., with *kipi* and *kopa* being judged to be significantly more appropriate as names for the

this is a reliable result, correctly indicating that consonants do not have the potential to contribute to sound symbolism. In which case, perhaps the consonant contrast did not contribute to the symbolism of pointiness in Imai et al.'s (2015) study, which instead was entirely attributable to the vowel contrast that co-existed with the consonant contrast. Previous results from studies of the sound symbolic representation of pointiness have been very mixed, there being occasions when the vowels alone, the consonants alone, or both the vowels and consonants, have supported the symbolism (for evidence and discussion see Aveyard, 2012; Fort, Alexander & Peperkamp, 2015; Monaghan, Mattock & Walker, 2012; and Nielsen & Rendall, 2011). According to Fort et al., the relative contribution of vowels and consonants to the symbolic representation of visual pointiness seems to be sensitive to a complex host of factors.

The present results reveal an interesting confound requiring consideration: The nature of the vowel sounds in the novel words, and the nature of their consonants, were both confounded with the spoken duration of the words. On the three occasions the experimenter was recorded speaking each of the novel words, it transpired that those with front/close vowels (i.e., *kipi* & *mimi*) took less time to say (mean = .45 and .48 s, respectively) than those with back/open vowel sounds (i.e., *kopa* & *moma*) (mean = .47 and .50 s, respectively). Similarly, the words with plosive consonants (i.e., *kipi* & *kopa*) took less time to say (mean = .44 and .47 s, respectively) than those with continuant consonants (i.e., *mimi* & *moma*) (mean = .48 and .50 s, respectively). Covariation of the two feature contrasts with spoken word duration allows for a cross-sensory correspondence between speed (duration) and heaviness to be responsible for the vowel-based sound symbolism of heaviness observed here. Though the existence of such a correspondence, and its potential to underpin sound symbolism, is

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heavier object), then the notion that cross-sensory correspondences support sound symbolism would have been seriously challenged.

worthy of future exploration, its involvement in the sound symbolism observed in the present study can be ruled out. The reason is that the same symbolism observed with the contrast in vowels should also have been observed with the contrast in consonants. This is because the 6.9% increase in the mean spoken duration of the novel words with continuant consonants, relative to those with plosive consonants, is bigger than the 4.7% increase for the novel words with back/open vowels, relative to those with front/close vowels, and yet sound symbolism was only observed with the latter contrast.

The present study was designed to assess three implications flowing from Walker's (2016a) proposal that cross-sensory correspondences can underpin sound symbolism, and the results provide support for all three. First is the implication that the full range of features involved in cross-sensory correspondences should be capable of being symbolised by the sounds of words. This was supported by adding heaviness to the list of object features capable of being symbolised by word sounds. Second is the implication that a sound feature known to symbolise one cross-sensory aspect of a word's referent, such as its pointiness, should also be capable of symbolizing corresponding aspects of the referent. This found support in the demonstration that vowels known to be optimum in the symbolization of pointiness are also capable of symbolizing heaviness. This was predicted on the basis that the core set of cross-sensory correspondences incorporate both pointiness and heaviness, with pointiness being aligned with lightness in weight. For this reason, whenever a word's acoustic features induce an expectation that feelings of pointiness will be associated with the word, they will also induce an expectation that feelings of lightness in weight also will be associated with the word, because the correspondence between pointiness and lightness suggests they will be co-occurring referent features. Third is the implication that, on the understanding that the same cross-sensory correspondences embrace all modalities of sensory encoding, sound symbolism will extend to situations where a word's referent features are

encoded through sensory modalities other than vision, and this was supported by obtaining evidence for sound symbolism after arranging for heaviness to be encoded as the felt heaviness of an unseen object.

The proposal that cross-sensory correspondences can provide a basis for sound symbolism generates more than the three implications (predictions) examined in the present study. For example, the notion that correspondences embrace all modalities does not imply only that a word's referent object can be encoded in any modality, it also implies that aspects of words other than their sounds can support symbolism. These aspects could include, for example, the visual features of words when they appear as text, their gestural features during signing, and their tactile features during the reading of Braille. Regarding the first of these possibilities (i.e., visual symbolism), Walker (2016a) has shown how the thinness and brightness of a word's letter strokes can enhance a reader's classification of a named sound according to whether the sound typically is high-pitched (e.g., *squeak*) or low-pitched (*rumble*). The nature of the enhancement reflected the cross-sensory correspondences between these three features, with relative thinness and brightness facilitating the identification of words referring to relatively high-pitch sounds.

Further exploration of the role cross-sensory correspondences play in sound symbolism, and in symbolism in language more generally, promises to deliver a theoretical framework in which to place a wide range of cognitive phenomena pertaining to animal and human communication.

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