CHILDREN AND ADULTS' UNDERSTANDING AND USE OF SOUND-SYMBOLISM IN NOVEL WORDS.

By

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"… a language without sound-symbolism would be as impossible as an existence without culture." (Nuckolls, 1999, pp. 226)

To Sarah, Christos, Harry and all my friends

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ABSTRACT

Sound-symbolism is the inherent link between the sound of a word and its meaning. The aim of this thesis is to gain an insight into the nature of sound-symbolism. There are five empirical chapters, each of which aims to uncover children and adults' understanding of sound-symbolic words. Chapter 1 is a literature review of sound-symbolism. Chapter 2 is a cross-linguistic developmental study looking at the acquisition of sound-symbolism. Chapter 3 looks at childrens use of sound-symbolism in a verb-learning task. Chapter 4 looks at childrens use of sound-symbolism when learning and memorising novel verbs. Chapter 5 consists of two experiments looking at what exact part of a word is sound-symbolic. This study compared different types of consonants and vowels, across a number of domains in an attempt to gain an understanding of the nature of sound-symbolism. Chapter 6 looks at the potential mechanisms by which sound-symbolism is understood. This study is a replication of previous research, which found that sound-symbolic sensitivity is increased when the word is said and not just heard. There are therefore a total of five empirical chapters each of which attempts to look at the nature of sound-symbolic meaning from a slightly different angle.

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CHAPTER 1: LITERATURE REVIEW

What is sound-symbolism?

For almost 100 years now it has been assumed that the sound of a word has an arbitrary relationship to its meaning (Newmeyer, 1993; Saussure, 1916/1983). Saussure argues that the essential feature of language is the lack of intrinsic connection between the sign (e.g., how a word sounds) and the signification (e.g., what the word means). When discussing onomatopoeic words Saussure argues that these are a marginal phenomena and not organic elements of a linguistic system. For example the French word “fouet” (whip) may sound onomatopoeic in nature. However, when one looks at the origin of this word, the Latin “fagus” (beach tree), it is clear that there is no intrinsic relationship between the sign and its meaning. Therefore, the general belief in language studies is that the word is an arbitrary symbol and that any other phenomenon, such as onomatopoeias are an exception to this rule. This statement is probably largely true when one considers only Indo-European languages, but becomes questionable when one looks beyond Indo-European languages.

Sound-symbolism is the inherent link between the sound and meaning of a word. “The term sound-symbolism is used when a sound unit such as a phoneme, syllable, feature, or tone is said to go beyond its linguistic function as a contrastive, non-meaning-bearing unit, to directly express some kind of meaning” (Nuckolls, 1999, pp. 228). Some languages have a large sound-symbolic lexicon that goes beyond onomatopoeias. For example, Japanese sound-symbolic words or mimetics as they are often referred to, can describe a number of concepts such as vision: *Kira Kira*: twinkle; touch: *Zara Zara*: to be coarse, sandy, gritty; motion: *Pyon Pyon*: to hop, romp, bounce, to jump lightly; and emotion: *Kara Kara*: to laugh heartily (Chang, 1990).

Many historically unrelated, geographically dispersed languages have grammatically defined word classes that are characterized by sound-symbolism. The terms used to describe this word class vary, largely dependent on the term used by the linguists who originally discovered the phenomenon in different parts of the globe. Hinton, Nichols, and Ohala (1994) provide an overview of a number of languages with sound-symbolic elements (see also: Nuckolls, 1999, Voeltz-Hatz, 2001). In sub-Saharan African languages sound-symbolic words are referred to as ideophones (Childs, 1994). Whilst in South-East Asian languages they are referred to as expressives (Diffloth, 1972, 1979; Enfield, 2005; Watson, 2001). The list of languages which have sound-symbolic word classes does not stop there though: East Asian languages (Korean: Lee, 1992; Chinese: Bodomo, 2006; Japanese: Hamano, 1998; Kita, 1997), Dravidian and Indo-Aryan languages of Southern India (Emeneau, 1969), Australian Aboriginal languages (Alpher, 1994; McGregor, 2001; Schultze-Berndt, 2001) and indigenous languages of South America (Nuckolls, 1996; Reuse, 1986). Even within Europe, non-Indo-European languages such as Basque (Ibaretxe-Antano, 2006), Finish and Estonian (Mikone, 2001) have also been shown to have sound-symbolic word classes.

The language with one of the most well-established and researched sound-symbolic system is Japanese. Sound-symbolic words in Japanese constitute a grammatically defined class, referred to as mimetics. This word class is relatively large. A dictionary of Japanese mimetics lists 4500 entries (Ono, 2007). Extensive studies have been carried out looking at the grammatical and semantic properties of mimetics (e.g., Hamano, 1998; Kita 1997, 2001). Japanese mimetics are often used in everyday conversation, newspapers, various forms of poetry, comic books and novels (Imai, Kita, Nagumo, & Okada, 2008; Schourup, 1993; Yamaguchi, 1986).

Though Indo-European languages do not have an extensive grammatically defined class of sound-symbolic words, it would be wrong to completely exclude them from the discussion of sound-symbolism. Phonaesthemes are frequently recurring sound-meaning pairings that are not clear morphemes (Firth, 1930). For example, the phoneme sequence “gl” often refers to light or vision (e.g., glimmer, glisten, glow, glitter, glint etc.) and “sn” often refers to the nose or mouth (e.g., snore, snout, snarl, sniff, sneeze etc.) (Bloomfield, 1933/1984). Bergen (2004) found that “A full 39% of the word types and 60% of word tokens starting with gl- have definitions that relate to ‘light' or 'vision' (….). Similarly, 28% of word types and 19% of word tokens with a sn- onset have meanings related to 'nose' or 'mouth'” (Bergen 2004, p. 293).

Experimental evidence for the psychological reality of phonaesthemes comes from Bergen (2004) who conducted a lexical decision task using phonaesthemes. Words were recognised faster when the prime and the target shared a phonaestheme, compared to when prime and target were semantically or phonologically related. The size of priming effects in the phonaestheme, semantic and phonological priming conditions suggested that phonaestheme priming could not be accounted for by the sum of phonological and semantic priming, though no direct statistical analysis was carried out. Therefore, words containing phonaesthemes appear to have a representation of their own in the mental lexicon.

Even with English words that do not include phonaesthemes, people differently treat words with fitting or non-fitting sound-meaning relationships. Wertheimer (1958) constructed a list of fitting (break, clean, cool, cut, rush) and non-fitting (belong, knee, sun, teach, write) words. The words were judged by three independent groups of judges as being either fitting or non-fitting. The participants rated the words on ten different semantic differential scales (angular-rounded, weak-strong, rough-smooth, active-passive, small-large, cold-hot, good-bad, tense-relaxed, wet-dry, fresh-stale). Participants' ratings showed that fitting words were more likely to be rated at the extreme ends of scales on various measures of emergent qualities. In a second study by Wertheimer (1958) participants looked at the word on a screen and pushed a button when they felt the word had lost its meaning. Fitting words took longer to "lose their meaning" than non-fitting words. Sound symbolic words are often described as creating a more embodied feeling in the listener. If phonaesthemes are also a type of sound symbolism then it is possible that the embodied nature of these words are what led participants to rate them at more extreme ends of the scales, but also meant they took longer to lose their meaning. These results are further evidence for the psychological reality of a non-arbitrary form-meaning link.

Experimental evidence for sound-symbolism in different domains

Psychological research into sound-symbolism first flourished in the late 1920's, early 1930's. There are five main domains in which sound-symbolism has been investigated: shape, size, taste, action and pain. Research in each of these domains will be discussed below.

Shape

Participants match angular shapes to words containing plosives and rounded shapes to words containing continuants (Davis, 1961; Holland & Wertheimer, 1964; Köhler, 1929/1947; Westbury, 2004). Participants in Köhler's study were shown a rounded vs. angular shape and asked to match these two shapes to the two novel words takete and baluma/maluma (baluma was changed to maluma in Köhler 1947, in an attempt to make it less similar to the word balloon). Köhler (1929/1947; see also Holland & Wertheimer, 1964) claimed that participants would overwhelmingly choose the word baluma/maluma to match a rounded object and the word takete to match an angular object. In fact Köhler claimed that this phenomenon was so overwhelming there was no need to carry out any quantitative analysis on this phenomenon. These results were confirmed using the words bouba and kiki. 95% of adults prefer to label the rounded object bouba, and the angular object kiki (Ramachandran & Hubbard, 2001). More recently it has been shown that children as young as 2-years-old, are able to detect shape-sound-symbolism (Maurer, Pathman, & Mundloch, 2006).

Sound-symbolism of shape can influence performance even in a task that does not require any direct judgment of word meaning. Namely, Westbury (2004) created a lexical decision task in which words and non-words were presented to participants in rounded or angular frames. Participants were asked whether each of the stimuli presented was a word or a non-word. He found that participants were slower to reject non-words when there was a sound-symbolic match between the non-word and the frame in which it appeared. In other words if the word *kabe* was presented in an angular frame then participants were slower to reject it as being a real word than if it was presented in an rounded frame. Westbury's results are interesting because they show that shape sound symbolism is not just the result of a forced judgment task, but can be seen when participants are unaware of the underlying sound symbolism task.

Size

Another domain investigated in sound-symbolism research is that of size. The vowel /i/ tends to be associated with small things, whereas the vowel /a/ tends to be associated with large things (Bentley & Varons, 1933; Newman, 1933; Sapir, 1929; Tarte & Barritt, 1971). In these studies, participants were asked which one of two novel words such as *mil* and *mal* represented a large table and which one represented a small table. A large majority of adults labeled the large table mal and the small table mil. Size sound-symbolism research was further supported by Johnson (1967) where participants were asked to produce English words associated with smallness and largeness. Using this list of words, the experimenters extracted the initial vowel and presented these vowels to a second group of participants. The second group of participants was asked to judge the vowel as being either large or small. The analysis revealed that the phonemes found in the real words produced and the phoneme size judgment tasks were very similar.

Taste

Sound-symbolism of taste has also been demonstrated. Participants were presented with sweet, sour, bitter and salty flavored solutions in low, medium and high potencies. Participants were also presented with four different sounds continua of F1, F2, voice discontinuity and spectral balance. The task was to match up the tastes to the sounds. Participants showed consistency in matching increased concentration to increasing values in F1, F2 and spectral balance. Sweet tastes were matched up to low F1, F2 and spectral balance. Sweet tastes were also matched to continuous vowel sounds more than bitter and sour (Simner, Cuskley, & Kirby, 2010).

Motion/action

English speaking and Japanese speaking adults rate novel word-action combinations similarly (Imai et al., 2008). Participants were presented with novel words, created on the basis of existing Japanese mimetics (sound-symbolic words), and videos of actions consisting of various manners of walking. The task was to rate the degree of match between the novel words and the actions. The ratings given by English speaking and Japanese speaking adults were very similar (Imai et al., 2008). These results indicate that cross-linguistically recognisable sound-symbolism for action exists.

Pain

English speaking and Japanese-speaking participants interpreted Japanese mimetic words for pain very similarly (Iwasaki, Vinson, & Vigliocco, 2007a). Adult speakers of English and adult speakers of Japanese were presented with Japanese mimetic words for pain. The task was to rate the words on various semantic dimensions, such as aching, bothering, continuous, affecting wide areas. The pattern of rating was similar between Japanese and English speakers (Iwasaki, Vinson, & Vigliocco, 2007a).

Conclusion

In this section a number of domains in which sound-symbolism has been identified were discussed. A question remains as to whether sound-symbolism is domain specific, or whether these domains are just examples of a more abstract type of sound-symbolism. For example shape sound-symbolism may be an example of a more abstract semantic category, such as abruptness of change. Size sound-symbolism may be an instance of a domain general magnitude symbolism that can be expressed across domains. Therefore, studies are needed looking at the generality of sound-symbolic meaning and whether the identified domains of meaning are only instances of a more abstract domain-general sound-symbolic meaning. This issue will be address in Chapter 5.

Universal sound-symbolism

Real words

A recurring theme in sound-symbolism literature is whether or not sound-symbolism is universal. Universal sound-symbolism refers to sound-symbolism recognised by speakers of different languages. There are two main categories of studies investigating universal sound-symbolism, those using real words and those using novel words. The real word experiments can be further divided into studies using the antonym-pair paradigm and those using other paradigms.

Antonyms

The basic principle of the antonym-pair matching procedure is that participants are presented with English antonym pairs and antonym pairs in a foreign language (Czech and Hindi: Brown, Black, & Horowitz, 1955; Old Hebrew, South Malaita, Kiwai, Tongan and Finish: Gebels, 1969; Chinese, Czech and Hindi: Brown & Nuttall, 1959; Japanese: Tsuru & Fries, 1933), or were presented with antonym pairs in two foreign languages (Chinese and Hindi: Brown & Nuttall, 1959; Maltzman, Morrisett & Brooks, 1956). The participant's task is to match the English words to the foreign words, or the foreign to foreign words in terms of meaning. English speaking participants could match English to foreign antonym pairs (Brown, Black, & Horowitz, 1955; Gebels, 1969). However the results are mixed for studies with foreign to foreign antonym pairs. One study found that participants could correctly match foreign to foreign pairs (Brown & Nutall, 1959), while another found that they could not do so (Maltzman, Morrisett, & Brooks, 1956). One outstanding issue with foreign to foreign antonym pair matching tasks is the bias of the foreign word translations. It is not clear from any of the above studies whether the translations were controlled for phonological similarity to the English words. Translators may have unwittingly picked the translation phonologically most similar to the English equivalent (Brackbill & Little, 1957). This would make the task somewhat equivalent to the foreign to English matching task, which would be easier. This might explain the mixed results for foreign to foreign matching tasks.

Participants are able to guess the meaning of foreign antonym pairs. Again based on antonym pairs Klank, Huang, and Johnson (1971) asked English speaking participants to place foreign word pairs (Chinese) on scales of three dimensions: activity (fast-slow), potency (strong-weak) and evaluative (good-bad). They found that participants were able to guess the meaning significantly above chance in the activity and potency domains, but not the evaluative domain. This could be because the activity and potency domains are more objective and can easily be quantified. The evaluative domain on the other hand would appear to be more subjective, in that participant's evaluation of what is good or bad might vary hugely. They conclude that the findings support universal sound-symbolism.

Real words-non-antonyms

English speaking participants are able to understand real Japanese mimetic words for laughing. Native English speakers and native Japanese speakers were asked to listen to mimetics for laughing, walking (Iwasaki, Vinson, & Vigliocco, 2007b) and pain (Iwasaki, Vinson, & Vigliocco, 2007a). Their task was to rate each word on semantic differential scales. They found that English-speaking and Japanese-speaking participants rated many of the features very similarly for laughing and pain. However, the ratings for walking given by English speaking and Japanese speaking participants were very different. Therefore, Japanese mimetics for laughing and pain may be cross-linguistically or universally recognized, whereas sound-symbolic words for walking may be language specific. It is unclear why laughing and pain mimetics were cross-linguistically recognised, where are walking was not. What is more striking is that Imai et al., (2008) have shown that English-speaking participants cross linguistically recognize Japanese mimetics. It is possible that the semantic differential scales used in Iwasaki, Vinson and Vigliocco's (2007a) study, were not conducive to cross-linguistic translation. Therefore, the mimetics for walking may well be universal, however, the scales used were not the best for showing these results.

Novel words

Using the maluma-takete task (Köhler, 1947) with speakers of different languages is another method used to look at universal sound-symbolism. Davis (1961) used the maluma/takete task to investigate the existence of universal sound-symbolism. Kitongwe speaking participants from Tanzania and English speaking participants both completed the maluma-takete task. Davis (1961) found that both groups of participants associated maluma with a round object and takete with an angular object. This study supports the claims to universal sound-symbolism.

Imai et al. (2008) found Japanese and English speakers have the same sound-symbolism for actions. The stimuli for Imai et al.'s (2008) study consisted of novel sound-symbolic words for actions. The novel words were derived from existing Japanese mimetics. Participants were asked to rate the degree of match between the novel words and the videos of actions presented. They found that both Japanese speaking and English speaking participants rated the matching word-video pairs high, and the mismatching word-video pairs low. This finding supports universal sound-symbolism. These findings contradict those found by Iwasaki, Vinson and Vigliocco (2007a), who showed that Japanese mimetics for walking were not recognized by English speaking participants. One key difference between the two studies is that the Iwasaki et al study used real mimetic words, where as the current study uses novel words created on the basis of Japanese mimetics. This difference may explain the contradictory findings in the two studies. Alternatively, as suggested previously the scales used in the Iwasaki, Vinson and Vigliocco (2007a) study may have been the reason behind these findings.

Miron (1961) found that Japanese speaking adults and English speaking adults rated vowels similarly on various scales of semantic differential. English speaking and Japanese speaking adults were presented with novel CVC (consonant, vowel, consonant) words. Participants were asked to rate the novel words on various scales of semantic differential. The scales reflected three overall factors (1) evaluation (good-bad, beautiful-ugly, pleasant-unpleasant, high-low, colourful-colourless), (2) potency (heavy-light, powerful-powerless, thick-thin, large-small, hard-soft, strong-weak) and (3) activity (quiet-noisy, slow-fast, passive-active and cold-hot). The results showed that both English and Japanese speaking adults rated front vowels and consonants as being more pleasant and weak, whereas back vowels and consonants tend to be rated as more unpleasant and strong. There is therefore an abundance of literature supporting the universal hypothesis of sound-symbolism.

Language specific sound-symbolism

Because sound-symbolic words for the same or similar meaning vary across languages, it is believed that sound-symbolism may have language specific aspects. For example to “rotate around an axis” (such as a spinning top) is *kuru kuru* in Japanese mimetics (Gomi, 1989) and *jiraka-biraka* in Basque ideophones (Ibarretxe-Antuañano, 2006). Though both these words are sound symbolic in the two languages and share some features (e.g., containing "k" and "r"), it is also clear that these words are very different to each other. Therefore, possible language-specific elements of sound-symbolism must also be considered.

There is also experimental evidence supporting the existence of language specific sound-symbolism. Taylor and Taylor (1962) provided support for the language specific hypothesis. Monolingual English, Japanese, Korean and Tamil speakers judged CVC syllables on 4 “dimensions of meaning” (size, movement, warmth and pleasantness). The results showed no similarity in the judgments of the syllables across the four dimensions made by participants from the different language backgrounds. This is taken as evidence against the existence of universal symbolism. Similarly, English-speaking and Japanese speaking participants were asked to rate Japanese mimetic words for walking on various semantic differential scales. Results showed that English-speaking participants did not rate (on scales such as ‘graceful-clumsy’) Japanese mimetic words for walking in the same way as Japanese speakers (Iwasaki, Vinson, & Vigliocco, 2007b).

Further support for the language specific sound-symbolism hypothesis comes from second language learners of Japanese. Japanese, as discussed above, is a language rich in sound-symbolic (mimetic) elements that are used in everyday interactions, in both written and verbal form. It is therefore vital for second language learners of Japanese to learn and use mimetic words. However, research in this area has revealed that second language learners find it very difficult to grasp the meaning of mimetic words and often misuse them (Hamano, 1998).

Taylor (1963) suggests that the language one speaks shapes the sound-symbolic sensitivities found among populations. This idea therefore implies that sound-symbolism is itself language or culture specific. There are two possible ways in which language specificity of sound-symbolism arises. First, sound-symbolism may develop as the statistical generalisation of form-meaning pattern in the lexicon. The sound-symbolism becomes stronger as the number of words increases and the statistical generalisation can be made on the basis of a larger data set. During this process some sound-symbolism will be universal, while other sound-symbolism will be specific to the language being learnt. Second, sound-symbolic sensitivity may be available to everyone, however, when the native language(s) is learnt one might prune or re-shape sound-symbolic sensitivity. This way, sound-symbolic links, which are not useful to one's native language, are lost. This question will be addressed in Chapter 2.

Sound-symbolism and learning

Sound-symbolism is also useful in word learning contexts. Two pathways have been taken in looking at sound-symbolism and word learning. The one involves participants learning the meaning of real foreign words, whilst the other involved learning novel words.

Real words

English speaking adult participants find it easier to learn the English translations of real Japanese words if the translation has a semantic relationship to the true meaning of the Japanese words, as opposed to a random translation

(Nygaard, Cook, & Namy, 2009). Participants were presented with a Japanese word, followed by the English translation of either the Japanese word or the antonym of the Japanese word or another random Japanese word. Participants were better at learning the Japanese word when it was paired with the accurate English translation or the translation of the antonym of the Japanese word, than when it was paired with translation of another random Japanese word. Furthermore the performance for the accurate translation and the antonym translation did not significantly differ. Though this study indicated the form-meaning relationship could have an impact on word learning, the effect was driven by an unusual type of sound-symbolism, in which both the actual translation and the antonym were both equally good matches to particular sounds.

Rather than using foreign words, Parault (2006) and Parault and Schwanenflugel (2006) used sound-symbolic and non-sound-symbolic obsolete English words. Participants were asked to generate definitions for the obsolete words (Parault, 2006), match the obsolete words to their definitions (Parault & Schwanenflugel, 2006) and learn the obsolete words (Parault & Schwanenflugel, 2006). Results showed that sound-symbolic words generated more correct definitions and more correct matches and were learned better than non-sound-symbolic obsolete words.

Novel words

A second set of studies has shown that sound-symbolism can help adults and children learn novel words more easily. Kovic, Plunkett, and Westermann (2010) taught English speaking adults sound-symbolically congruent (rounded object+ the word "mot", angular object + the word "riff)" or incongruent (rounded object + the word "riff", angular object +the word "mot") word-object pairs. Participants were trained to learn either the congruent or incongruent pairs. When tested participants were faster to accept the correct object-label pairs that were sound-symbolic than those that were not sound-symbolic. They were also slower to reject an incorrect label-object mapping that was sound-symbolic than if it was non-sound-symbolic. However, it is questionable as to whether these results are really showing an effect of learning, or whether participants were detecting sound-symbolism during the testing phase. If sound-symbolism was helping participants learn the novel word-object associations then we might expect participants to make fewer errors and be faster at learning sound-symbolically matching pairs. However, this is not the case, participants took the same number of trials to learn the word-object association in the match and mismatch conditions. Participants also made the same number of errors in the match and mismatch conditions. Previous research in sound-symbolic word learning task has shown that adult participants who learn congruent (sound-symbolically matching) word-object pairs were more likely to correctly remember the correct word-object pairs and were also less likely to make errors than participants who were taught non-congruent pairs (non-sound-symbolically matching) (Wicker, 1968). It is therefore likely that in Kovic, Plunkett, and Westermann's (2010) study participants were detecting sound-symbolic matches during the test phase and not using sound-symbolism to learn during the training phase.

Monolingual English and Japanese speaking children find sound-symbolically matching verb-action pairs easier to learn than non-sound-symbolically matching verb-action pairs. The stimuli consisted of word-action combinations. The novel sound-symbolic words were created on the basis of existing Japanese mimetic words, and the actions were various manners of walking. Both Japanese (Imai et al. 2008) and English (Kantartzis, Imai, & Kita, 2011) speaking children were better able to identify the referent of a novel verb and generalize it in a new situation, when the word-action combinations sound-symbolically matched.

Sound-symbolism does facilitate word learning for both adults and children. Why does sound-symbolism facilitate word learning? The answer to this question may be found in the evolution of language (Ramachandran & Hubbard, 2005). Sound-symbolism has been discussed in light of language evolution, as a potential candidate for the link between non-verbal communication and language. The iconic nature of sound-symbolism would make it an ideal candidate for speakers to agree on the meaning of novel words.

The previous research on sound-symbolic facilitation of word learning leaves an important open question. That is, are the effects of sound-symbolism on word learning short term or can they be seen in the long term as well? We know sound-symbolism facilitates verb generalization when tested immediately after training (Imai et al., 2008; Kantartzis et al., 2011). However, can sound-symbolism help children memorise the semantic representation of the novel verb and generalise the novel verb after a delayed period of time? This question was addressed in Chapter 4.

Mechanisms

The mechanisms of sound-symbolism are relatively poorly understood. There are three broad ways in which researchers have attempted to explain the basis of sound-symbolism. The first proposal is that sound-symbolism is based on iconic mapping between articulatory movements and referents. The second is that sound-symbolism is based on some kind of mapping between acoustic features of sound and referents. The third is the idea of orthographic symbolism, in which the shapes of the letters in a word make the word-object relationship sound-symbolic.

Articulatory

Articulatory mechanisms may be involved in the perception of and sensitivity to sound-symbolism. Oda (2000) used Japanese mimetics in a word-picture matching task to test this idea. Participants either only heard the mimetic words, or they heard and said the mimetic words. Participants were more accurate in the picture-word matching tasks when they both heard and said the sound-symbolic word. Therefore Oda argued that saying a sound-symbolic word increases participants' sensitivity to the meaning of the word as compared to just hearing the sound-symbolic word. However, participants who said and heard the mimetic words also heard their own production. Thus, hearing the sound-symbolic words more times and therefore making it unclear whether saying the words was crucial or hearing their own production of the word was crucial.

It has been proposed that manner of articulation may be the basis of sound-symbolism . Looking at size sound-symbolism, high vowels, such as /i/, in which lips and the tongue form a narrow constricted space are associated with small objects (Hamano, 1986; Oda, 2000; Sapir, 1929), whereas low vowels, such as /a/, in which the lips and tongue form a large, unconstructed space are associated with large objects. Newman (1933) found that the size judgment, from small to large, for a novel word follow the pattern i, e, ɛ, ä, a. Newman argues that this pattern can be explained in terms of: (1) kinesthetic factors: articulatory position of the tongue, (2) acoustic factors: "characteristic high frequency of vocalic resonance (p.62)" (3) kinesthetic or visual factors: size of the mouth opening. Though acoustic explanation cannot be ruled out, articulatory factors such as the position of the tongue or the size of the oral cavity may play an important role in sound-symbolism.

Acoustic

Fundamental frequency and formant frequency may play a role in the perception and understanding of sound-symbolism. Across species it is found that high frequency vocalizations are associated with smallness and low frequency vocalizations are associated with largeness (Ohala, 1984). Tarte (1982) found that subjects rated the vowel /i/ and high tones as being active but not potent, low tones and /a/ were rated potent, low tones and /u/ were passive. Ohala (1984) concluded that fundamental frequency might be an important meaning carrying component, as are formant frequencies of vowels, and that both these are important in sound-symbolism. This theory led to the development of the frequency code hypothesis.

The frequency code hypothesis states that sound-symbolism found in vowels, consonants, tones and intonations might potentially be explained through acoustic frequency representation (Ohala, 1994).

The acoustic properties of words also have an effect on the perception of sound-symbolic words. English speaking participants were presented with Japanese antonym pairs in three different conditions (Kunihara, 1972). (1) Acoustically in monotone voice, (2) acoustically in expressive voice, and (3) written in roman form. In all three conditions participants were able to guess the meaning of the Japanese antonym pairs significantly better than chance. However, performance was significantly better in the group that heard the words pronounced in an expressive voice. These results indicate that the perception of sound-symbolism may be influenced by the expressive qualities and intonations of the speaker's voice.

Orthographic

Finally, another potential mechanism by which sound-symbolism may be understood is orthography. Siegel, Silverman, and Markel (1965) used the antonym-pair matching task and found that when stimuli are presented acoustically participants can detect sound-meaning links, however, this sensitivity is increased when stimuli are presented both acoustically and visually. This theory links the shape of the letters in a word to its sound-symbolic meaning. The letters in the word *maluma* are more rounded than the letters in the word *takete.* However, there is limited research looking at this potential mechanism of sound-symbolism. It is also unlikely that orthography is the key factor to understanding sound-symbolism because young children who are not old enough to read or write well are able to detect sound-symbolism (Maurer et al., 2006). Similarly sound-symbolism can be found in non-literate cultures such as Ponapean (Koenig & Fischer, 1980).

Conclusion for mechanisms

There is therefore evidence for articulatory, acoustic and orthographic effects of sound-symbolism. It is possible that sound-symbolism is understood in terms of all three of these features, they are not necessarily mutually exclusive to each other.

This area of work addresses “why-questions”. Looking at size sound-symbolism as the example, having found that /i/ is associated with smallness it is now important to explain *why*. It may be the articulatory properties of the vowel /i/, the smallness of the oral cavity for example. In terms of shape sound-symbolism, *baluma* may be associated with roundedness because of the shape of the oral cavity when producing the word. Alternatively, as proposed by Ohala (1984) sound-symbolism might all be associated with fundamental frequency and formant frequency. Research that investigates all potential explanations of why sound meaning links are made is lacking in the field. More research is needed looking at the effects of articulation more carefully. In terms of orthographic symbolism there are very few studies looking at the effects of seeing the sound-symbolic word written as opposed to just hearing it.

Sound-symbolism and brain imaging

A more recent advance in the field of sound-symbolism is that of using brain imaging tools to look at how sound symbolic words are processed by the brain. More specifically researchers are interested in understanding more about the brain mechanisms involved in the understanding and processing of sound-symbolism.

Hashimoto et al. (2006) found that extensive brain regions process onomatopoeic words. They conducted an fMRI study in which participants heard onomatopoeic sounds, nouns, animal sounds and pure tones. The brain regions activated by onomatopoeias are a combination of regions involved in the processing of both verbal (nouns) and nonverbal (animal sounds and pure tones) sounds. The authors therefore argue that onomatopoeic sounds function as a bridge between nouns and animal sounds. Arata, Imai, Okuda, Okada and Matsuda (in prep) also looked at the processing of sound-symbolic words using fMRI. They presented participants with action videos, along with sound-symbolic words, non-sound-symbolic adverbs and verbs that referred to the actions in the videos. They found that mimetic words tended to be processed bilaterally. It was concluded that due to the nature of sound-symbolic words they have dual neural status as both linguistic and non-linguistic elements in language. Osaka (2008) presented participants with either mimetic words for walking or nonsense words. Japanese mimetic words activated the visual cortex located in the extrastriate occipital region and superior temporal sulcus, while nonsense words did not. Osaka, Osaka, Morishita, Kondo, and Fukuyama (2004) used fMRI with mimetic words for pain and novel words. Mimetic words activated the anterior cingulated cortex (ACC), while nonsense words did not. The authors interpret this as the ACC being a pivotal locus for perceiving affective pain evoked by a sound-symbolic word. However the results from both these studies are difficult to interpret, as there was no real word control such as verbs or adverbs.

Another line of research linking sound-symbolism and brain functioning comes from Ramachandran and Hubbard (2005), who believe that sound-symbolism and synaesthesia are two related phenomena. They also propose the angular gyrus as a likely candidate for the brain area involved in such mechanisms. Synaesthesia is a condition in which activation of one sensory modality (graphemes) automatically activates a second unrelated modality (colours). Synaesthesia is caused by the excess communication between two distinct brain areas (Ramachandran & Hubbard, 2005). This excess communication is potentially facilitated by the angular gyrus, which may have developed for cross-modal associations (Ramachandran & Hubbard, 2005). According to this view, sound-symbolism may be an effect of this cross-modal activation caused by the angular gyrus. Further evidence supporting this theory comes from Osaka (2008) who found activation in the angular gyrus when comparing mimetic words for walking with nonsense words. However, in other studies looking at the effects of sound-symbolic words on the brain activation of the angular gyrus is not found (Arata et al., in prep.; Osaka et al., 2004).

Using ERP Kovic, Plunkett, and Westermann (2010) found evidence for audio-visual integration during early sensory processing in sound-symbolic words.

In many ways sound-symbolism represents a case of multimodal sensory integration. Previous research (Giard & Peronnet, 1999; Molholm, Ritter, Javitt, & Foxe, 2002) has shown that early negative ERP components are an index of multisensory feature integration. Participants were presented with sound-symbolically congruent sound-object pairs and sound-symbolically incongruent sound-object pairs. They found an early (140-180ms after onset of stimulus) negative difference between the congruent and incongruent conditions. The congruent condition showed a strong, negative wave.

Conclusions

We have looked at literature covering various aspects of sound-symbolism. Sound-symbolism has been shown to exist in a number of domains: shape, size, action, taste and pain. Evidence for universal and language specific sound-symbolism has been discussed, as well as its use in word learning. Furthermore, the mechanisms behind the perception of sound-symbolism, including brain processing were identified. However, there are still many unanswered questions remaining.

There are a number of domains in which evidence for sound symbolism has been shown. Shape sound symbolism seems to be understood by adults (Köhler, 1947; Westbury, 2004) and children (Maurer, et al., 2006), across languages (Davis, 1961). Research into size sound symbolism has shown that small objects tend to be associated with /i/, where as large objects tend to be associated with the vowel /a/

(Bentley & Varon, 1933; Newman, 1933; Sapir, 1929; Tarte & Barritt, 1971). Consistencies in participant's responses in a matching task have also been found when they were presented with different tastes (sour, bitter, sweet and salty) and various sound continua (F1, F2, voice discontinuity and spectral balance) (Simner, Cuskley, & Kirby, 2010). Furthermore, sound symbolism in action or motion has been shown (Imai et al., 2008). Finally, sound symbolism has also been shown to exist in the domain of pain (Iwasaki, Vinson, & Vigliocco, 2007a). What is unclear is whether these are the only domains which exobit sound symbolism. This seems unlikely if one looks at a single dictionary of Japanese mimetics (e.g. Chang, 1990), where one finds thousands of entries across a number of domains including, but not exclusive to the ones discussed in the present literature review.

The literature covered in this review indicates that sound symbolism appears to be universal or cross-linguistically recognized. However, there is also theoretical and empirical evidence for a more language or culture specific sound symbolism. Whether sound-symbolism is universal or language specific remains an open question in the field, it seems likely that sound symbolism is both universal and language specific. It is also not clear why some sound symbolism might be universal where as other sound symbolism might be language specific.

Sound symbolism helps participants learn real foreign words (Nygaard, Cook, & Namy, 2009), obsolete English words (Parault, 2006; Parault & Schmanenflugel, 2006) and novel words (Imai et al., 2008; Kantartzis et al., 2011; Kovic, Plunkett, & Westermann, 2010). Both adults (Nygaard, Cook and Namy, 2009; Parault, 2006; Parault & Schwanenflugel, 2006; Kovic, Plunkett, & Westermann, 2010) and children (Imai et al., 2008; Kantartzis et al., 2011) are shown to benefit from sound symbolism in word learning. It is not clear at what point sound symbolism starts helping. Sound symbolism may be useful to very young infants at the beginning stages of word learning, or it may only help 3-year olds (Imai et al., 2008; Kantartzis et al., 2011) who already understand the basic concepts of language and have gone through the vocabulary spurt. This question remains unanswered by research in sound symbolism thus far.

Three main mechanisms by which sound symbolism is understood or perceived are discussed, namely, articulatory (Newman, 1933; Oda, 2000), acoustic (Kunihara, 1972; Ohala, 1984; Tart, 1982) and orthographic (Maurer et al., 2006; Siegel, Silverman & Markel, 1965). All of these factors may play a role in the perception of sound symbolism. However, more research is needed before the mechanisms of sound symbolic perception can be understood fully.

Finally, recent advances in the field of sound symbolism include looking at how the brain processes sound symbolic words. The literature ends to suggest that sound symbolic words tend to be processed over much more extensive brain regions than either non-sound symbolic words or onomatopoeic words (Hashimoto et al., 2006). While Ramachandran and Hubbard (2005) speculate that the angular gyrus in particular may be involved in the processing of sound symbolic words. Although the research in this area has been largely fruitful and interesting, many of the studies lack good controls, such as real word equivalents to the sound symbolic words.

Future directions

Children are sensitive to sound-symbolism (Imai et al., 2008; Maurer et al., 2006), but it is not clear how this sensitivity is acquired. Sound-symbolism has been shown to be both universal and potentially language specific. Using both universal and language specific sound-symbolism it is important to see how sensitivity to sound-symbolism is acquired (Chapter2). Discovering how sound symbolism is acquired will give researchers more insight into why sound symbolism exists in languages all over the world, and maybe even why it does not exist in most Indo-European languages. Sound symbolism may have been an important step in the evolution of language, and may still be important in language acquisition.

In terms of how sound symbolism is acquired one possibility is that sound-symbolism is acquired alongside the development of language. If this is the case we would expect adults to be more sensitive than children to both universal and language specific sound-symbolism. Another possibility is that all infants are born with sensitivity to all possible sound-symbolisms, which are then pruned and shaped according to their native language. If this were the case then we would expect children to be sensitive to non-native language specific sound-symbolism, whilst adults would not be sensitive to non-native language specific sound-symbolism.

Knowing that children are sensitive to sound-symbolism it is important to know whether sound-symbolism is useful for word learning. Can English-speaking children use sound-symbolism to learn novel verbs? Previous research has shown the Japanese-speaking children are able to use sound-symbolism to learn and generalize verbs more effectively (Imai et al., 2008). However, Imai et al.'s study used Japanese speaking 3-year olds, it is known that Japanese is a language rich in sound symbolic elements. It is therefore questionable whether the Japanese-speaking children were able to use sound symbolism in word learning because it is a fundamental part of their native language or whether sound symbolism is useful to children speaking other languages as well. Thus, it is important to see whether English-speaking children can use the same sound-symbolic words to learn and generalize verbs as well (Chapter 3).

Are the benefits of sound-symbolism on verb learning seen in the short-term only or can they also be seen in the long term? Research into verb learning (Imai et al., 2008; Kantartzis et al., 2011) has used a training period followed immediately by a testing period. It is therefore not clear whether the effects of sound-symbolism on verb learning can only be seen in the short term or are available to the children after a delayed testing period. Furthermore, previous research (Imai et al., 2008; Kantartzis et al., 2011) showing an advantage for using sound-symbolism in verb learning have used forced choice procedures. Where children are presented with two videos, one is the correct extension of the verb while the other is not. Using this design it is not clear if sound-symbolism is helping children accept the correct referent of the verb, reject the incorrect referent or both. Using a modified design would shed light on this question and tell us more about the nature of sound symbolism and how it helps word learning (Chapter 4).

Is sound-symbolism domain specific or domain general? A number of domains have been discussed in which sound-symbolism had been identified.

However, it is still not clear if this sound-symbolism is domain specific or domain general and these domains are just examples of a more abstract type of sound-symbolism. For example shape sound-symbolism may be an example of a more abstract semantic category, such as abruptness of change. Whereas size sound-symbolism may be an instance of a domain general magnitude symbolism that can be expressed across categories and cannot be broken down into anything more domain general. The domain generality of sound symbolism is addressed in Chapter 5.

The general aim of this thesis is to shed more light on the field of sound-symbolism. Two pathways are taken in doing this. Using developmental studies, we investigated how sound-symbolism is acquired and whether it is useful to English speaking children. The existence of universal and English-language specific sound-symbolism is also addressed using developmental studies. The nature of sound-symbolic meaning and the mechanism of sound-symbolism perception are investigated with studies with adult participants. The nature of domain generality of sound-symbolism is investigated. Finally, whether understanding sound-symbolism is acoustic or articulatory is investigated.

CHAPTER 2: TODDLERS ARE SENSITIVE TO A WIDER RANGE OF SOUND-SYMBOLIC LINKS BETWEEN THE FORM AND MEANING OF WORDS THAN ADULTS: A COMPARISON OF GREEK AND ENGLISH SPEAKERS.

Katerina Kantartzis, Mutsumi Imai, Sotaro Kita

Abstract

Sound-symbolism can be cross-linguistically recognised. The present study investigated how sensitivity to sound-symbolism is acquired. Participants selected which one of two videos (a target and a distractor) matched a novel word. The target was either a universal (common) or an English language-specific sound-symbolic match to the novel word. English speaking adults and toddlers and Greek speaking adults and toddlers completed the task. All participants, across both languages and age groups, detected common sound-symbolism. However, Greek-speaking adults did not detect English language-specific sound-symbolism. The results suggest that toddlers may be sensitive to all sound-symbolic links, but will then lose sensitivity to the sound-symbolism that is not relevant for their native language, in much the same way as phonological sound contrasts are acquired.

Introduction

Sound-symbolism is the inherent link between the sound and meaning of a word. Many languages across geographically diverse areas have a large sound-symbolic lexicon. Some examples include mimetics in Japan (Kita, 1997), ideophones in Africa (Childs, 1994) and expressives in South East Asia (Diffloth, 1994) (see Hinton, Nichols, & Ohala, 1994). Köhler (1947) developed an experimental paradigm to demonstrate sound-symbolism in which participants were presented with a rounded and angular shape and asked to label one *maluma* and the other *takete*. The majority of adults prefer to label the rounded object *maluma* and the angular object *takete* (e.g., Davis, 1961; Holland & Wertheimer, 1964). This task has been the basis for much research into sound-symbolism.

Research into sound-symbolism has focused a great deal on the common properties of sound-symbolism in cross-linguistic studies. Davis (1961) used the *maluma-takete* task with English speaking children and Kitogwe speaking children in Tanzania. He found that both groups of children succeeded in the task. In a verb learning study, Japanese speaking (Imai, Kita, Nagumo, & Okada, 2008) and English speaking (Kantartzis, Imai, & Kita, 2011) children were taught the same novel words that were either sound-symbolically matching or mismatching to the referent actions, and they were asked to generalise the novel words to new instances of the referent actions. Both groups of children performed better when the novel words were sound-symbolically related to the referent. In other words the same sound-symbolism benefited both Japanese and English speaking children. Further evidence for common sound-symbolism comes from research on cross-linguistic sensitivity to the meaning of existing foreign words. Specifically, English-speaking adults could correctly identify the sound-meaning correspondence of foreign words (Brown, Black, & Horowitz, 1955; Iwasaki, Vinson, & Vigliocco, 2007a&b; Klank, Huang, & Johnson, 1971; Nygaard, Cook, & Namy, 2009). Thus, there is evidence that some sound-symbolism is cross-linguistically recognized.

There is also reason to believe that sound-symbolism has language-specific aspects. Sound-symbolic words describing similar concepts are not the same across languages. For example, to "rotate around an axis" (such as a spinning top) is *kuru kuru* in Japanese mimetics (Gomi, 1989) and *jiraka-biraka* in Basque ideophones (Ibarretxe-Antuañano, 2006). Although the two words are similar in some respects, such as the /r/ and /k/ sounds, the words are different, e.g., the choice of vowels, in the two languages. Studies of second language learners provide converging evidence. Second language learners of Japanese typically cannot easily grasp the meaning of mimetic words (Hamano, 1998). If there were no language-specific element to sound-symbolism then this would not be the case.

Toddlers are sensitive to cross-linguistically recognizable sound-symbolism. Maurer, Pathman and Mondloch (2006) used a similar task to that developed by Köhler (1947) with 2.5-year-old toddlers and adults, and found that both adults and toddlers matched novel words to shapes in much the same way. Furthermore, as mentioned above, Japanese speaking (Imai et al., 2008) and English speaking (Kantartzis et al., 2011) toddlers used sound-symbolic words to help them in a word learning task. It is therefore clear that toddlers are sensitive to sound-symbolism. A question still remains however as to how children comprehend language-specificity of sound-symbolism. This question has a theoretical implication as to how sound-symbolism develops during childhood.

One possibility is that the sensitivity to sound-symbolism may develop through statistical analysis of the lexicon of the native language(s). Phonaesthemes are systematic links between sounds and meaning of words. For example “gl” in the English language is often associated with light and vision, such as in the words *glare*, *glow*, *glimpse* (see Bergen, 2004). Similarly, the grammatical class (noun vs. verbs) of low-frequency words can be distinguished by phonological cues (Monaghan, Charter, & Christiansen, 2005). Children may be picking up on such regularities within their language, which becomes the basis for sound-symbolic links between sound and meaning. If sound-symbolism develops in this way then we would expect younger children to be less sensitive to sound-symbolism (common and language-specific) than adults. Common sound-symbolism would then be found only in sound-meaning matches that were consistent across languages.

Alternatively, children may initially be sensitive to a wide variety of sound-symbolism, which is pruned or shaped into a language-specific way when language is learnt. Sound-symbolism may develop in a similar way to phonological contrasts between sounds in certain languages. Phonology is largely believed to innate (see Kuhl, Stevens, Hayashi, Deguchi, Kiritani & Iverson, 2006); therefore if sound symbolism develops in a similar way, this implies sound symbolism may also be innate. However, much research, beyond this current study, is needed before claims on innateness can be made. Research on the acquisition of phonology has found that infants are sensitive to non-native sound contrasts, while adults are not (Werker & Tees, 1983). For example infants younger than 10 months raised in an English-speaking family can discriminate non-native Hindi phonological distinctions, which English-speaking adults cannot (Werker, Gilbert, Humphreys, & Tees, 1981). It has been proposed that infants analyze the distribution of sounds in their native language and reorganize the phonetic space into categories relevant for the language (Kuhl, 2004). Similar pruning or reorganisation might be observed for sound-symbolism. Infants may be sensitive to all possible sound-symbolic links, but gradually as the native language is acquired, infants become less sensitive to the sound-symbolism not used in its native language.

Thus, this study addressed the following question: how does sound-symbolism develop in children? More specifically, we investigated whether adults and toddlers are sensitive to common sound-symbolism and sound-symbolism that is specific to another language (different from their native language). English-speaking adults, English speaking toddlers, Greek speaking adults and Greek speaking toddlers took part in the forced choice task. They were presented with novel words, together with two videos, a target and a distractor. The target sound-symbolically matched the novel word. The sound-symbolic match was either common or English language-specific. The stimuli used in the forced choice task were selected on the basis of a rating study with English, Greek, and Japanese speaking adults in order to verify the sound-symbolic relationships between the word-action pairs (see below in the Stimuli section).

There are two possible hypotheses for the question on how sensitivity to sound-symbolism develops. The first hypothesis is that toddlers develop sound-symbolic sensitivity by analyzing statistical patterns of sound-meaning association in the lexicon in their native language. This hypothesis would predict that both English speaking and Greek speaking toddlers would perform worse than the adults, irrespective of the common and language-specific nature of sound-symbolism. The second hypothesis is that sound-symbolism develops in much the same way as phonological sound contrast, whereby young children are sensitive to all possible sound-symbolic links; as they learn their native language, they lose sensitivity not supported by the native language or shape their sensitivity according to their native language patterns. This hypothesis would predict that English speaking adults, English speaking toddlers and Greek speaking toddlers would be able to detect common and English language-specific sound-symbolism, whilst Greek adults would only be able to detect common sound-symbolism.

Method

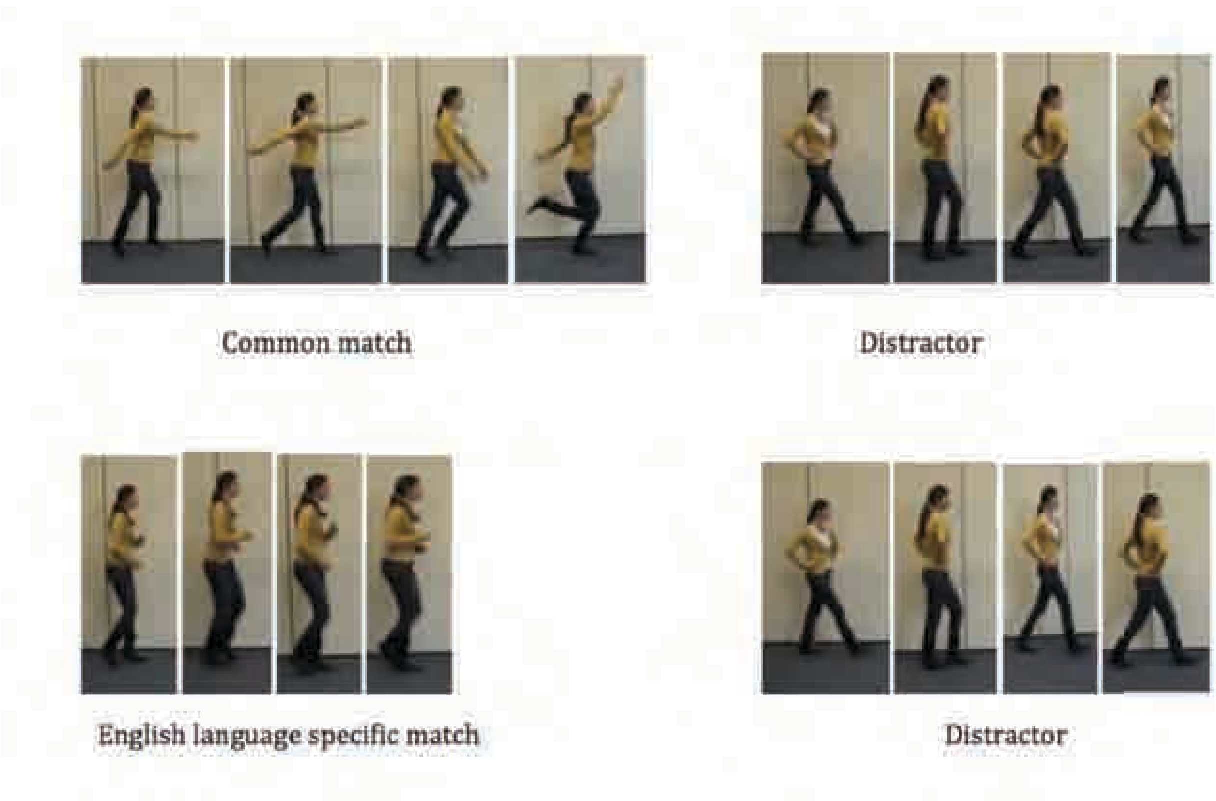
Participants

25 Greek-speaking adults (mean age: 23years, 3months; SD: 2.64 years; 10 male) recruited from Athens, Greece and Birmingham, UK and 25 English speaking adults (mean age: 18years, 11 months; SD: 0.81 years; 6 male) recruited from the School of Psychology at the University of Birmingham, UK, participated in the study. All participants were controlled for second language exposure. Five Greek-speaking

adults and four English-speaking adults were removed because they spoke a second language fluently, or daily as part of their work. 22 English speaking 2-year old toddlers (mean age: 2 years, 3 months; SD:0.14 years; 10 boys) were recruited, with prior parental consent, form nurseries around the Birmingham, UK area. Two were removed, 1 for second language exposure, 1 because he/she failed the practice trials. 24 Greek speaking 2-year old toddlers (mean age: 2 years, 3 months; SD: 0.14 years; 12 boys and 12 girls) were recruited from nurseries in Athens, Greece. Consent for the Greek speaking toddlers was received from nursery managers acting in loco-parentis.

Stimuli

Stimuli consisted of 12 word-action combinations. The four words were altered versions of existing Japanese mimetics (*bato bato*, *choka choka*, *yoto yoto* and *toku toku*) and so were novel to all participants. The 12 actions consisted of videos of the same female actor walking in various manners from the left to the right side of a room. Each word was paired with three actions: a common sound-symbolically matching action, an English language-specific sound-symbolically matching action and a non-sound-symbolically matching distractor action (see Figure 2.1 for an example of the stimuli).



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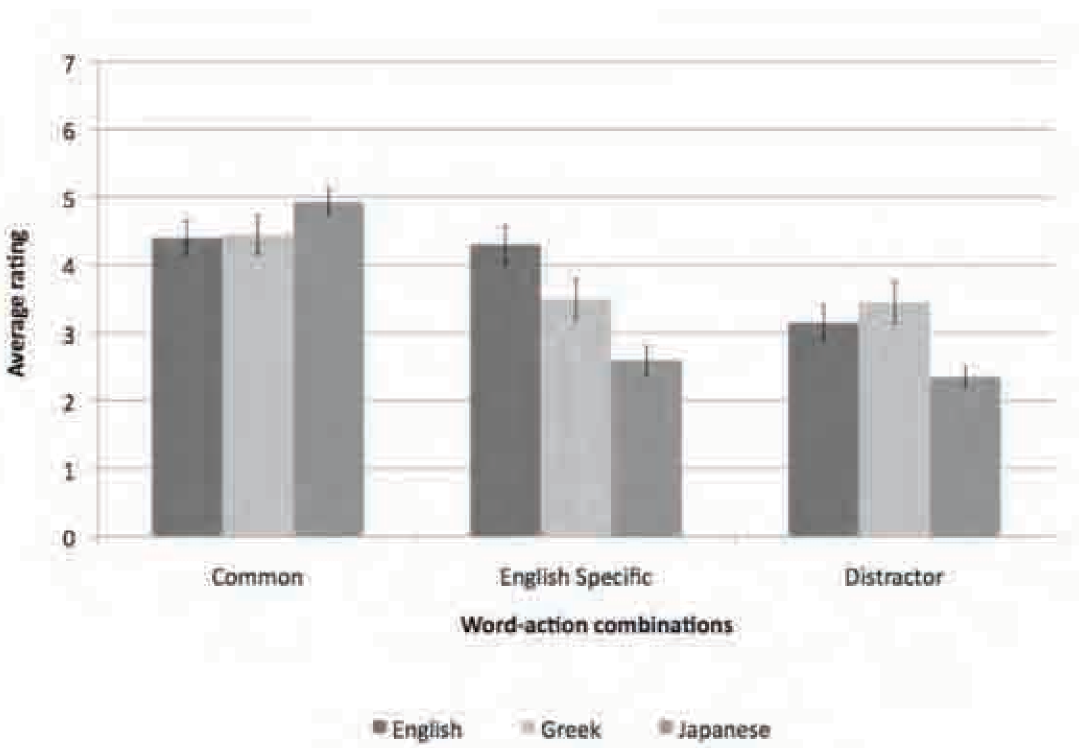
Stimuli pre-test

The novel words were presented (as an audio recording) along with the twelve videos to 21 English-speaking adults (without any knowledge of Japanese), 30 Greek-speaking adults (without any knowledge of Japanese) and 15 Japanese-speaking adults. Videos showed various manners of walking. Six novel words and twelve videos were paired together exhaustively, resulting in a total of 72 word-video pairs. The participants were asked to rate how well they thought each word-action combination matched on a scale from 1 (did not match at all) to 7 (matches very well).

Among the 72 word-video pairs, we selected four *common* pairs, four *English-specific* pairs and four *distractor* pairs for the main experiment in the following way. The common pairs were rated highly by participants from all three languages. English-specific pairs were rated highly by English-speaking participants only. Participants from all three languages rated distractor pairs low. Only four of the six novel words pre-tested were selected. The mean ratings for the three types of pairs by three groups of participants are shown in Figure 2.2.


Average rating
7
6
5
4
3
2
1
0
Common
English Specific
Distractor
Word-action combinations
English
Greek
Japanese

LSD post-hoc (as recommended by Howell, 2007, for a comparison of three means) revealed that English speaking adults gave significantly higher scores to English language-specific items than both Greek speaking $p<.05$ and Japanese speaking $p<.001$ participants.

Next, the scores given to each word-action pair group (common, English language-specific and distractor) within each language were compared. The average ratings given to common, English language-specific and distractor items, by English, Greek and Japanese speaking participants were entered into three separate repeated measures ANOVAs. There was a significant difference in the mean ratings given to the three test types by English speakers $F(2,40)=13.27$, $p<.001$, $\eta_p{}^2=.399$. An LSD posthoc revealed that, for English speakers there was no significant difference in the ratings given to common and English language-specific items, common word-action combinations were rated significantly higher than distractor word action combinations $p< .01$, and English language-specific word-action combinations were rated higher than distractor word-action combinations $p<.01$. There was a significant difference in the mean ratings given to the three test types by Greek speaking participants $F(2.58)=8.53$, $p<.01$, $\eta_p{}^2=.227$. An LSD posthoc revealed that Greek-speaking participants rated common word-action combinations significantly higher than English language-specific word-action combinations $p< .01$, and distractor word-action combinations $p< .05$. Greek-speaking participants did not rate English language-specific and distractor word-action combinations significantly differently. There was a significant difference in the mean ratings given to the three test types by Japanese speaking participants $F(2, 28)=89.46$ $p<.001$,

η_p^2=.865 . An LSD posthoc revealed that Japanese speaking participants rated common word-action combinations significantly higher than English language-specific word-action combinations $p < .001$ and distractor word-action combinations $p < .001$. Finally, Japanese-speaking participants did not rate English language-specific and distractor word-action combinations significantly differently.

In order to make the materials appropriate for the forced-choice method in the main experiment, the videos were re-shot using only one actor (the previous stimuli had used a number of actors).

Procedure

Toddlers were shown 5 practice trials. First, to ensure that toddlers could select the correct choice item, in three of the practice trials they were shown two still pictures and asked to identify one as the referent of a noun. In the final two practice trails, were verb practice trials, toddlers were presented with two action videos. One of the verb practice trails was a known verb (hopping). The final practice trial was the same for adults and toddlers. Participants were presented with two action videos along with the novel word "nosu nosu". This trial was included to assure both adults and children were comfortable with assigning meaning to novel words. For adults, there was one practice trial, in which participants were presented with two action videos along with the novel word "nosu nosu".

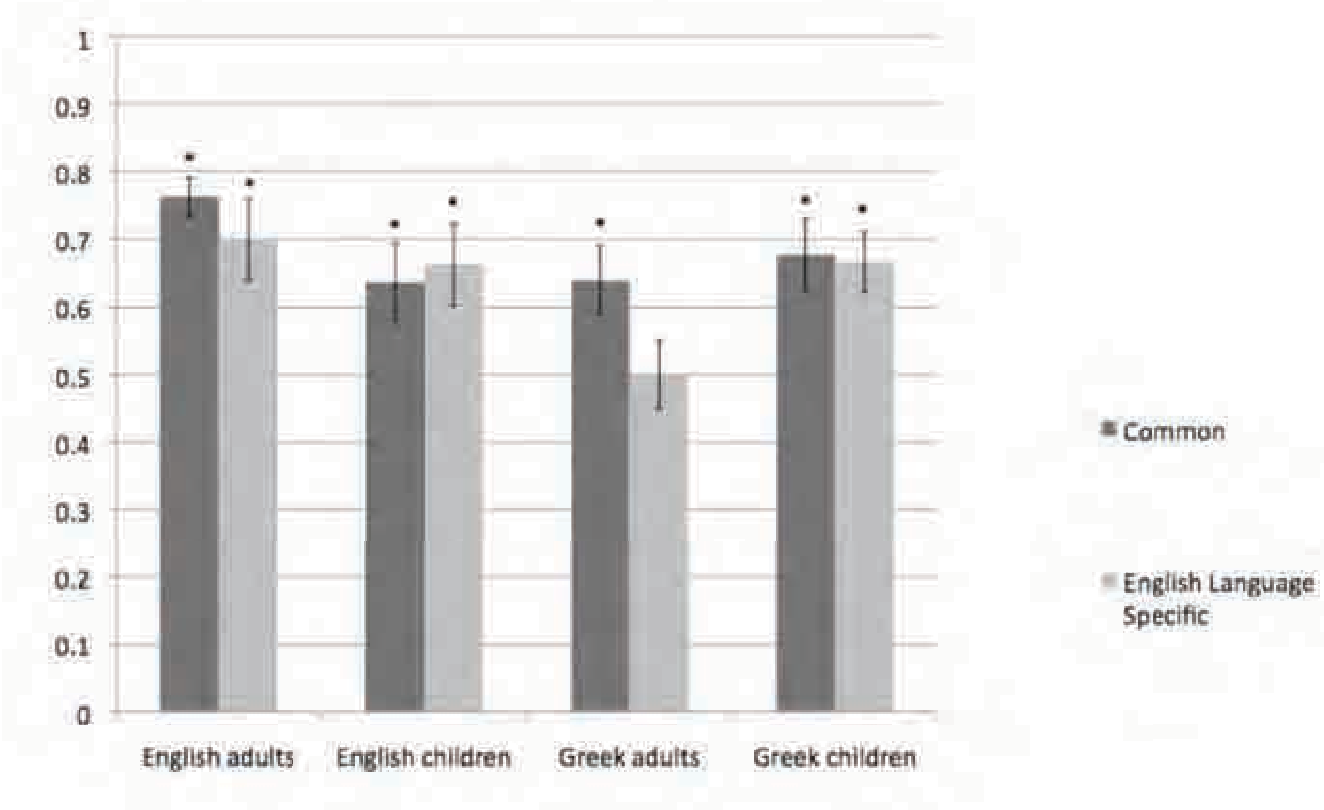
In the main trials, participants were presented with the two videos simultaneously, whilst the experimenter orally presented a novel word three times, embedded into a sentence, "Which one is doing, X, X, X?" (for example 'Which one is doing *bato bato*, *bato bato*, *bato bato*'). The two actions were either a common or an English language-specific match to the novel word, and a distractor. Videos were presented in a loop. The participant's task was to indicate which one of the two videos matched the novel word. Toddlers were asked to point to which video they thought the novel word corresponded to and the experimenter recorded their response. Adults recorded their own responses on an answer sheet. Each participant was presented with one of the six counterbalancing sets, in which the order each slide was presented in was counterbalanced.

Results

First the hypothesis that English speaking adults are sensitive to both common and English-language specific sound symbolism whereas Greek-speaking adults are sensitive to only common sound symbolism was tested. If this was the case then for English speakers the proportion correct responses would not differ from each other but for Greek speakers common sound symbolism would have had a higher proportion of correct responses than English language specific. So the proportion correct responses were entered into a 2(language: English speaking adults, Greek speaking adults) x 2(test-type: common, English language specific). There was a significant effect of language $F(1, 19)=10.67$, $p<.005$, $\eta_p^2=.360$ and test type F(1,19)=7.04, p<.05, η_p^2=.270. The interaction between language and test-type however was not significant F(1,19)=2.11. Though the expected interaction was not significant, descriptively we obtain the expected pattern of data (see Figure 2.3). Furthermore, the validity of the stimuli has been verified in the pre-test reported in the method section. The lack of expected interaction in this analysis could be because of the forced choice task used. The forced choice task might not be as sensitive to showing the interaction as the rating study used in the pre-test.

If participants picked the target (common or English language-specific video) this was coded as correct in all participant groups. For the hypothesis that children, but not adults, are sensitive to all possible sound-symbolisms, the key comparison is how Greek adults and children respond to English language-specific items. Despite not finding a significant interaction in the previous ANOVA, we analyzed English and Greek data separately. The mean proportion of correct responses was entered into 2(age: Adults vs. Toddlers; between participants;) x 2(test type: common vs. English language-specific; within participants) ANOVA for English and for Greek separately (see Figure 2.3 for the means). First, for English speaking participants there was no main effect of test types $F(1, 38)=.144$, or ages $F(1, 38)=2.01$ and no interaction between age and test types $F(1, 38)=.782$. These results indicate that English speaking adult and English speaking toddlers did not differ in their responses to common and English language-specific items. Next for Greek speaking participants common word-action combinations were detected more often than English language-specific word-action combinations $F(1, 43)=6.323$, $p<.05$, $\eta_p^2=.128$. Greek speaking children performed significantly better than Greek speaking adults *F*(1, 43)=4.479, p<.05, η_p^2=.094. There was also a significant interaction between age and test type F(1, 43)=5.21, p<.05, η_p^2=.108. These results indicate that Greek adults and toddlers performed differently in their responses to common and English language-specific items. Tukey post-hoc tests revealed that (1) Greek adults were significantly better at detecting common sound-symbolic matches than English language-specific sound-symbolic matches p<.01. (2)There was no significant difference in Greek toddlers' ability to detect common and English language-specific matches. (3) Greek speaking toddlers were significantly better than Greek speaking adults at detecting English language-specific sound-symbolic pairs, p<.01. Finally, (4) there was no significant difference in Greek speaking adults and Greek-speaking toddlers ability to detect common sound-symbolic matches.

The proportions of correct responses to common and English language-specific targets for each participant group were compared to a chance level (.5). For the common word-action combinations, all participant groups performed significantly better than chance, ps < .05. For the English language-specific word-action combinations, English speaking adults, English speaking toddlers and Greek speaking toddlers performed significantly better than chance ps <. 05. However, Greek-speaking adults did not significantly differ from chance in their ability to detect English language-specific word-action combinations.



1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
English adults
English children
Greek adults
Greek children
Common
English Language Specific

Discussion

speaking toddlers and Greek speaking toddlers were sensitive to both sound-symbolism common to three languages and English language-specific; however, Greek-speaking adults were only sensitive to common sound-symbolism.

This study provides further evidence that common sound-symbolism exists. Greek speakers and English speakers, adults and children were able to identify common sound-symbolism. These findings are compatible with previous research. Davis (1961) showed that English speaking children and Kitogwe speaking children both respond similarly in a shape sound-symbolism task. Further evidence for common sound-symbolism comes from numerous studies looking at adults' ability to guess the meaning of real foreign words (Brown, Black, & Horowitz, 1955; Iwasaki, Vinson, & Vigliocco, 2007a & b; Klank, Huang, & Johnson, 1971; Nygaard, Cook, & Namy, 2009).

The present study is the first to experimentally show evidence of language-specific sound-symbolism. English speaking adults, English speaking toddlers and Greek speaking toddlers were able to identify English language-specific sound-symbolism, whilst Greek-speaking adults were not. These results indicate that there is sound-symbolism that is specific only to English speakers. These findings dovetail with the fact that sound-symbolic words expressing similar concepts are different across languages. It is also compatible with the fact that second language learners of Japanese typically find it hard to learn Japanese sound-symbolic (mimetic) words (Hamano, 1998).

The current findings show that sound-symbolism is acquired in much the same way as phonological contrasts (Werker & Tees, 1983). English speaking toddlers and Greek speaking toddlers performed similarly to adults in their ability to detect common sound-symbolism. Critically, Greek-speaking toddlers were able to identify English language-specific sound-symbolism, significantly better than Greek speaking adults. Young children may be sensitive to all sound-symbolic links including common and language-specific ones. However, as children's experience with their native language grows, they may be pruning or re-organizing their sound-symbolic sensitivities excluding non-native sound-symbolic links. This would explain why we found that Greek-speaking toddlers are sensitive to English language-specific sound-symbolism while Greek-speaking adults are not.

Why toddlers are more sensitive to sound-symbolism than adults is not clear; however, facilitation of word learning may be the key. Previous research has shown that sound-symbolism can help toddlers learn verbs more effectively, regardless of whether the language they are learning has an extensive sound-symbolic lexicon (Imai et al., 2008; Kantartzis et al., 2011). If we suppose that sound-symbolism is one of the key tools for toddlers to start learning words then toddlers should have a heightened sensitivity to sound-symbolism. This sensitivity may well be innate, or develop very early on in infants. However, further research is needed before such questions can be answered. This is especially pertinent if toddlers are learning one of many languages of the world with an extensive sound-symbolic lexicon (Voeltz & Kilian-Hatz, 2001). Toddlers may be equipped with sensitivity to all possible sound-symbolic links so that they can readily learn any language. However, as the majority of the words in a give language are not sound-symbolic, sound-symbolic links not supported by the native language may be gradually lost in the course of development. Cross-linguistic sensitivity remains for sound-meaning mappings that are supported by the native language. Some of these mappings may be common across languages and therefore cross-linguistic sensitivity to sound-symbolism is found. Further research is necessary to find out why children may be sensitive to more sound-symbolic links than adults.

What is still unclear from this line of research is exactly how sensitivity to sound symbolism is acquired. The findings from this experiment indicate that like phonology, toddlers seem to be sensitive to a wider variety of sound symbolism than adults. Phonology is believed to be innate, in that infants are born with a heightened sensitivity to phonology (see Kuhl et al. , 2006). If the analogy between phonology and sound symbolism holds then it might be suggested that sensitivity to sound symbolism also be innate. However, much research is needed before such a conclusion can be reached. For instance it is important to investigate whether much younger infants and even neonates are sensitive to sound symbolism as well.

CHAPTER 3: JAPANESE SOUND-SYMBOLISM FACILITATES WORD LEARNING IN ENGLISH-SPEAKING CHILDREN.

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Abstract

Sound-symbolism is the nonarbitrary link between the sound and meaning of a word. Japanese-speaking children performed better in a verb generalization task when they were taught novel sound-symbolic verbs, created based on existing Japanese sound-symbolic words, than novel non-sound-symbolic verbs (Imai, Kita, Nagumo, & Okada, 2008). A question remained as to whether the Japanese children had picked up regularities in the Japanese sound-symbolic lexicon or were sensitive to universal sound-symbolism. The present study aimed to provide support for the latter. In a verb generalization task, English-speaking 3-year-olds were taught novel sound-symbolic verbs, created based on Japanese sound-symbolism, or novel nonsound-symbolic verbs. English-speaking children performed better with the sound-symbolic verbs, just like Japanese-speaking children. We concluded that children are sensitive to universal sound-symbolism and can utilize it in word learning and generalization, regardless of their native language.

Keywords: Sound-symbolism; Word learning; Verb; Mimetics; Language development; Language acquisition

Introduction

The task of word learning is an important step in children's lives. There are various challenges the child is presented with when learning a novel word. Initially the child must identify the referent of a novel word in a complex reality (see Quine, 1960; for a more extensive discussion of difficulties at the identification stage). Following identification, the child must then store this novel word in such a way that makes it generalizable to new situations. Studies have shown that generalization is particularly difficult in verb-learning tasks (Imai, Haryu, & Okada, 2005; Maguire et al., 2002), even though children use verbs in their daily language. When 3-year-olds are presented with a novel verb while seeing Actor A doing Action X, they are not able to generalize the verb to a new situation with Actor B doing the same action (X). That is, they are unable to separate the actor or the patient object from the action in the semantic representation of the verb (Imai et al., 2005; Maguire et al., 2002) and thus are unable to correctly generalize novel verbs to new situations.

Previous research demonstrated that generalization of novel verbs becomes easier for 3-year-olds when the verbs sound-symbolically match the action they represent. In Imai et al.'s (2008) study, Japanese 3-year-olds were taught novel verbs that either sound-symbolically matched or did not match the referent actions. The novel sound-symbolic verbs were created on the basis of existing Japanese sound-symbolic words. The 3-year-olds failed to generalize a newly taught verb to an instance of the same action performed by a different actor, when the novel word did not have a sound-symbolic relation to the referent. However, they succeeded in the task when the novel verb sound-symbolically matched the action it represented. That is, Japanese children learned and stored new verbs in such a way that they were then able to correctly generalize them, when the novel word sound-symbolically matched the action it represents. These findings led the authors to propose the ‘‘sound-symbolism bootstrapping hypothesis,’’ which states that sound-symbolism can help children single out the referent of a novel word in the complex reality, which in turn allows them to store the semantic representation in such a way that children can correctly generalize the verb to new situations.

Sound-symbolism is the nonarbitrary relationship between a word and its referent (Jespersen, 1933; Sapir, 1929), and such relationships are often recognized crosslinguistically. Köhler's (1947) research illustrated a well-known example of such an inherent sound meaning link. He reported that when adults are presented with two novel labels, maluma[1] and takete, and two referents, a rounded and an angular object, they prefer to label a rounded object as maluma and an angular object as takete. This type of sound-symbolism can be recognized by English-speaking adults (Kovic, Plunkett, & Westermann, 2010; Westbury, 2005) as well as by both English-speaking 11- to 14-year-old children and Kitongwe-speaking 8- to 14-year-old children in an isolated part of Tanzania (Davis, 1961). More recently, it has been shown that English-speaking 2.5-year-olds can recognize this shape sound-symbolism (Maurer, Pathman, & Mondloch, 2006). Previous studies have further demonstrated that adult English speakers are able to detect the sound-meaning correspondence of novel words (e.g., Imai et al., 2008; Sapir, 1929) or foreign words (Brown, Black, & Horowitz, 1955; Iwasaki, Vinson, & Vigliocco, 2007a & b; Klank, Huang, & Johnson, 1971; Nygaard, Cook, & Namy, 2009).

Given the crosslinguistic recognizability of sound-symbolism, a question arises as to whether children can use universal sound-symbolism to bootstrap their verb learning independent of their native language. The study with Japanese children by Imai et al. (2008) left this question unanswered because they tested Japanese children with novel words based on Japanese-existing sound-symbolic words (mimetics). Thus, it is not clear whether the children benefited from regularities in the existing Japanese sound-symbolic lexicon or they accessed sound-symbolism that can be universally detected by speakers of different languages. The former possibility cannot be dismissed a priori because Japanese is a language with a very rich inventory of sound-symbolic words (Hamano, 1998; Kita, 1997, 2001). A midsize dictionary of Japanese sound-symbolic words (Atoda & Hoshino, 1995) lists more than 1,700 entries. These words are frequently used by adults and by 3-year-olds (e.g., Allen et al., 2007).

In order to determine whether children can use universal sound-symbolism in word learning and generalization, it is important to test whether the Japanese-based sound-symbolism can benefit children whose native language has words with very different phonological properties to Japanese. If so, we can conclude that children in general can universally detect sound-symbolism and utilize it for word learning independent of their native language.

Method

Participants

Forty-five monolingual English-speaking 3-year-olds (M = 41.57 months, range = 36-48 months, 20 boys, 25 girls) were recruited from nurseries around Birmingham, UK, with prior parental consent.

Stimuli

The materials were word-action combinations. There were eight novel words. Four of the words were novel words created by altering Japanese mimetics (batobato, nosunosu, chokachoka, and tokutoku). The other four were nonwords with the structure of typical English verbs (bretting, blegging, blicking, and truffing). There were eight novel actions, which were various manners of walking. Four of the actions sound-symbolically matched one of the altered versions of Japanese mimetics, but not the English-type words. The other four did not sound-symbolically match either the mimetic-type words or the English-type words. The sound-symbolically matching word-action combinations were as follows: batobato = as large energetic movement, arms are swinging back and forward outstretched, whereas legs are making large leaping movement; chokachoka = walking quickly in very small steps with the arms swinging quickly with bent elbows; nosunosu = walking slowly in large steps with bent knees and the hands on knees (see the video screen shots for the training video and the same action video in Fig. 3.1); tokutoku = a small shuffling movement, with straight arms rigidly at the side and legs moving very slightly and rigidly. The same set of novel words were used in the sound-symbolism mismatch condition as were in the sound-symbolic match condition; what changed was the actions the words were paired with. This change in the actions made the word-action pairs nonsound-symbolic. The sound-symbolically mismatching word-action combinations were as follows: batobato = walking slowly, with arms loosely bent and hands touching in the front; chokachoka = legs slightly bent, walking slowly and in a controlled fashion, with arms bent and held out in front of body (as if carrying a tray); nosunosu = legs making large steps forward, with a bounce, arms swinging freely from side to side; tokutoku = creeping-type walk with medium sized steps, with arms bent and held closely in front of body.

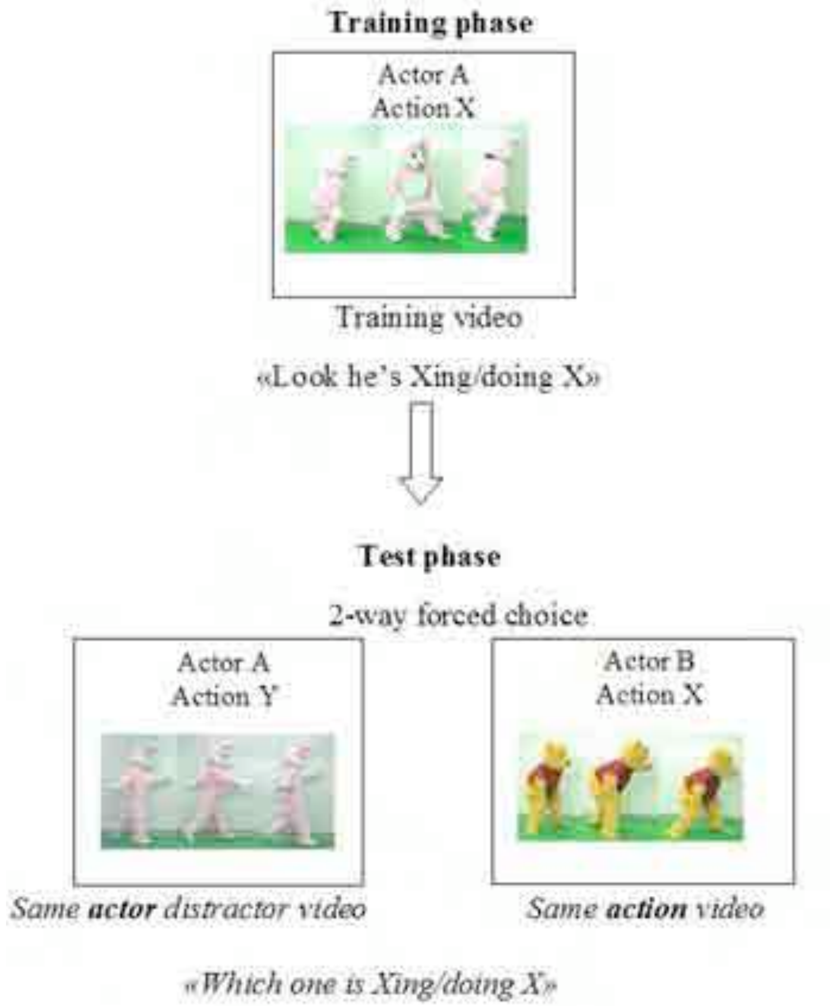


Figure. 3.1. The structure of a trial, consisting of the training and test phases, in the verb generalization task. If the children correctly generalized the novel verb based on the same action, they should pick the same-action video. The novel words used in the training phase sound-symbolically matched the action in the training video and in the same action video for the sound-symbolic match condition (the word was "nosunosu" for this example), but not for the sound-symbolic mismatch condition ("batobato") and the neutral baseline condition ("blicking"). Furthermore, the words for the sound-symbolic mismatch condition ("batobato" for this example) sound-symbolically matched the same actor distractor video, which was the incorrect choice for verb generalization.

A pretest was conducted to check whether the eight actions did indeed have the presumed relationships to the four mimetic-type words and the four English-type words. First, the mimetic-type words were presented (as an audio recording) along with the eight videos to 21 English-speaking adults (without any knowledge of Japanese) and 15 Japanese-speaking adults. The four words and eight videos were paired together exhaustively, resulting in a total of 32 word-video pairs. The participants were asked to rate how well they thought each word-action combination matched on a scale from 1 (did not match) to 7 (matches very well). The mean rating was significantly higher for the sound-symbolically matching word-action combinations than for the nonsound-symbolically matching word-action combinations for English speakers (sound-symbolically matching: $M = 4.4$, $SD = 1.02$; nonsound-symbolically matching: $M = 3.50$, $SD = 1.04$), $t(20) = 3.8$, $p < .001$, $d = 0.87$, and Japanese speakers (sound-symbolically matching: $M = 5.71$, $SD = 0.66$; nonsound-symbolically matching: $M = 2.06$, $SD = 0.78$), $t(14) = 14.7$, $p < .001$, $d = 4.68$.[2] The videos in the sound-symbolically matching combinations later served as the same-action videos (see Fig. 3.1) and the videos in the nonsound-symbolically matching combinations, as the same-actor distractor videos, in the test phase for the sound-symbolic match condition in the main experiment (see below for more information about the conditions).

Four novel English-type words (to be used in the neutral baseline condition in the main experiment) were also pretested with the same eight action videos as above. The degree of the sound-action match was tested by 20 English-speaking adults. The words and actions were paired exhaustively, and each pair was presented together individually, as above. The results ensured that the novel verbs did not sound-symbolically match any of the actions: The degree of match was judged to be poor for all the actions. The word-action combinations were divided into two sets: those with the videos that later served as the same-action videos and those with the videos that later served as the same-actor distractor videos in the test phase of the main experiment. The first set was the same as those in the sound-symbolically matching combinations in the pretest described above, and the second set was the same as those in the nonsound-symbolically matching combinations. There was no significant difference in the rating between the two sets (same-action: $M = 3.81$, $SD = 0.57$; same-actor: $M=3.63$, $SD=0.79$), $t(19)=1.0$.

Procedure

Each child was tested individually in a quiet area of the nursery. Two warm-up trials using familiar nouns were given to establish the procedure (of indicating the referent of a word by pointing). Then, a practice trial with a familiar verb preceded the main experiment to ensure that the children understood the training-test procedure. The practice trials followed the same procedure as the experimental trials.

All conditions followed the same structure of a training phase followed by a test phase (see Fig. 3.1). In the training phase, children were presented with a video of an actor carrying out an action (Actor A, Action X) on a laptop computer; the experimenter simultaneously presented the novel verb in one of the two sentences, depending on the condition they were in. In the test phase, which immediately followed the training phase, the experimenter asked the children to indicate the referent of the novel verb by pointing to one of the two action videos on the screen. In one video, the action was the same but the actor was different (same-action: Actor B, Action X); in the other video the actor was the same, whereas the action was different (same-actor distractor: Actor A, Action Y).

Conditions

Participants were systematically assigned to one of three conditions.

Sound-symbolic match condition

Fifteen children were assigned to this condition (mean age = 41.7 months, range = 33-48 months, 9 girls). The newly taught verb was embedded in the sentences, ‘‘Look! He is doing X’’ (training) and ‘‘Which one is doing X’’ (test). The newly taught verb sound-symbolically matched the action in the training video and therefore matched the action in the same-action video but not the action in the same-actor distractor video (see Fig. 3.1 for an example of the videos used as same-action and same-actor distractor videos; see the Section 2.2 for verification of sound-symbolism). The action used in the same-action video or same-actor distractor video did not re-appear for another word.

Neutral baseline condition

Fifteen children (mean age = 42.5 months, range = 35-48 months, 8 girls) were tested in this condition. The newly taught verb was embedded in the sentences, ‘‘Look he is Xing’’ (training) and ‘‘Which one is Xing’’ (test). This condition provided a baseline for 3-year-olds’ performance in this verb generalization task when the newly taught verb did not sound-symbolically match the same-action or the same-actor distractor video. The verbs were presented in a form that resembled typical English verbs (e.g., blicking). The training videos, same-action videos, and same-actor distractor videos were all identical to those in the sound-symbolic match condition.

Sound-symbolic mismatch condition

Fifteen children (mean age = 40.5 months, range = 33-47 months, 8 girls) were taught the same set of words as in the sound-symbolic match condition and were therefore embedded in the same sentences. The two videos shown at the test phase for each word were identical to the ones in the sound-symbolic match condition. However, the newly taught verb did not sound-symbolically match the action in the training video and, consequently, the same-action video in the test phase. Instead, the verb did sound-symbolically match the action in the same-actor distractor video (see Fig. 3.1). Accordingly, the training videos differed from those in the sound-symbolic match condition because the same-action videos were different.

This condition allowed us to eliminate alternative explanations for the predicted finding that children would perform better in the sound-symbolic match condition than in the neutral baseline condition. Namely, if children were performing above chance in the match condition, one might suggest that the children were detecting sound-symbolism at the test phase and not learning anything in the training phase. In the mismatch condition, the children were taught a novel verb that did not sound-symbolically match the action, but they were presented with the sound-symbolically matching action as a same-actor distractor at the test phase. If children were simply detecting sound-symbolism at the test phase, then in the mismatch condition they should pick the sound-symbolically matching action, which in this condition was the same-actor distractor. If they were learning verbs despite the lack of sound-symbolism, they should be picking the same-action video. Therefore, if children's good performance in the sound-symbolic match condition was due to the benefit of sound-symbolism in the learning phase (in line with our hypothesis), children in this condition should perform at chance and worse than those in the sound-symbolic match conditions.

Another concern is that the sentential frame (i.e., He is doing X) and/or features of word forms (e.g., reduplication) used in the sound-symbolic match condition might help children identify and learn the verbs more effectively than in the neutral baseline condition. In the mismatch condition, novel verbs and their sentential frame were identical to the match condition, but the novel verbs did not sound-symbolically match the action. If the sentential frame and/or features of word form assisted children in learning the novel verbs, then children should perform equally well in the mismatch condition as they do in the match condition.

Results

When a child correctly extended the novel verb on the basis of the same action, the response was coded as correct. For each child, the proportion of correct responses out of the four trials was calculated and served as the dependent variable. As we expected, the children performed differently across the three groups, $F(2, 42) = 4.04$, $p < .05$, $\eta^2 = .161$ (see Fig. 3.2). The children in the sound-symbolic match condition performed better than those in the sound-symbolic mismatch condition or in the neutral baseline condition (Fisher's LSD as recommended by Howell, 2007, for three means, both ps < .05). Children more successfully learned and generalized novel verbs based on the identity of the action when the word sound-symbolically matched the action than when the word did not sound-symbolically match the action.

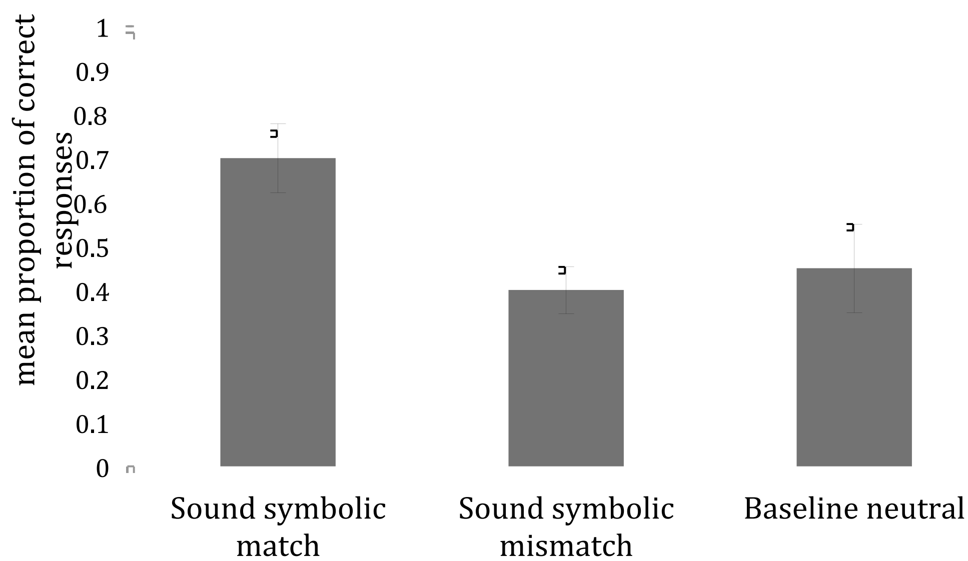


Figure 3.2. Mean proportion of correct responses given in the sound-symbolic match, sound-symbolic mismatch and baseline neutral conditions in the verb generalization task. The error bars represent the standard error of the mean for each condition.

Consistent with the previous findings (Imai et al., 2005, 2008; Maguire et al., 2002), the performance of the children in the two control conditions did not significantly differ from chance (where chance is 0.5), t(14) = 1.87 (sound-symbolic mismatch condition), and t(14) = 0.49 (neutral baseline condition). In sharp contrast, the children in the sound-symbolic match condition successfully generalized the novel verbs and performed significantly above chance, $t(14) = 2.57$, $p < .05$.

The performance in the sound-symbolic mismatch condition ruled out two possible alternative interpretations. First, the results may not have reflected the success of verb generalization but reflected success in detecting sound-symbolism between the word and the action at test. However, because the children in the sound-symbolic mismatch condition did not select the sound-symbolically matching distracter significantly more than chance, this alternative is unlikely. Secondly, the sentence structure (‘‘doing X’’) or features of word forms (e.g., reduplication) may have caused good performance in the sound-symbolic match condition. These possibilities can also be ruled out because the children were presented with the same set of novel sound-symbolic verbs in the same sentence frame in both sound-symbolic match and mismatch conditions, but only the latter group performed at chance and the difference between the two groups was significant.

It should be noted, however, that numerically (but not statistically) children chose the sound-symbolically matching distractor more often than the sound-symbolically mismatching target in the sound-symbolic mismatch condition (the proportion of correct responses is numerically slightly lower than chance, .50). This might be interpreted as the children using sound-symbolism to guide their choices in the test phase, rather than using sound-symbolism at the training phase. However, comparing the difference between the proportion of correct responses in the sound-symbolic mismatch condition and the baseline neutral condition, the difference is very small (.05) and not significant. Thus, we maintain that sound-symbolism assisted children in the training phase to form a semantic representation of the novel words based on action, which lead to better performance in the task.

Further evidence in support of children using sound symbolism at the training phase in the current study, comes from the results of Experiment 2, Chapter 4. In this experiment children were shown a scene of an actor carrying out an action on one day. The following day the children were asked to identify whether or not they had seen a scene before. Children showed a strong preference to say they had seen both the identical and the same-actor-different-action scene before (see results of Chapter 4, Experiment 2). These results indicate that children may tend to focus on the actor in a scene and ignore an action change. In the current experiment children in the sound symbolic mismatch condition performed slightly, but not significantly, below chance, or in other words showed a slight preference for the same-actor video. Given the results from Experiment 2, Chapter 4, it is likely that children were using sound symbolism at training, but had a slight preference for picking the same-actor video, which is why the mismatch condition falls slightly below chance.

Discussion

This study demonstrated that English-speaking children performed better in a verb generalization task when the novel verb sound-symbolically matched the referent action than when it did not. Importantly, the novel sound-symbolic words were derived from Japanese sound-symbolic words, and the sound-symbolism could be detected by English-speaking adults and utilized by English-speaking children with no knowledge of Japanese. The English-speaking participants could not have derived the sound-symbolism from sound-meaning regularities in the Japanese lexicon; therefore, the sound-symbolism is likely to have a universal basis. Thus, we conclude that children are, in general, sensitive to universal sound-symbolism and can use this sensitivity in verb learning and generalization.

The current findings suggest that English-speaking adults and children can detect universal sound-symbolism. English-speaking 2.5-year-olds matched rounded versus pointed shapes to novel words in the way compatible with Kohler's (1947) celebrated sound-symbolism for shapes (Maurer et al., 2006), which has been identified in speakers of different languages and ages (Davis, 1961). Furthermore, adult English speakers with no knowledge of Japanese could correctly guess some aspects of the meaning of Japanese sound-symbolic words (Imai et al., 2008; Iwasaki et al., 2007a & b). The current study went beyond the previous studies in demonstrating that children use the sensitivity to universal sound-symbolism in word learning and generalization.

Exactly how does sound-symbolism help children learn verbs? When presented with a novel verb with an actor performing an action, 3-year-olds typically assume that both actor and action are necessary for verb meaning generalization and find it difficult to separate the critical component (i.e., action) from the noncritical one (i.e., object) (Imai et al., 2005; Maguire et al., 2002). Sound-symbolism seems to help children break down the action-actor combination and identify the action as the referent. As a consequence, the semantic representation of the verb is stored in such a way that the verb can be correctly generalized to new situations with the same action regardless of the actor (see also Imai et al., 2008). It should be noted, however, that the exact nature of the sound-symbolism used in this study (i.e., exactly what sound properties of words caused sound-symbolism) is not clear. Different aspects of the sound-symbolic words (phonetic, phonotactic, and prosodic properties) may have contributed to the sound-symbolism. This would be an important topic for future research.

Why do children have the capacity to use universal sound-symbolism when learning new words? We suggest that that is because sound-symbolism is a vestige of language evolution. Some researchers have suggested that sound-symbolic words played an important role in the evolution of human language (Kita, 2008; Kita, Kantartzis, & Imai, 2010; Ramachandran & Hubbard, 2001).[3] One key step in language evolution is the emergence of a system for agreeing upon the referent of a novel word. One easy way in which such an agreement could have been made is universal sound-symbolism. If an inherent sound-meaning link exists in everybodys' mind, then the listener would be able to easily identify the referent of the speaker's novel word, making communication easier. Thus, universal sound-symbolism could facilitate a rapid growth of a shared lexicon (Kita, 2008; Ramachandran & Hubbard, 2001). Given that sound-symbolic words in modern languages can refer to information in various domains such as vision, touch, smell, taste, manners of movement, emotion, and attitude (e.g., Kita, 1997; Voeltz & Kilian-Hatz, 2001), sound-symbolic proto words of our ancestors may have had a considerable expressive power (Kita, 2008). Thus, universal sound-symbolism would have had great adaptive values for our ancestors.

Universal sound-symbolism in modern languages may be the ''fossils'' of a sound-symbolic communication system our ancestors once used. Such fossils might have been preserved in today's languages because children have a preference to use sound-symbolic words over nonsound-symbolic words. For example, it has been shown that Japanese children have a stronger preference than Japanese adults to use sound-symbolic words when describing the manner of motion in a narrative task (Kita, Özyurek, Allen, & Ishizuka, 2010).

We suggest that all humans are disposed to develop abilities to sense universal sound-symbolism and use it for word learning, and that the emergence of this disposition was a crucial step in language evolution. Because the capacity to use sound-symbolism in word learning is rooted in the evolutionary history, it is observable in children who are learning languages that are geographically separated and do not belong to the same language family, for example, Japanese (Imai et al., 2008) and English (the current study). It is possible that the present study tapped into the vestige of this evolutionary process still present in all children.

Notes.

1. In the first edition published in 1929, the word ‘‘baluma’’ was used, but was changed to ‘‘maluma’’ in the 1947 edition.

2. Japanese speakers’ ratings were lower for the nonsound-symbolic matching pairs and higher for the sound-symbolic matching pairs than English speakers’ ratings. This may be either because Japanese speakers have stronger intuitions about how well word-action pairs matched due to extensive experience with sound-symbolic words or because the sound-symbolic words in this study were created on the basis of existing Japanese sound-symbolic words.

3. One of the reviewers questioned whether these suggestions are compatible with the fact that frequency-size sound-symbolism is shared by humans (Ohala, 1984, 1994) and other mammals and birds (Morton, 1994). Across species, high-frequency vocalizations

are associated with smallness (and appeasement) and low-frequency vocalizations are associated with largeness (and hostility). We maintain that this does not necessarily undermine the possibility that sound-symbolism played a role in language evolution for two reasons. First, frequency-size symbolism is only one of many types of sound-symbolism, and other types of sound-symbolism may be specific to humans and their close evolutionary relatives. Second, even if all types of sound-symbolism are shared by humans and a wide range of species, including birds, it could still be argued that sound-symbolism is an important precursor of language, but the evolution of language required additional cognitive changes unique to the human lineage.

CHAPTER 4: SOUND-SYMBOLISM FACILITATES LONG-TERM RETENTION OF THE SEMANTIC REPRESENTATION OF NOVEL VERBS IN THREE-YEAR-OLDS.

Kantartzis, K., Imai, M., & Kita, S.

Abstract

Previous research has shown that children benefit from sound-symbolism when learning new verbs (Imai et al., 2008; Kantartzis et al., 2011). The current study investigated whether the benefits of sound-symbolism in verb learning can be seen in the long term. In a between participant design three-year-olds were trained with either sound-symbolically matching or mismatching combinations of a novel verb and an action. The testing session took place a day later, and children's memory of the novel verb was tested. It was found that sound-symbolism significantly improved children's ability to encode the semantic representation of the novel verb and generalise the novel verb the following day.

Introduction

Verb learning presents certain challenges to children. In order to learn new words children must identify the referent of the word in a complex reality. Identifying the correct referent of a word is no small task, as discussed by Quine (1960). For example, when a parent points to a rabbit hopping and says, "hopping", the child must identify the action as the referent of the word. The word hopping however could refer to the name of the animal, the colour or the fur for example. Previous experimental studies showed that three-year-olds could not generalise newly learned novel verbs to a novel situation (Imai, Haryu, & Okada, 2005). The children were unable to separate the action from the agent in the semantic representation of a newly learned verb. That is, having learned a novel verb while watching action A performed by actor X, children typically do not extend the meaning of the novel verb to action A performed by actor Y. However, Japanese-speaking (Imai, Kita, Nagumo, & Okada, 2008) and English-speaking (Kantartzis, Kita, & Imai, 2011) children could generalise novel verbs on the basis of the same action successfully if the novel verbs sound-symbolically match the action. It has been argued that this is because sound-symbolism highlights the action as the referent.

Sound-symbolism is the inherent link between the sound and meaning of a word, and it is recognised and used cross-linguistically. One of the original and most famous examples is Köhler's (1947) sound-symbolism for shapes. Participants were asked to match the two shapes, rounded and angular objects, to the two novel words, *maluma* and *takete*. A large majority of adults from different linguistic backgrounds pick *takete* for the angular object and *maluma* for the rounded object (e.g., Davis, 1961; Holland & Wertheimer, 1964). Another classic method used in the sound-symbolism literature to identify cross-linguistic sensitivity to sound-symbolism is antonym pair matching. Participants could match foreign antonym pairs to English antonym pairs above chance (Brown, Black, & Horowitz, 1955; Brown & Nuttall, 1959; Gebels, 1969; Klank, Huang, & Johnson, 1971; Kunihara, 1971; Siegel, Silverman, & Markel, 1965). Other studies showed that sound-symbolism for action can be recognised cross linguistically (Japanese and English: Imai et al., 2008; English, Greek: Kantartzis, Kita & Imai., Chapter 2).

Children can use sound-symbolism to learn words. Japanese-speaking children (Imai et al., 2008) and English-speaking children (Kantartzis et al., 2011) could learn and generalise novel verbs when the novel word and action sound-symbolically matched. Sound-symbolism therefore is one mechanism adults and children use when learning new words.

Previous studies on sound-symbolism and children's word learning (Imai et al., 2008; Kantartzis et al., 2011) left two questions unanswered. (1) Does sound-symbolism have a long-lasting benefit for verb learning? It is not clear whether people retain the memory of the semantic representation of a novel verb beyond the immediate testing. Because words are learned for long-term future use, it is interesting to know whether the benefits of sound-symbolism can be seen in the long term. The current study used a delayed test to investigate this issue (a method used by, e.g., McGregor, Rohlfing, Bean & Marschner, 2009, for children). (2) How exactly does sound-symbolism help people learn words? In previous research (Imai et al., 2008; Kantartzis et al., 2011) a two-way forced choice task was used at test making it unclear whether sound-symbolism helps people accept the correct referent, or whether sound-symbolism helps people reject the incorrect referent or both. To investigate this issue, in the current study, during the training session we taught an action word and during the test session we presented a word with either the correct referent action or an incorrect action and asked whether the word referred to the action (a method used by, e.g., Imai, Haryu & Okada (2005) for children).

The current study focused on three-year-old children and investigated the two open questions discussed above. The first question is whether sound-symbolism can help children retain the semantic representation of a novel verb until the following day. There are two sub questions which follow on from this, (1) does sound-symbolism help children recognise that the identical scene to the one seen in training contains the referent of the verb and (2) does sound-symbolism help children generalise the verb to a new scene with the same action performed by a different actor? The second question is the nature of the help sound-symbolism provides: does sound-symbolism help children accept the correct action or reject the incorrect action as the referent of the verb? We conducted two experiments. Experiment 1 concerns verb learning, and Experiment 2 concerns memory of video clips shown in the training session of Experiment 1. In Experiment 1, children were assigned to two groups. Those in the sound-symbolically matching group were taught four novel verbs with sound-symbolically matching referent actions, while those in the sound-symbolically mismatching group were taught four novel words with sound-symbolically mismatching referent actions. On the second day children were tested with four videos for each word they had been taught. The four videos differed as to whether they contained the same or different action and actor as in the training video: (1) same-action, same-actor (2) same-action, different-actor, (3) different-action, same-actor, (4) different-action, different-actor. We hypothesised that children in the sound-symbolically matching group would retain the semantic representation of the verb better for long-term use than those in the sound-symbolically mismatching condition. More specifically, children in the sound-symbolically matching condition would be better at identifying the referent action (the videos with the same-action) and also at rejecting non-referent actions (the videos with a different action). Note that identifying the referent action in the same-action-different-actor video would constitute successful generalisation of the learnt verb in a new situation, based on the identity of action. In Experiment 2, we tested how well children remembered the videos shown in the training session of Experiment 1 to rule out an alternative explanation for Experiment 1's results that is based on poor memory.

Experiment 1

Method

Participants.

Seventy-eight, 3-year-old, monolingual English speaking children, were recruited from various nurseries around Birmingham, UK. 29 children were removed, 12 due to a yes bias (i.e., a yes-answer in all trials), one due to a no bias (i.e., a no-answer in all trials), 11 because they were not available to complete the testing on the second day and five were older than 3-years. Therefore there were 49 children (Mean: 3 years; 7 months, Range: 3;0 -3;11) who were included in the final analysis, 25 in the sound-symbolically matching group and 24 in the sound-symbolically mismatching group.

Stimuli.

We used the same word-action pairs as in the previous study (Kantartzis et al., 2011) except that the videos were re-shot. There were four novel words (bato bato, choka choka, nosu nosu and toku toku). Each novel word had a sound-symbolically matching action and a sound-symbolically mismatching action. The sound-symbolically matching word–action combinations were as follows: batobato = a large energetic movement, arms are swinging back and forward outstretched, whereas legs are making large leaping movement; chokachoka = walking quickly in very small steps with the arms swinging quickly with bent elbows; nosunosu = walking slowly in large steps with bent knees and the hands on knees tokutoku = a small shuffling movement, with straight arms rigidly at the side and legs moving very slightly and rigidly. The same set of novel words were used in the sound-symbolically mismatch condition; however, the words were paired with different actions in such a way that the word–action pairs were non sound-symbolic. The sound-symbolically mismatching word–action combinations were as follows: batobato = walking slowly, with arms loosely bent and hands touching in the front; chokachoka = legs slightly bent, walking slowly and in a controlled fashion, with arms bent and held out in front of body (as if carrying a tray); nosunosu = legs making large steps forward, with a bounce, arms swinging freely from side to side; tokutoku = creeping-type walk with medium sized steps, with arms bent and held closely in front of body.

The stimuli in Kantartzis et al. (2011) had been pretested to verify the sound-symbolically matching and mismatching relationships between the novel words and actions, and so this was not repeated for the current study. For the purpose of the current study four new distractor actions were also created-one action for each word- in which the actor and the action were different from any of other videos (see Figure 1 for examples for the distractor actions). One female and one male actor performed all the sound-symbolically matching and mismatching actions, while a second female actor performed the distractor actions. The identical test-type was the same video as in the training session. The same-action test-type contained the same-action as the training session performed by a different actor. The same-actor test-type contained the same-actor as in the training session performing a different action. Finally, the distractor test-type contained a different actor performing a different action (see Figure 1 for an example of the training video, and the four test videos).

Manipulation of sound-symbolism.

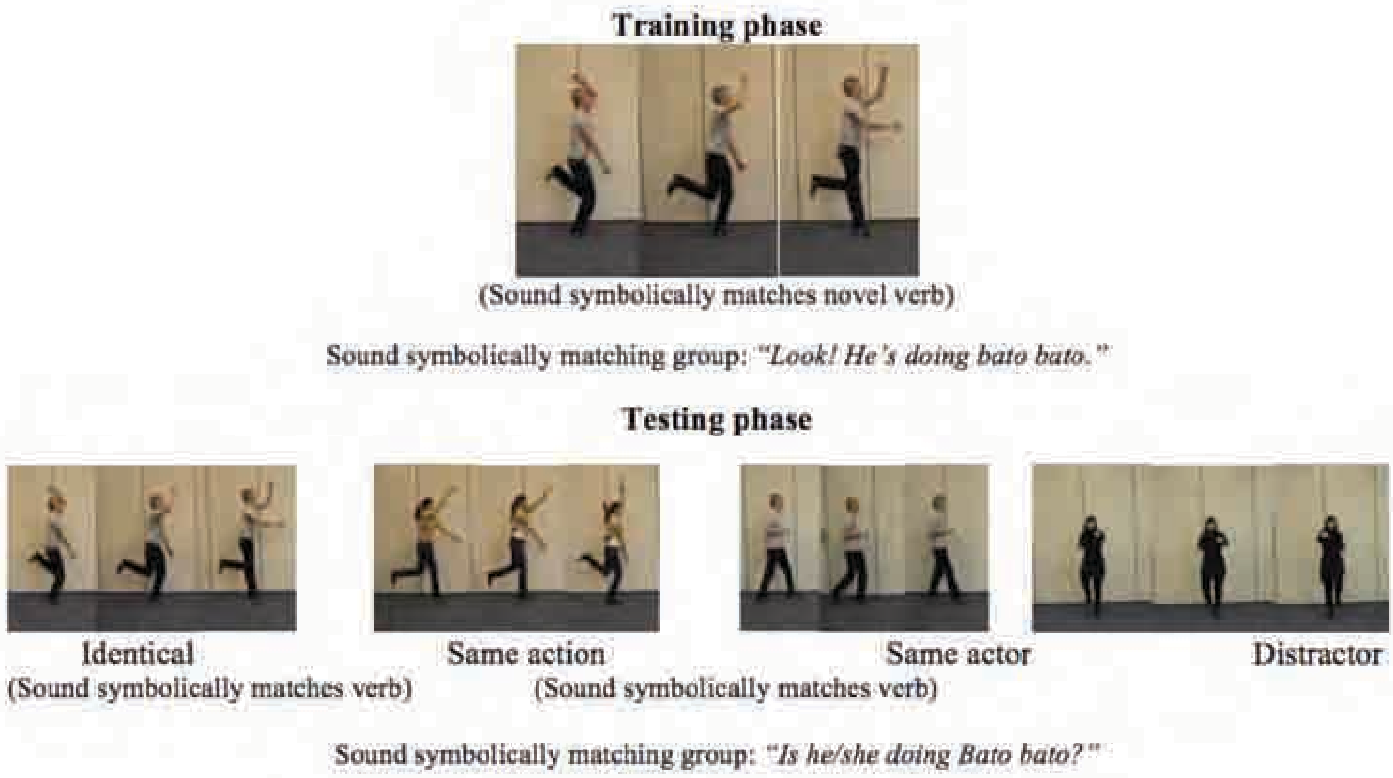
The children were systematically assigned to one of the two groups. In the sound-symbolically matching group (n = 25; mean age = 3years 7months, range: 3;0-3;11) children were taught novel verbs that sound-symbolically matched the action they represented in the training session (see Figure 4.1a.). Consequently, in the test session, the verbs sound-symbolically matched the action in the identical and same-action test videos, but not in the same-actor and distractor videos.

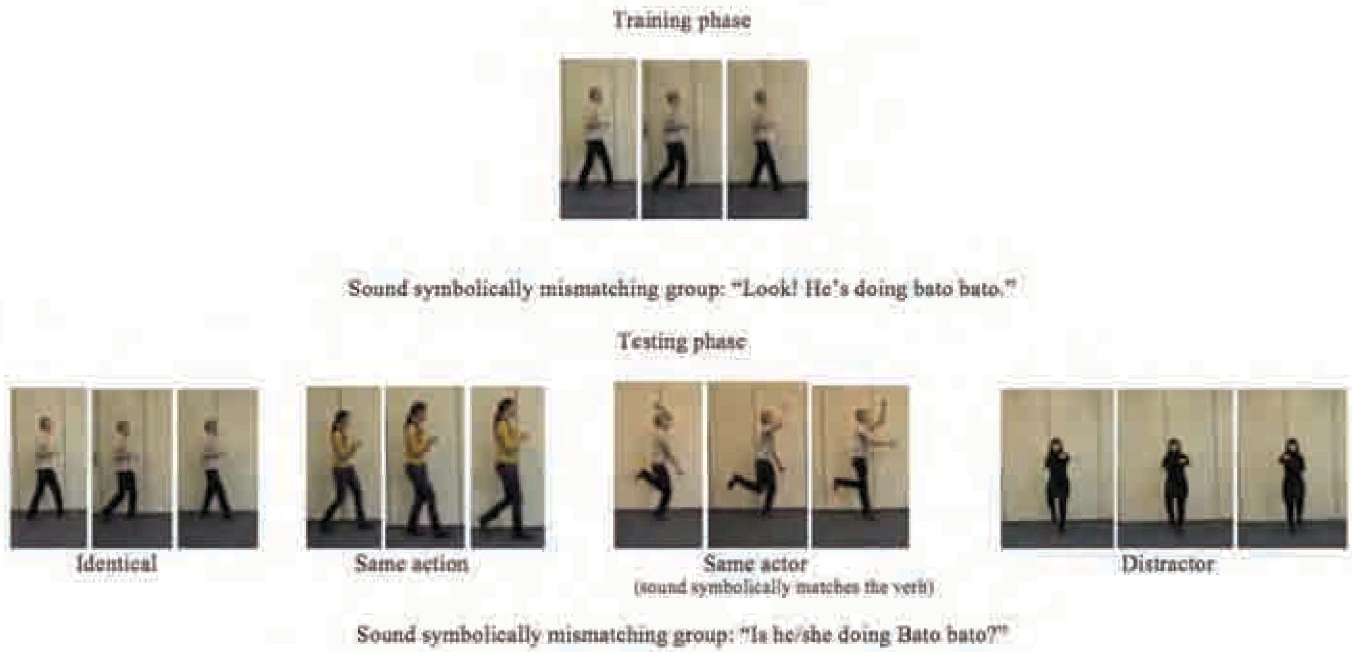
In the sound-symbolically mismatching group, (n=24; mean: 3years, 6months, range: 3;0-3;11), children were taught novel verbs that did not sound-symbolically match the action in the training session. Consequently, in the test session, the verbs did not sound-symbolically match the actions in the identical and same-action videos. However, the new action in the same-actor test video sound-symbolically matched the verb (see Figure 1b.).

The sound-symbolically mismatching condition was set up in such a way that it could be used to rule out an alternative interpretation of the predicted results. We predicted that children in the sound-symbolically matching condition should identify the referent action in the identical and same-action videos in the test session (see Figure 1a) more often than children in the sound-symbolically mismatching condition. We would interpret this result as evidence that sound-symbolism helped children store semantic representation of the novel verb in a better way during the training session. However, one might argue that this predicted outcome would also be compatible with an alternative interpretation that sound-symbolism had no impact in the training session, but children simply detected sound-symbolic match between a word and an action in the test session. If this alternative interpretation is correct, then children in the sound-symbolically mismatching condition should erroneously say "yes" for the same-actor test-type more often than those in the sound-symbolically matching condition.

Procedure.

The procedure spanned two days: a training session on the first day and a test session on the second day. The test session always took place during the same time period (for example in the morning) as in the training session. Each child took part in the experiment individually in a quiet area of the nursery. The procedure was embedded in a game in which children were helping a puppet learn new words (see Appendix A for a complete script of the story used). During the training session children were shown four warm-up slides with a familiar object (cat, apple and biscuits) and a video of a familiar action (hopping). For each slide, the experimenter labelled the object or the action. For each novel word, the experimenter showed one of the training videos and said, "Look! He is doing X" (where X represents the novel word). This was repeated for the four novel words. The test session started with four practice trials. In each practice trial, either a picture of an object (apple, cat) or a video of an action (hopping, walking) was shown, and the experimenter asked a yes-no question (e.g., "Is this an apple?", "Is he clapping?") in such a way that children were expected to give two yes-answers and two no-answers. In the main trials, the experimenter showed one of the test videos and asked , "Is he doing X?" (where X represents one of the novel words taught in the training session). For each novel word, four trials of different test-types were carried out: identical, same-action, same-actor and distractor. The order of the four test-types were counterbalanced across the four words within a participant and across participants in such a way that the test-type order differed across four word within in a participant, but each test-type appeared equally often in the first, second, third and


Training phase
(Sound symbolically matches novel verb)
Sound symbolically matching group: *"Look! He's doing bato bato."*
Testing phase
Identical
(Sound symbolically matches verb)
Same action
(Sound symbolically matches verb)
Same actor
Distractor
Sound symbolically matching group: *"Is he/she doing Bato bato?"*

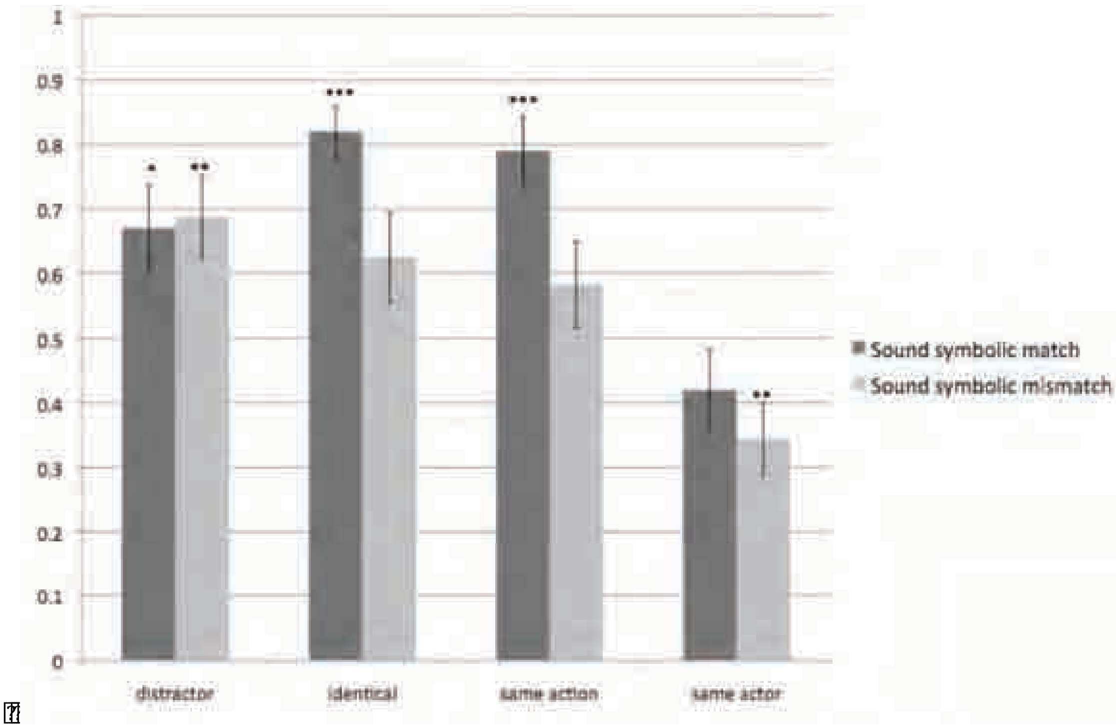

Training phase
Sound symbolically mismatching group: "Look! He's doing bato bato."
Testing phase
Identical
Same action
Same actor
(sound symbolically matches the verb)
Distractor
Sound symbolically mismatching group: "Is he/she doing Bato bato?"

Results

helps children identify the referent of a novel verb and generalize the verb more effectively, then children in the sound-symbolically matching condition should perform better in the identical and the same-action test-types as compared to children in the sound-symbolically mismatching condition. In order to test this prediction, the proportions of trials with correct responses were entered into a 2(between participant, group: sound-symbolically matching, sound-symbolically mismatching) x 4 (within participant, test-type: identical, same-action, same-actor and distractor) ANOVA (see Figure 4.2 for the means and SEs). When the sphericity assumption was violated, the Greenhouse-geisser correction of degrees of freedom was used throughout the paper. There was a significant main effect of test-type, $F(2.25, 105.71)= 15.99$, $p<.001$, $\eta_p^2=.25$ That is, children gave correct answers more often in the identical, same-action and distractor than in the same-actor condition (Tukey HSD $p<.05$). The main effect of sound-symbolism indicates that children in the sound-symbolically matching group performed better than children in the sound-symbolically mismatching group $F(47,1)=5.10$, $p<.05$, $\eta_p^2=.\ 10$. There was no significant interaction between test-type and group (p=.15).

In order to investigate whether sound-symbolism facilitated performance in each test-type, a planned comparison of sound-symbolic match versus mismatch was carried out for each test-type. Children in the sound-symbolically matching condition performed better than those in the sound-symbolically mismatching condition in the identical ($t(47)=2.48$, $p<.05$) and same-action test-types ($t(47)=2.43$, $p<.05$), but not in the distractor ($t(47)=-.19$)and same-actor ($t(47)=.369$) test-types.

The proportion correct responses for each test-type (distractor, identical, same-action, same-actor) for both the sound-symbolically matching and sound-symbolically mismatching group were compared against chance (.5). The proportion of correct responses was significantly different from chance for distractor, identical and same-action for the sound-symbolically matching group and for distractor and same-actor for the sound-symbolically mismatching group ($ps < .05$; see Figure 4.2). Children were therefore saying 'yes' to the same actor-different action video in the sound symbolic mismatch group. The action presented in this test type was the sound symbolically matching action to the word. It is therefore possible that children were using sound symbolism in the test phase to guide their response and not in the training phase to help them learn the verb-action combination.



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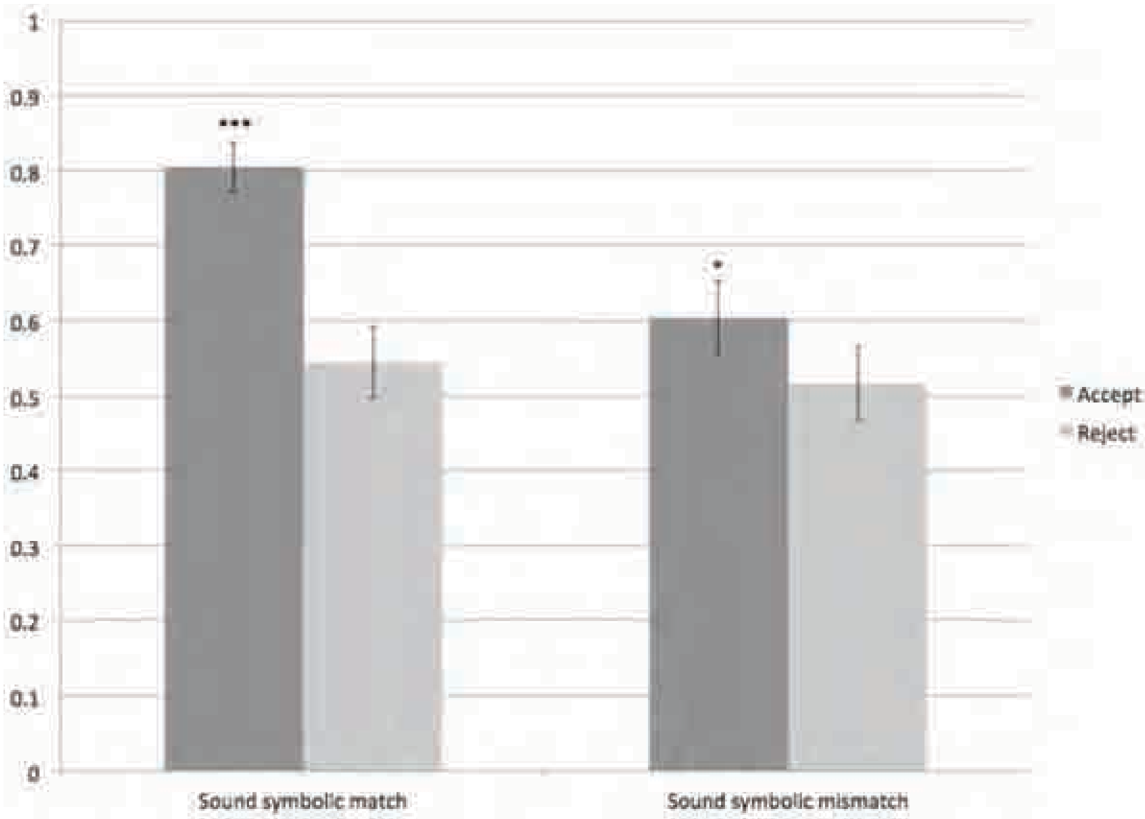
Sound symbolic match
Sound symbolic mismatch
distractor
identical
same action
same actor

ANOVA was carried out with the proportion correct responses as the dependent variable (see Figure 4.3 for the mean and SE). There was a significant main effect of sound-symbolism $F(47,1)=7.40$, $p<.01$, $\eta_p^2= .14$, and test-type, $F(47,1)=12.91$, $p<01$, $\eta_p^2= .22$, indicating that the children in the sound-symbolically matching group performed significantly better than children in the sound-symbolically mismatching group and that children were better at accepting an action as a referent of a word than rejecting a non-referent action. There was a marginally significant interaction between sound-symbolism and test-type $F(47,1)=3.54$, $p=.066$, $\eta_p^2 =.07$. Children in the sound-symbolic match condition performed better than those in the sound-symbolic mismatch condition for the accept trials (Tukey HSD, $p < .001$), but not for the reject trials. Thus, sound-symbolism helped children accept the correct action as the referent of the word, but it did not help them reject the incorrect action as the referent. The performance in the accept trials was significantly above chance (.5) in both the sound-symbolically matching and mismatching groups ($ps < .05$, see Figure 4.3). This indicates that the children were accepting the correct action as the referent of the verb, but sound symbolism was not helping children reject the incorrect action as the referent of the verb.



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*
Accept
Reject
Sound symbolic match
Sound symbolic mismatch

[illegible]

[illegible]

actor and the sound-symbolically mismatching same-actor-different-action test-types, for both these test-types the children are presented with the sound-symbolically matching word-action combination. If children were simply identifying sound-symbolism at the test session, children should be equally likely to respond with “yes” in these two types of test trials. This prediction was not borne out. There was a higher proportion of “yes” responses in the sound-symbolically matching group’s same-action test-type than there was in the sound-symbolically mismatching group’s same-actor test-type (see Figure 4.2 for the proportion correct responses. Note that a “yes” response is correct for the same-action test-type but incorrect for the same-actor action test-type) $t(1,47)=2.36$, $p<.05$. These results indicate that sound-symbolism helped children during the training session and not during the test session.

Discussion

This experiment investigated the role of sound-symbolism in verb learning. The results indicated that sound-symbolism helped children identify and store the semantic representation of the verb and then generalize the verb successfully the following day. Children who were taught sound-symbolically matching word action combinations could identify and store the semantic representation of the verb in such a way that they could not only apply the verb to the identical scene used in the training session, but also generalize the verb to a new scene in which the action was the same but the actor was different. Furthermore, sound-symbolism helped children accept correct actions as the referent of the verbs, but it did not help children reject incorrect actions as the referents of the verbs. Thus, sound-symbolism helped children store an action as the referent of a novel verb and use this knowledge to recognize the correct referent of the verb on the following day.

We argued above that the successful performance in the same-action test-type was evidence that children generalised the verbs to a new situation with a different actor; however, an alternative account is possible. Children may have mistakenly thought that the same-action video was the same as the identical video. A question remains as to how accurate children' memory for a scene is, as children's memory is not as accurate when two situations are similar. Lindsay, Johnson, and Kwon (1991) argue that children are more likely to confuse a memory of different situations if these situations have similar visual and semantic contents. The videos of actions children were trained and tested with in the current study were very similar to each other (see Figure 1). Therefore, children may have confused them with each other. That is, it is possible that children have poor memory for who the actor was in the training videos, and they mistook the same-actor test-type (with a different actor) as the same as the training videos (i.e., the identical test-type). It has been shown that children tend to confuse a memory of different situations if these situations have similar visual and semantic contents (Lindsay et al., 1991). Therefore, it is plausible that children in the current study were not able to detect an actor change in the same-actor test-types. Experiment 2 was set up to test children's memory for the training videos when an actor or action changes.

Experiment 2

Experiment 2 investigated children's memory for the events in the training video used in Experiment 1 when a novel word was not introduced. In order to support the interpretation of the results from Experiment 1 that sound-symbolism helped children generalize novel verbs more effectively, we needed to show that children did not have a poor memory for actors. In Experiment 2, children were shown target videos on the first day and on the following day they were shown a set of test videos, which included the target videos, and asked whether they have seen the videos on the first day. The videos were the same as those shown to the sound-symbolically matching group in Experiment 1 (the target videos = the training videos in Experiment 1; the test videos = the test videos in Experiment 1). If children perform as adults they should say 'yes' to having seen the identical video before, but 'no' to the rest (same action, same actor and distractor). However, if the children are confusing the same action as being the same as the identical, then they should say 'yes' to the same action and identical, and say 'no' to the same actor and distractor videos.

Method

Participants

Participants were 37, 3-year-old monolingual English speaking children, from various nurseries around Birmingham, UK. 18 children were removed, eight were removed due to yes-bias, two were removed because they were too old, one because he/she was too young and seven were removed because they were not available for the testing session. Therefore a total of 19 children (Mean: 3years, 6 months; Range 3;0-3;9) were used in the analysis.

Stimuli

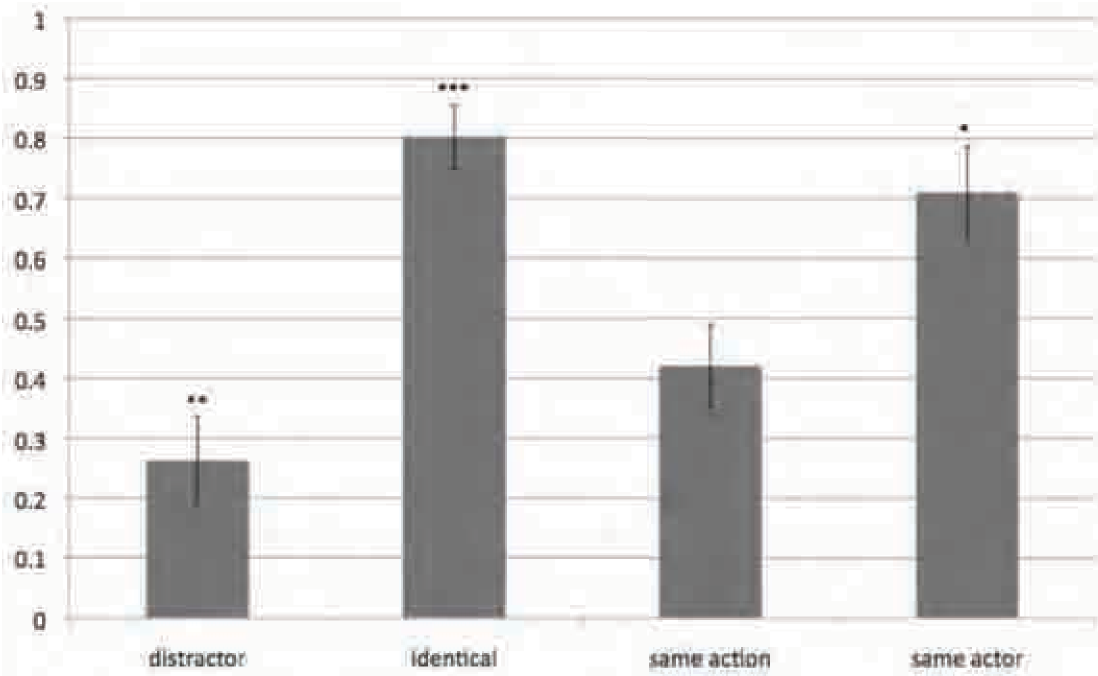
The videos used in this task were identical to those used in the sound-symbolically matching condition of Experiment 1. There were therefore 4 training videos, and 16 test videos. Unlike Experiment 1, no novel words were involved.

Procedure

The procedure spanned two days: a training session on the first day and a test session on the second day, just as in Experiment 1. The test session always took place the following day during the same time period (for example in the morning). Each child was tested individually in a quiet area of the nursery. The procedure was embedded in a game where children were helping the puppet watch videos and remember them (see Appendix B for a complete script of the story used). During the training session children were shown four warm-up slides with a familiar object (cat, apple and biscuits) and a video of a familiar action (hopping). For each slide, the experimenter encouraged the children to look at the picture or action by saying "Look! Look! Look!". The children were then shown the four experimental target videos, each one individually. During the test session children were again shown four practice slides with a familiar object or action, and 16 experimental test videos of four test-types: identical, same-action, same-actor and distractor. The same counterbalancing as Experiment 1 was used. Each video was accompanied by the sentence “Ellie thinks he/she say this video yesterday. Did you see this video yesterday?”said by the experimenter. Children’s response was therefore “yes” or “no”, and the researcher recorded this.

Results and Discussions

The aim of the experiment was to look at children’s ability to remember a scene in which an actor carried out an action. Particularly of interest was whether videos containing the same-action but a different actor were identified as being different from the target videos. The proportion of “yes” responses was entered into a repeated measures ANOVA, with test-type (identical, distractor, same-action, same-actor) as the within subject factor. There was a significant effect of test-type $F(3,54)=21.29$, $p<.001$, $\eta_p^2=.54$ (see Figure 4.4). There is therefore a difference in children’s performance across the four test-types. There were significantly more ‘yes’ responses in the identical than in the distractor: t(18)=-.603, p<.001, d=1.43 and same action: $t(18)=5.09$, $p<.001$, d=1.21 test types. There were significantly fewer ‘yes’ responses in the distractor test type than in the same action: t(18)=-2.12, p<.05, d=-0.36; and the same actor test type: t(18)=-5.29, p<.001, d=-1.01 test types. There were significantly more ‘yes’ responses in the same actor test type than in the same action test type t(18)=-3.36, p<.01, d=0.70. Finally, there was no significant difference in the ‘yes’ responses between the identical and same actor test types t(18)=1.681. A Bonferroni correction showed that there were significantly more ‘yes’ responses in the identical than in the distractor ($p<.001$), and same action ($p<.001$) test types. There were significantly fewer ‘yes’ responses in the distractor than in the same actor ($p<.001$) test type. Finally, there were significantly more ‘yes’ responses in the same actor than in the same action ($p<.001$) test type. The key comparison is identical vs. same-action test-types. “Yes” responses were significantly more frequent in the identical test-type than in the same-action test-type (see Figure 4.4 for the proportion yes responses). These results indicate that children could detect an actor change from the training video to the test video. Finally, the proportion yes responses were significantly above chance (.5) for identical and same-actor videos ($ps < .05$).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distractor
identical
same action
same actor

sound-symbolism helped children learn and store the semantic representation of the novel verb in such a way that made it generalisable the following day.

Furthermore, in light of the findings from Experiment 2, it is possible to conclude that children in Experiment 1 were not using sound symbolism in the test phase to guide their response, but were in fact using sound symbolism in the training phase. Experiment 2 showed that children have a general bias or preference to remember the actor over the action. Therefore, because children have a general bias to select same-actor responses it is not surprising the results from the mismatch group in Experiment 1 fall significantly below chance in the same-actor test type.

General Discussion

This study investigated whether sound symbolism facilitates three-year-olds' verb learning when the test session is conducted after a day's delay. Children in the sound-symbolically matching condition performed significantly better than those in the sound-symbolically mismatching condition (Experiment 1). Children in the sound-symbolically matching condition correctly identified the referent action in the video identical to the training video and in the video showing the same action carried out by a different actor, but those in the sound-symbolically mismatching condition did not. Thus, sound-symbolism helps children identify and store the semantic representation of a novel verb in such a way that they could generalise the verb the following day. Furthermore, children used sound-symbolism to accept the correct action as the referent of the verb, but not to reject the incorrect action. Thus, sound-symbolism helps store the semantic representation of a verb in such a way that it is easier to recognise the referent action, but not to recall the referent action when an incorrect one is presented. An additional analysis and experiment ruled out potential alternative interpretations such as sound-symbolic benefit at the test session only (Experiment 1) and children's poor memory for who the actor was in the training videos (Experiment 2). Thus, we conclude that sound-symbolism helps children accept the correct action as the referent of a verb even after a delayed testing session.

The current study went beyond the previous studies in two important ways. First, sound-symbolism facilitates learning not only when the test session immediately follows the training session (Imai et al., 2010; Kantartzis et al., 2011), but also when the test session is delayed by one day. Because words are learnt to be stored for long term, it is important to have demonstrated that sound-symbolism facilitates long-term storage. Second, unlike the previous studies (Imai et al., 2008; Kantartzis et al., 2011) with a two-way forced choice method, the current study used a yes-no paradigm for the response. This made it possible to investigate whether sound-symbolism helped children accept the correct referent action and/or reject the incorrect action. We found that sound-symbolism helped children accept the correction action, but not reject the incorrect action.

The current study adds to the growing evidence for children's and adults ability to recognise sound-symbolism and use it in word learning. The current results dovetail with previous findings that certain sound-symbolism can be recognised cross-linguistically by children (Davis, 1961; Maurer, Pathman, &

Mundloch, 2006; Imai et al., 2008; Kantartzis et al., 2011) and by adults (Brown et al., 1955; Brown & Nuttall, 1959; Gebels, 1969; Imai et al., 2008; Iwasaki, Vinson, & Vigliocco, 2007a & b; Klank, Huang, & Johnson, 1971; Kunihara, 1971; Siegel et al., 1965). The current study also demonstrated that sound-symbolism facilitates word learning in three-year olds. This is in line with previous findings (Imai et al., 2008; Kantartzis et al., 2011).

Learning a new word in an ostensive situation is a challenging task for children because it is often not clear which aspect of the scene is the referent of the word (see Quine, 1960). With the help of sound-symbolism children can identify the referent and store the semantic representation of a novel verb in such a way that they can recognise the referent action in a new situation the following day. In other words, sound-symbolism highlights the part of the scene relevant for the meaning of a novel word and this facilitates children's word learning.

CHAPTER 5: SOUND-SYMBOLISM IS DOMAIN GENERAL

Abstract

There are a number of theories surrounding the nature of sound-symbolism. More specifically, there have been analogies drawn between sound-symbolism and synaesthesia (Ramachandran & Hubbard, 2005). However, it can be argued that there are qualitative differences between sound-symbolism and synaesthesia. One of the differences lies in the domain specificity of synaesthesia. The current study aims to investigate the domain generality of sound-symbolism. In Experiment 1 participants were asked to rate the degree of match between audio and visual stimuli. The audio stimuli consisted of novel words, containing either continuant or plosive consonants. The visual stimuli were divided into five domains (colour, shape, speed, emotion and trajectory). In Experiment 2 participants were asked to match two visual to two audio stimuli in a two way forced choice task. The results from both experiments revealed that sound-symbolism is domain general.

Introduction

Research into sound-symbolism has flourished over the last few years, with many researchers attempting to discover the underlying properties of sound-symbolism (see Imai, Kita, Nagumo, & Okada 2008; Maurer & Mondloch, 2004; Ramachandran & Hubbard, 2005; for examples of discussions on the nature of sound-symbolism). Sound-symbolism is the inherent link between the sound and meaning of a word. The nature of sound-symbolic meaning provides insights into the underlying mechanism for sound-symbolism, and how sound-symbolism may be related to other similar phenomena, such as synaesthesia for example (see Maurer & Mondloch, 2004; Ramachandran & Hubbard, 2005). What exactly sound-symbolism expresses is not well understood (but see Kita, 1997). This study investigated the nature of sound-symbolic meaning, in particular the extent to which sound-symbolic meaning is generalisable across semantic domains.

It has been proposed that the neural basis for sound-symbolism is similar to that of adult synaesthesia (Ramachandran & Hubbard, 2001). Synaesthesia is thought to be the result of cross-activation between two regions of the brain. For example, one common form of synaesthesia is grapheme-colour synaesthesia, in which seeing a grapheme automatically elicits a colour (Hubbard, Arman, Ramachandran, & Boynton, 2005). Hubbard et al. (2005) found that when shown a grapheme, grapheme-colour synaesthetes produced larger activations in the colour-selective area of the brain. Ramachandran and Hubbard (2001) propose that sound-symbolism is a phenomenon similar to that of synaesthesia and also arises from cortical connections amongst mostly unrelated areas. For example, the bouba-kiki phenomenon, in which participants consistently label an angular shape as kiki and a rounded shape as bouba might be the result of cross-cortical connection (Ramachandran & Hubbard, 2001). If this proposal is true then sound-symbolism is a form of synaesthesia.

Particular interest has arisen in the idea that neonatal synaesthesia or cross modal mapping may relate to both adult synaesthesia and sound-symbolism (Maurer & Mondloch, 2005; Ramachandran & Hubbard, 2001, 2005). Neonates and infants have been shown to engage in cross-modal mapping between touch and sight (Gibson & Walker, 1984), light and sound (Lewkowicz & Turkerwitz, 1981) and odor and objects (Fernandez & Bahrick, 1994), amongst others. Sound-symbolism, which is the mapping of sound to meaning, may be related to the cross-modal mapping seen in very young infants (Maurer & Mondloch, 2005). Neonatal cross-modal mapping may be caused by an inability to distinguish between stimulation in different modalities. Maurer and Mundloch (2005) state that due to their undeveloped cortex, neonates do not respond to stimulation in different modalities separately, instead they respond to the "amount of energy" or intensity produced by a certain stimulation (Maurer & Mundloch, 2005). This claim would argue that the infants in Gibson and Walker's (1984) study for example, who matched tactile sensation of a toy to the visual perception of the same toy, were identifying a common element between the haptic and visual information provided, rather than identifying the two stimuli as different. The common feature-roundedness or angularity in the baluma-takete task may be perceived as a common feature of the audio and visual elements of the task. It is therefore found that adults

(Köhler, 1929/1947; Westbury, 2005) and children (Maurer, Pathman, & Mondloch, 2006), across languages (Davis, 1961) are able to detect the sound-symbolic link between roundedness and *maluma*, and angularity and *takete* (moma/kipi task).

Sound-symbolism has been said to be a remnant of this neonatal synaesthesia that in turn is linked to adult synaesthesia (Ramachandran & Hubbard, 2005). Ramachandran and Hubbard suggest that sound-symbolism and adult synaesthesia share the same underlying mechanisms. However, it would appear that sound-symbolism and adult synaesthesia are qualitatively different in a number of ways. First, adult synaesthesia is domain specific. That is, stimulation in one modality (e.g. graphemes) automatically activates a second, specific, unrelated modality (e.g. colours) (Ramachandran & Hubbard, 2003). A synaesthete who experiences grapheme-colour synaesthesia will only experience grapheme-colour synaesthesia. Second, synaesthetic perceptions are also specific to individuals (Ramachandran & Hubbard, 2003), while one synaesthete might experience the letter A as being red, another might experience it as blue.

Sound-symbolism, on the other hand, may be both domain general and generalisable across people. The evidence for domain generality comes from the fact that existing sound-symbolic words in languages like Japanese are often polysemous. For example, in the Japanese sound-symbolic lexicon (mimetics), the word "goro-goro" can indicate related meanings in different domains: something rolling, a rumbling stomach, thunder and hanging around (Gomi, 1989). However, such polysemy is common in both sound-symbolic and non-sound-symbolic lexicons; thus it is not clear whether polysemy reflects the domain general nature of sound-symbolic meaning. Furthermore, the same sound-meaning links are found across languages (Köhler, 1929/1947; Davis,1961), and age groups (Imai et al., 2008; Maurer et al., 2005), making sound-symbolism generalisable across people and not specific to individuals.

The focus of the current research is on these two contrasting ideas. The first idea is proposed by Ramachandran and Hubbard (2001) and states that sound-symbolism is a similar process to synaesthesic perception, involving similar brain functions. The second argues that sound-symbolism is qualitatively different to adult synaesthesia but may be similar to neonatal cross-modal mapping. The point at which these two theories conflict is in the idea of domain generalisability, adult synaesthesia is domain specific, whereas sound-symbolism and neonatal cross-modal mapping is domain general.

This study aims to show that sound-symbolism is indeed domain general, in that one word can extend its sound-symbolic meaning to a number of unrelated domains. In the theory of neonatal cross-modal mapping, infants perceive a common feature between sensory modalities such as intensity. The current research aims to investigate whether sound-symbolic perception in adults can also be domain general provided there is a common feature across the domains.

Is the sound-symbolism of abruptness vs. gradualness domain general? Previous research looking at shape sound-symbolism (angular versus rounded) used words that were made up of either continuant or plosive consonants (Köhler, 1947; Westbury, 2004). Both Köhler and Westbury found that participants matched rounded shapes to words containing continuant consonants (e.g. maluma, nool), whilst angular shapes were matched to words containing plosive (or all-stop) consonants (e.g. takete, dibe). The visual stimuli in these shape-sound-symbolism studies consist of rounded and angular stimuli. The difference between these two sets of stimuli could be *abruptness or gradualness of change*. In the angular shape the lines change direction abruptly, whereas in the rounded shape the lines change directions gradually. Therefore, abruptness or gradualness of change may be a common feature which can be expressed sound-symbolically across domains. This sound-symbolic distinction- (1)gradual change (rounded shape)-continuants and (2) abrupt change (angular shape)-plosives which is found in previous studies forms the base of the current study. In Experiment 1 participants had to make a judgment on the degree of match between an audio stimulus and a visual stimulus. In Experiment 2 participants completed a two-way forced choice task in which they had to match up two audio stimuli to two visual stimuli. The audio stimuli were made up of non-words created using either continuant (/m/, /n/, /l/, /r/) or plosive (/b/, /d/, /p/, /t/) consonants. The visual stimuli were made up of events in which a change took place either abruptly or gradually. The visual stimuli were also divided into five different domains: shape, colour change, speed change, emotion change and trajectory change. The hypothesis is that across all the five domains, abrupt changes will be matched to plosive audio stimuli, while gradual changes will be matched to continuant audio stimuli. Furthermore, it is explored whether other sound contrasts in the audio stimuli (liquids vs. nasals, voiced vs. voiceless, and different vowels), might be systematically related to the distinction between abrupt and gradual change.

Experiment 1

Method

Participants

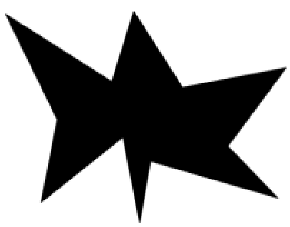
23 monolingual English speakers took part in this study (mean age: 21.52, range: 18-37; 18 female). They were all students at the University of Birmingham, and were given 12 pounds or course credits for their participation.

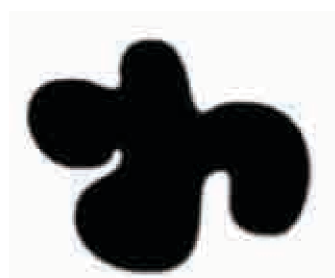
Stimuli

Visual Stimuli.

We used visual stimuli representing abrupt and gradual change in the following five domains: colour, shape, speed, emotion and trajectory. Each domain contained a total of 32 items. Half of the stimuli represented an abrupt change, and the other half represented a gradual change. All videos clips were created using Flash (except for the emotion domain, which was made up of text, created using a word document).

Colour: Video clips (duration: 6 seconds) showed a square in the center of the screen (dimension: W:100mm, H:95mm), which changed colour from colour A to colour B and then back to colour A again (e.g., pink to yellow to pink again- see the





accelerating and decelerating either gradually or abruptly. The change happened 5-10 times per clip for abrupt stimuli, and 2-4 times per clip for gradual stimuli.

Emotion: Text described stories in which one's emotions (happiness, sadness, fear or anger) changed either gradually or abruptly (see Appendix E for a complete list of the stories used). An example of a story with an abrupt change of fear is as follows, "You see a snake in your house. You immediately feel very scared". The corresponding story with a gradual change is as follows, "You think you can hear a snake in your house. As the time goes by you keep hearing it. The more you hear the more and more scared you get, until you are very scared". Text was presented for 8 seconds.

Trajectory: Video clips (total duration: 6 seconds) showed a square moving around the screen, changing direction abruptly or gradually (see Figure 5.2 for examples of the trajectories made by the objects).

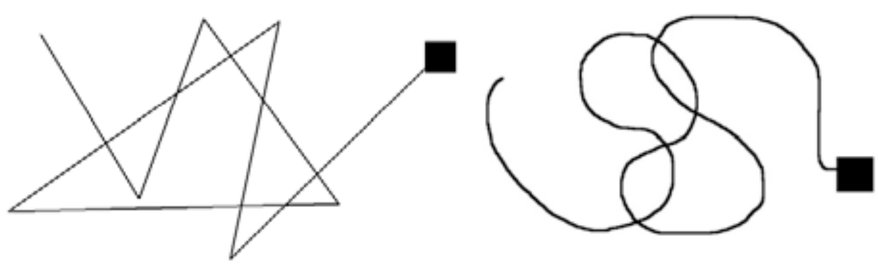


Figure 5.2. Example trajectories made by a square, for the abrupt and gradual stimuli. The abrupt visual stimulus changes direction abruptly while the gradual visual stimulus changes direction gradually.

Audio Stimuli.

Thirty-two novel words were created and audio-recorded by a native speaker of English. Each word was 3 syllables long, and took the form of $C_1VC_2VC_2V$. This template for the words ensured that created words did not exist in the English lexicon. The continuant words contained either 2 liquids (/r/ and /l/) or 2 nasals (/m/ and /n/). The plosive words contained either 2 voiced audio plosives (/b/ and /d/) or 2 voiceless plosives (/p/ and /t/). Within each subgroup (e.g. Liquids) /r/ and /l/ appeared in both C1 and C2/C3 positions. In other words both the word "rololo" and the word "lororo" were used as audio stimuli. This was the case for all consonant subgroups. Each word contained one vowel, which was either high-front vowel /i/, high back vowel /u/, mid front vowel /e/ or mid back vowel /o/. All vowels were paired exhaustively with all consonant pairs (See Table 5.1).

Combination of audio and visual stimuli.

All audio and visual stimuli were paired together exhaustively, giving a total of 512 pairs. All combinations were rated by all participants.

Table 5.1. Audio stimuli used in Experiment 1.

	Plosives		Continuants	
	Voiced /d/, /b/	Voiceless /p/, /t/	Liquids /r/, /l/	Nasals /n/, /m/
/e/	Debebe, Bedede	Petete, Tepepe	Relele, Lerere	Nememe, Menene
/i/	Dibibi, Bididi	Pititi, Tipipi	Rilili, Liriri	Nimimi, Minini
/o/	Dobobo, Bododo	Pototo, Topopo	Rololo, Lororo	Nomomo, Monono
/u/	Dububu, Bududu	Pututu, Tupupu	Rululu, Lururu	Numumu, Mununu

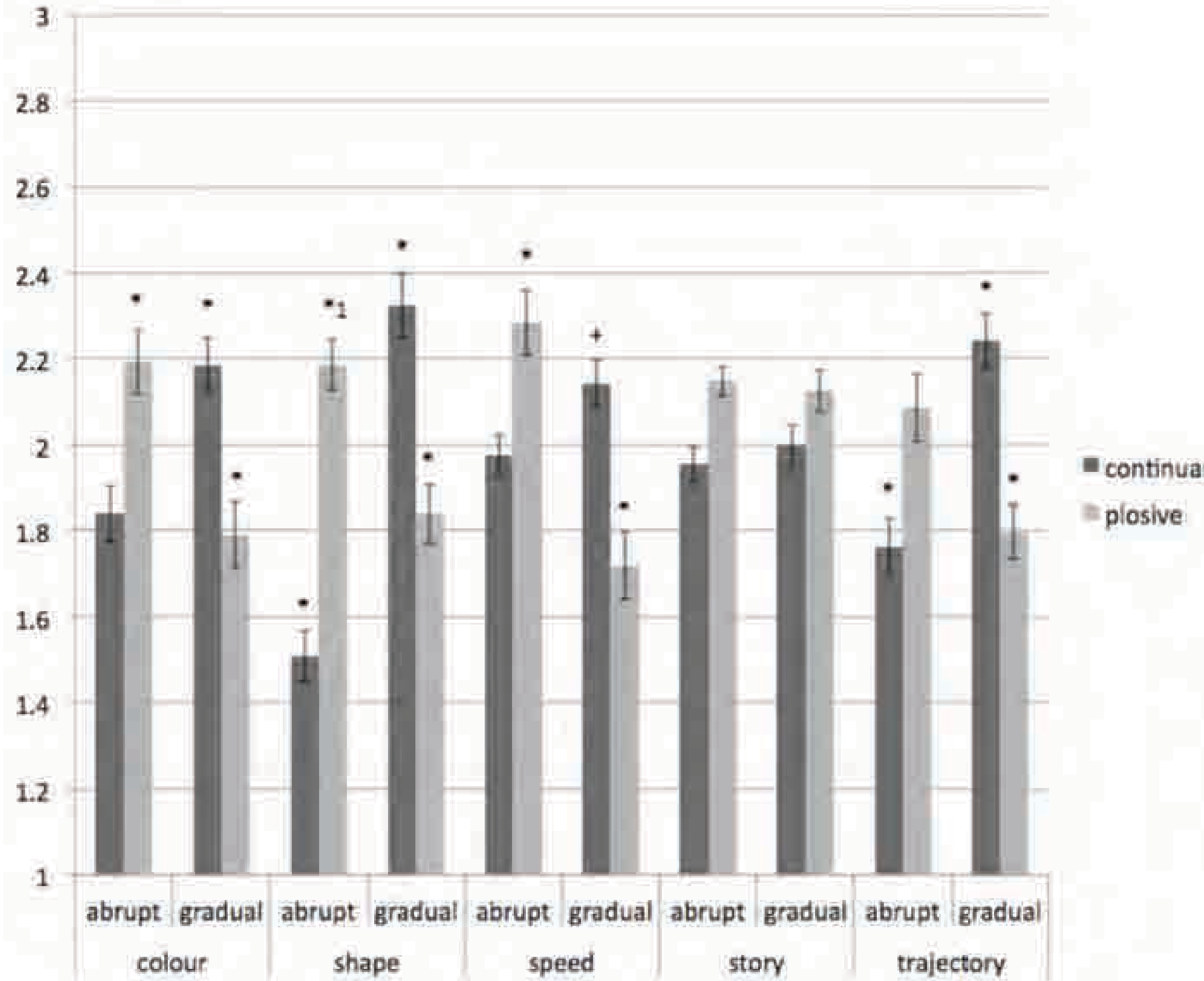
Procedure

The experiment consisted of five blocks, one for each domain (shape, colour, speed, emotion and trajectory). Participant completed all five blocks. The order in which each domain (block) was presented was rotated between participants. Within each block, the order in which stimuli were presented was randomised. Participants were presented with one audio-visual pair at a time. Participants were first presented the visual stimulus on a computer. Once the visual stimulus had finished, it disappeared and participants heard the audio stimulus through headphones. The task was to rate the degree of match between the audio and visual stimuli on a scale of 1 “does not match”, 2 “neutral”, or 3 “matches”. Participants recorded their responses on an answer sheet by circling a number 1, 2 or 3. Participants had as much time as they needed to respond, as the next visual stimulus would not appear until the space bar was pressed.

Results and Discussion

Plosives and continuants

We examined whether the audio-visual pairs that were hypothesised to sound-symbolically match (continuant-gradual and plosive-abrupt) were rated higher than the pairs that were hypothesised not to sound-symbolically match (continuant-abrupt and plosive-gradual). The mean rating scores were entered into 2 (visual stimuli: abrupt, gradual) x 2 (audio stimuli: continuant, plosive) x 5 (domains: colour, shape, speed, emotion and trajectory) repeated measures ANOVA (see Figure 5.3 for the means and standard errors). Both participant and item analyses were carried out (the F statistic for a participant analysis is reported as F_1 and that for an item analysis as F_2, throughout the paper). When sphericity was violated, the Greenhouse-geisser correction of degrees of freedom was used throughout the paper.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The main effects of visual and audio stimuli were not significant: visual stimuli: $F_1(22,1)=.866$, $F_2(15,1)=.181$; audio stimuli: $F_1(22,1)=.350$, $F_2(15,1)=1.209$. The main effect of domain was not significant for participant analysis, but was for item analysis significant: domain: $F_1(55.081, 2.504)=2.29$, $F_2(34.970, 2.331)=3.032$, $p<.05$, $\eta_p^2=.168$.

The two-way interactions were all significant: visual stimuli x audio stimuli, $F_1(22,1)=45.543$, $p<.001$, $\eta_p^2=.674$, $F_2(15,1)=75.195$, $p<.001$, $\eta_p^2=.834$; visual stimuli x domains, $F_1(88,4)=7.749$, $p<.001$, $\eta_p^2=.260$, $F_2(60,4)=5.937$, $p<.001$, $\eta_p^2=.284$; audio stimuli x domains, $F_1(88,4)=2.570$, $p<.05$, $\eta_p^2=.105$, $F_2(60, 4)= 4.707$, $p<.01$, $\eta^2=.239$. The visual stimuli x audio stimuli interaction indicated an effect of sound-symbolism. The interaction between visual stimuli, audio stimuli and domains was significant, $F_1(88,4)=12.283$, $p<.001$, $\eta_p^2=.358$, $F_2(60,4)=11.275$, $p<.001$, $\eta_p^2=.429$. The three-way interaction indicated that sound-symbolism differed across domains.

Because of the significant three-way interaction, the mean rating scores were entered into 2 (visual stimuli: abrupt, gradual) x 2 (audio stimuli: plosive, continuant) repeated measures ANOVAs for each domain separately (see Table 5.2). The interactions between audio stimuli (plosive, continuant) and visual stimuli (abrupt, gradual) were significant for all domains, except for emotion (see Table 5.2). These results provided evidence for hypothesised sound-symbolism in all domains but emotion.

Table 5.2. F values and partial eta squared (in brackets) for the main effects and interactions in the 2 (audio stimuli: continuant, plosive) x 2 (visual stimuli: abrupt, gradual) ANOVAs in the 5 domains. The results from both participant analyses and item analyses are reported.

	Audio stimuli		*Visual stimuli*		*Audio stimuli x Visual stimuli*	
	Participant	Item	Participant	Item	Participant	Item
Colour	.09(.00)	.25 (.02)	.15(.01)	.29 (.02)	28.98**(.57)	95.09**(.86)
Shape	2.72 (.11)	7.723* (.34)	9.05** (.29)	2.98 (.17)	59.21** (.73)	28.26** (.65)
Speed	.71(.03)	.84 (.05)	25.84** (.54)	15.93** (.52)	18.90** (.46)	92.87** (.86)
Emotion	12.08** (.35)	26.77** (.64)	.101(.01)	.04 (.00)	1.34 (.06)	.29(.02)
Trajectory	.60(.03)	1.16 (.07)	4.29* (.16)	1.54(.09)	21.36** (.50)	46.72** (.76)

Note: *p<.05, **p<.01. Df in the participant analysis are 1 for audio stimuli, visual stimuli and audio stimuli x visual stimuli interactions and 22 for error. Df in the item analysis are 1 for audio stimuli, visual stimuli and audio stimuli x visual stimuli interactions and 15 for error.

The nature of the significant two-way interactions was explored by Tukey HSD post-hoc tests. When paired with abrupt visual stimuli, plosive audio stimuli were rated higher than continuant audio stimuli (*ps* <.05, except that speed and trajectory were not significant in the participant analysis). When paired with gradual visual stimuli, continuant audio stimuli were rated higher than plosive audio stimuli (*ps*<.05). When paired with continuant audio stimuli, gradual visual stimuli were rated higher than abrupt visual stimuli (*ps*<.05, except that speed was not significant for participant analysis). When paired with plosive audio stimuli, abrupt visual stimuli were rated higher than gradual visual stimuli (*ps*< .05, except that trajectory was not significant for participant analysis). Thus, in all domains but emotion, there is evidence that the combinations, abruptness-plosives and gradualness-continuants, were better sound-symbolic matches than the combinations, abruptness-continuants and gradualness-plosives.

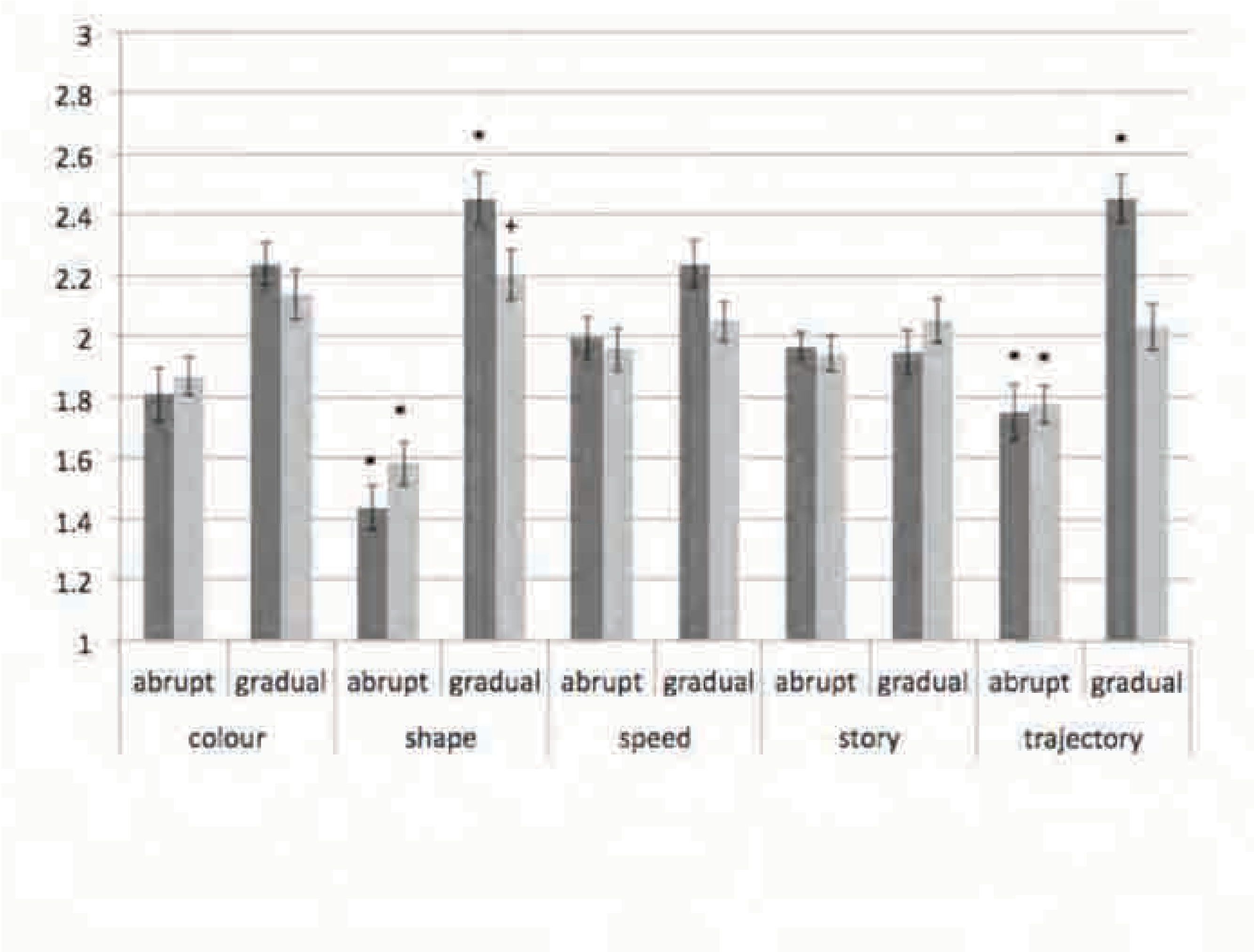
In order to draw more precise conclusions about the relationship between visual stimuli (abrupt, gradual) and audio stimuli (continuant, plosive) it is important to see whether the ratings were different to neutral (2). One sample t-tests were carried out for the domains in which the 2 (abrupt, gradual) x 2 (continuant, plosive) interaction was significant, which were the colour, shape, speed, and trajectory domains. The means that are significantly different from 2 are indicated by *, *1 or + in Figure 5.3. For the domains investigated (all except for emotion), the sound-symbolic matching pairs were rated above neutral; whereas the sound-symbolic mismatching pairs were rated below neutral.

To summarise, for all domains except emotion, there was evidence for the hypothesised sound-symbolism. That is, participants rated the combination of plosive audio stimuli and abrupt visual stimuli and the combination of continuant audio stimuli and gradual visual stimuli to be a good match. And, they rated the combination of plosive audio stimuli and gradual visual stimuli and the combination of continuant audio stimuli and abrupt visual stimuli to be a poor match.

Nasal- Liquid Distinction

The continuant audio stimuli can be divided into two groups, nasals and liquids. Though we had no specific hypothesis, we explored whether there is a relationship between the visual stimuli (gradual, abrupt) and the audio stimuli (continuant: nasal, liquid).

The mean rating score was entered into a 2 (visual stimuli: abrupt, gradual) x 2 (audio stimuli: nasal, liquid) x 5(domain: color, shape, speed, emotion and trajectory) repeated measures ANOVA, we carried out both participant and item analysis. Figure 5.4 displays the mean scores for liquid and nasal audio stimuli, when paired with abrupt and gradual visual stimuli, in each domain.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participant and item analyses; +, p<.05 in participant analysis and p <.10 in item analysis.

The main effect of domain was not significant, F_1(64.600, 2.936)=.1.75, F_2(28, 4)=2.227. The main effects of audio stimuli and visual stimuli were significant: audio: F_1(22,1)=3.922, p=.06, η_p^2=.151, F_2(7,1)=11.563, p<.05, η_p^2=.623; visual stimuli: F_1(22,1)=43.086,p<.001, η_p^2=.677, F_2(7,1)=34.892, p<.001, η_p^2=.833. Some of the two-way interactions were significant: visual stimuli x audio stimuli, F_1(22, 1) =7.281, p<.05, η_p^2=.249, F_2(7,1)=6.440, p<.05, η_p^2=.479; visual stimuli x domains, F_1(88,4)=15.918, p<.001, η_p^2=.420, F_2(10.706, 1.529)=13.241, p<.01, η_p^2=.654. The two-way interaction between audio stimuli x domains was not significant, F_1(88,4)=1.971, F_2(28,4)=2.146. The visual stimuli x audio stimuli interaction indicated sound-symbolism. The interaction between visual stimuli, audio stimuli and domains was significant, F_1(64.119, 2.915)=4.433, p<.01, η^2=.168, F_2(28,44)=4.621, p<.01, η_p^2=.398. Thus, the sound-symbolism differed across domains.

Because of the significant three-way interaction, the mean rating scores were entered into 2 (visual stimuli: abrupt, gradual) x2 (audio stimuli: plosive, continuant) repeated measures ANOVAs for each domain separately (see Table 5.3). The interactions between audio stimuli (nasal, liquid) and visual stimuli (abrupt, gradual) were significant for the shape and trajectory domains, suggesting sound-symbolism in these domains (see Table 5.3).

Table 5.3. *F* values and partial eta squared (in brackets) for the 2 (audio stimuli: nasal. liquid) x 2 (visual stimuli: abrupt, gradual) ANOVAs, for the main effects and interactions in the 5 domains.

	Audio stimuli		*Visual stimuli*		*Audio * Visual stimuli*	
	Participant	Item	Participant	Item	Participant	Item
Colour	.11(.01)	.17 (.02)	15.90** (.42)	35.84** (.84)	2.40(.10)	3.34(.32)
Shape	.692 (.03)	1.02 (.13)	59.20** (.73)	34.62** (.83)	11.82** (.35)	7.92* (.53)
Speed	2.26(.09)	2.08 (.23)	4.77* (.18)	5.74 *(.45)	1.26(.05)	1.33(.16)
Emotion	.18(.01)	.57 (.08)	1.05(.05)	.15 (.02)	1.03(.04)	.79 (.10)
Trajectory	11.00**(.33)	14.73** (.68)	23.42** (.52)	34.57** (.83)	10.73** (.33)	15.50** (.69)

Note: *p<.05, **p<.01. df in the participant analysis are 1 for audio, visual and audio x visual interactions and 22 for error. *Df* in the item analysis are 1 for audio, visual and audio x visual interactions and 7 for error.

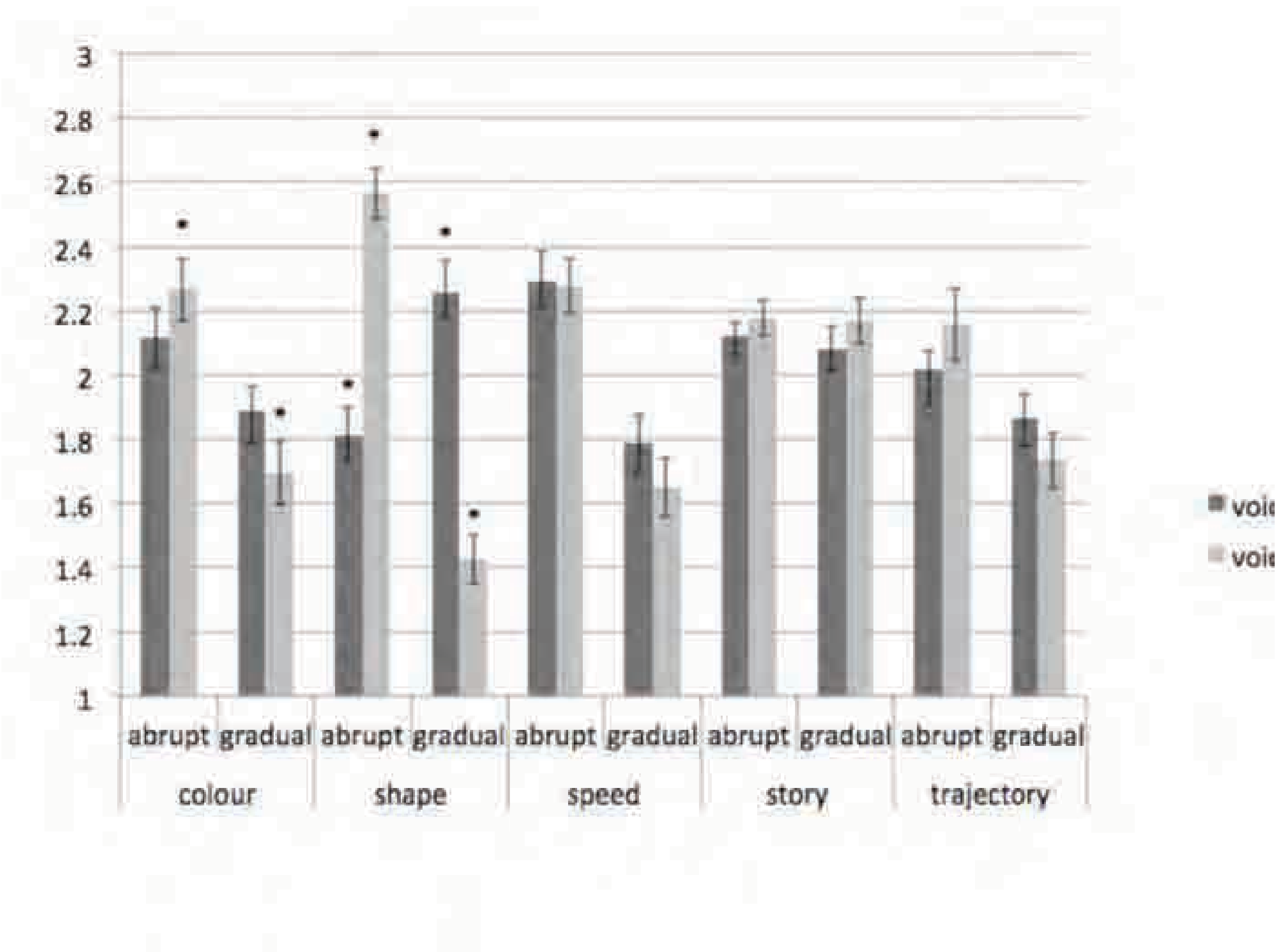
The nature of interaction was explored by Tukey HSD posthoc tests. As the 2 x 2 interaction was only significant for shape and trajectory, only these two domains were explored further. There was no significant difference in the rating of abrupt visual stimuli, when paired with nasal audio stimuli, compared to liquid audio stimuli. For gradual visual stimuli the rating for liquid audio stimuli was higher than that for nasal audio stimuli (*p*s<.05, except that shape was not significant for the item analysis). For liquid audio stimuli the rating of gradual stimuli was higher than that for abrupt stimuli (*p*s<.01). For nasal audio stimuli, the rating of gradual stimuli was higher than that for abrupt stimuli (*p*s<.05, except that trajectory was not significant for participant analysis). In order to draw precise conclusions about the relationship between visual stimuli (abrupt, gradual) and audio stimuli (nasal, liquid) it is important to see whether the ratings are different to neutral (2). One-sample *t*-tests against the neutral rating (2) were carried out for the domains in which the 2 (abrupt, gradual) x 2 (nasal, liquid) interaction was significant, which were the shape and trajectory domains. The means that are significantly different from 2 are indicated by *, *1 or + in Figure 5.4.

The findings from the liquid and nasal audio stimuli analysis, reveals that both liquid and nasal audio stimuli are better sound-symbolic matches for gradual visual stimuli, than for abrupt items. More interestingly, liquid audio stimuli are a better sound-symbolic match for gradual visual stimuli than nasal audio stimuli. This is numerically true in all domains (other than emotion) and statistically significant in the shape and trajectory domains.

Voiced –Voiceless Distinction

The plosive audio stimuli can be divided into two groups, voiced and voiceless audio stimuli. It is then also interesting to look at whether there is a relationship between the visual stimuli (gradual, abrupt) and the audio stimuli (plosive: voiced, voiceless).

The mean rating score was entered into 2 (visual: abrupt, gradual) x 2 (audio: voiced, voiceless) x 5 (domain: color, shape, speed, emotion and trajectory) repeated measures ANOVA, we carried out both participant and item analysis. Figure 5.5 displays the mean scores for voiced and voiceless audio stimuli, when paired with abrupt and gradual visual stimuli, in each domain.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interaction between audio and visual stimuli: *, $p < .05$ in both participant and item analyses.

The main effect of visual stimuli and domain were significant: visual $F_1(22,1)$= 23.280, p<.001, η_p^2=.571, $F_2(7,1)$=36.08, p<.001, η_p^2=. 838; domain, $F_1(88, 4)$=3.18, p<.05, η_p^2=.126, $F_2(28,4)$=4.18, p<.01, η_p^2=.374, but not the main effect of audio, $F_1(22,1)$=.264, $F_2(7,1)$=.467. The following two-way interactions were significant, visual x audio stimuli, $F_1(22,1)$=25.23, p<.001, η_p^2=.534, $F_2(7,1)$=30.47, p<.001, η_p^2=.813, visual x domain, $F_1(88,4)$=5.36, p<.001, η_p^2=.196 , $F_2(28,4)$=11.77, p<.001, η_p^2=.627, but audio x domain was not significant, $F_1(52.754, 2.398)$=.78 $F_2(28,4)$=1.19. The visual stimuli x audio stimuli interaction indicated sound-symbolism. The interaction between visual stimuli, audio stimuli and domain was significant, $F_1(88,4)$=19.50, p<.001, η_p^2=.470, $F_2(28,4)$=29.18, p<.001, η_p^2=.807. Thus, the sound-symbolism differed across domains.

Because of the 3-way interaction, the mean rating scores were entered into 2 visual stimuli (abrupt, gradual) x 2 audio stimuli (voiced, voiceless) repeated measures ANOVAs for each domain (Table 5.4). The interactions between audio stimuli (voiced, voiceless) and visual stimuli (abrupt, gradual) were significant in both participant and item analyses for shape (see Table 5.4).

Table 5.4. *F* values and partial eta squared (in brackets) for the 2 (audio stimuli: voiced, voiceless) x 2 (visual stimuli: abrupt, gradual) ANOVAs, for the main effects and interactions in the 5 domains.

	Audio stimuli		*Visual stimuli*		*Audio x Visual stimuli*	
	Participant	Item	Participant	Item	Participant	Item
Colour	.12(.01)	.11(.02)	13.49** (.38)	76.06** (.92)	4.00 (.15)	6.08*(.47)
Shape	1.62(.07)	.82(.11)	9.77** (.31)	16.95** (.71)	52.39** (.70)	160.79** (.96)
Speed	1.36(.06)	2.88(.29)	28.17** (.56)	104.00** (.94)	.83(.04)	1.15(.14)
Emotion	.77(.03)	2.38 (.25)	.25(.01)	.16(.02)	.16(.01)	.02(.00)
Trajectory	.01(.00)	.02(.00)	10.13** (.32)	6.84* (.49)	.3.39(.13)	2.65(.28)

Note: **p*<.05, ***p*<.01. *df* in the participant analysis are 1 for audio, visual and audio x visual interactions and 22 for error. *Df* in the item analysis are 1 for audio, visual and audio x visual interactions and 7 for error.

The nature of interaction was explored by Tukey HSD post-hoc tests. As the 2x2 interaction was only significant for shape and colour (except participant analysis was not significant for colour), only these two domains were explored further. When paired with abrupt visual stimuli, voiceless audio stimuli were rated higher than voiced audio stimuli (*ps*<.01 in the shape domain, but not significant in the colour domain). When paired with gradual visual stimuli, voiced audio stimuli were rated higher than voiceless audio stimuli (*ps*<.01 in the shape domain, but not in the colour domain). When paired with voiceless audio stimuli abrupt stimuli were rated higher than gradual stimuli (*ps*<.01 in both the shape domain and the colour domains). When paired with voiced audio stimuli, gradual stimuli were rated higher than abrupt stimuli (*ps*<.05,in the shape domain, but not in the colour domain). Thus, in the shape and in some cases in the colour domain, there is evidence that the combinations, abruptness-voiceless, were better sound-symbolic matches than the combinations, abruptness-voiced.

In order to draw precise conclusions about the relationship between visual stimuli (abrupt, gradual) and audio stimuli (voiced, voiceless) it is important to see whether the ratings are different to neutral (2). *T*-tests were carried out for the domains in which the 2 (abrupt, gradual) x 2 (voiced, voiceless) interaction was significant, which were the colour and shape domains. The means that are significantly different from 2 are indicated by * in Figure 5.5.

Results from the voiced-voiceless consonant investigation revealed that voiceless consonants are a better sound-symbolic match to abrupt items than voiced consonants in the shape domain. It is however, unclear how domain general this finding is. The same pattern of results holds numerically in the trajectory and colour domains, but not the speed and emotion domains.

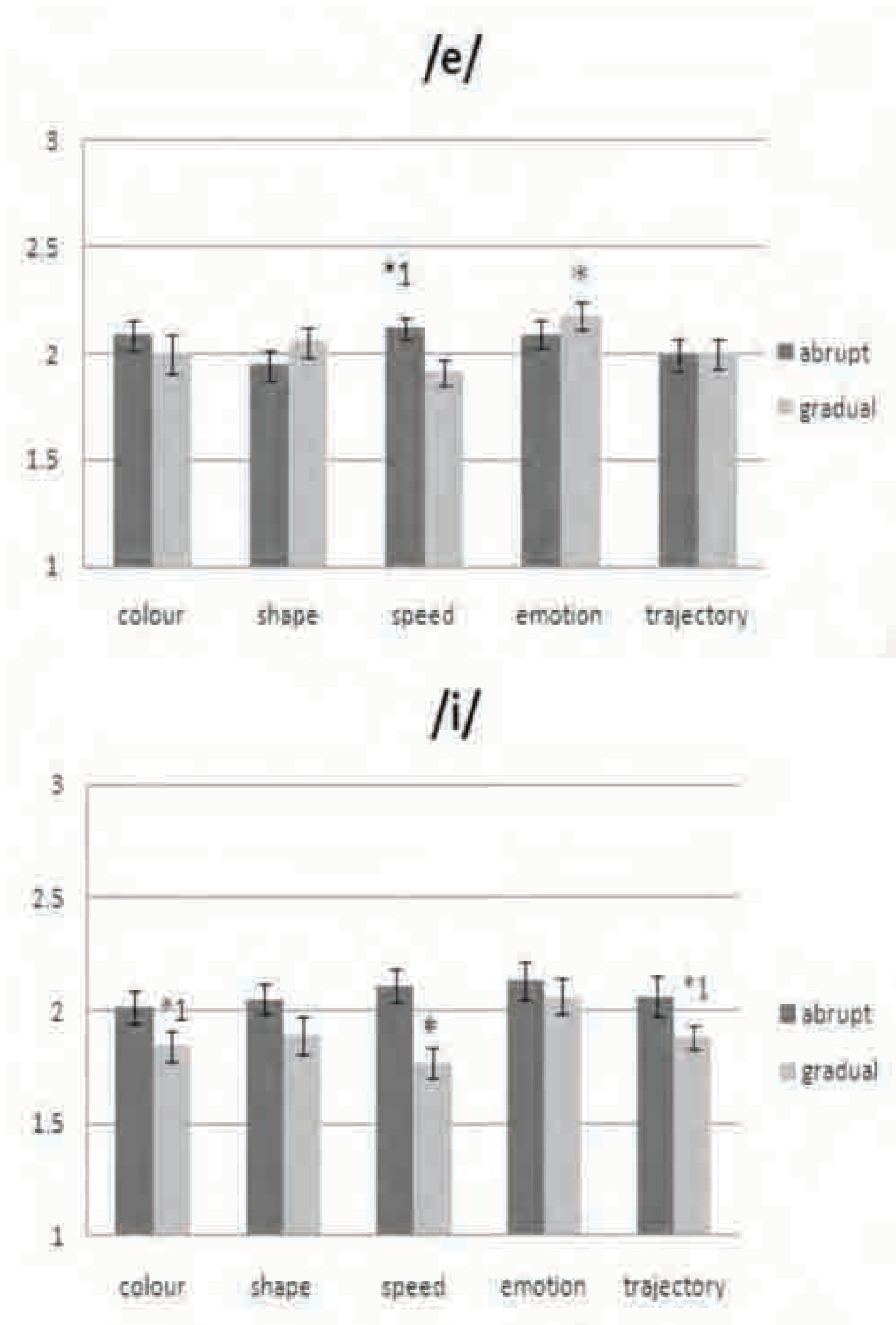
Interim discussion: summary of consonant findings.

To conclude, continuant audio stimuli and gradual visual stimuli were good sound-symbolic matching pairs, as were plosive audio stimuli and abrupt visual stimuli pairs. Furthermore, continuant audio stimuli and abrupt visual stimuli were bad sound-symbolic matching pairs, as were plosive audio stimuli and gradual visual stimuli pairs. This pattern was statistically significant in the colour, shape, speed and trajectory domains.

Furthermore, even though liquid and nasal audio stimuli were both good sound-symbolic matches to gradual visual stimuli, the degree of match differed. More specifically, liquid audio stimuli were a better sound-symbolic match to gradual visual stimuli, than nasal audio stimuli. This pattern of results is statistically significant in the shape and trajectory domain, and numerically true in all domains, except for the emotion domain. Moreover, even though voiced and voiceless stimuli were both good sound-symbolic matches to abrupt visual stimuli, the degree of match differed. More specifically, voiceless audio stimuli were a better sound-symbolic match to abrupt visual stimuli than voiced audio stimuli. This pattern was statistically significant in the shape domain, and numerically true in the other domains, except for the speed and emotion domains.

Vowel distinction

We also explored the effect of vowels on sound-symbolism. The four vowels used were (/e/, /i/, /o/, /u/). These were paired with all consonants exhaustively (see Table 1). The mean rating score was entered into a 2 (visual stimuli: abrupt, gradual) x 4 (vowels; /e/, /i/, /o/, /u/) x 5 (domains) repeated measures ANOVA (see Figure 5.6). We carried out both participant and item analysis. When sphericity is violated, the Greenhouse-Geisser correction of degrees of freedom is used.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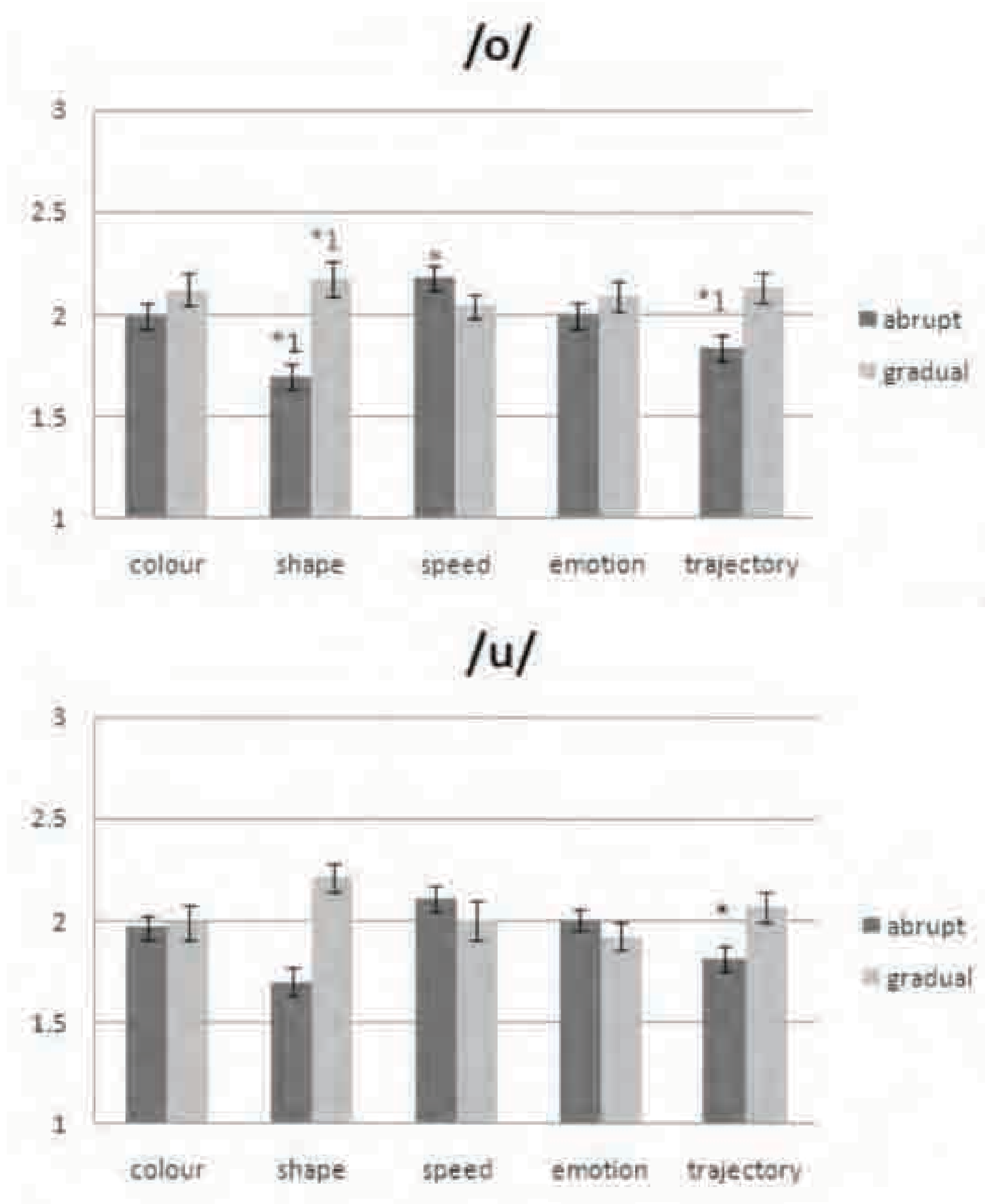
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and visual stimuli, the colour domain showed a significant interaction for item analysis only: *, $p < .05$ in both participant and item analyses or *[1] when participant analysis $p<.05$, but item analysis not significant.

The main effects of visual stimuli and vowel were not significant, visual: $F_1(14,1)=.005$, $F_2(7,1)=.024$; vowel: $F_1(48, 3)=1.463$, $F_2(21,3)=2.462$. There was a main effect of domain: $F_1(34.743, 2.171)=4.530$, $p<.01$, $\eta_p^2=.221$, but not for item analysis: $F_2(28,4)=1.678$. The two-way interactions were significant: visual stimuli x vowel, $F_1(24.101, 1.506)=5.031$, $p<.01$, $\eta_p^2=.239$, $F_2(21,3)=9.937$, $p<.001$, $\eta_p^2=.587$, visual x domain, $F_1(64,4)= 4.280$, $p<.01$, $\eta_p^2=.211$, but not significant for item analysis, $F_2(9.723, 1.389)=1.711$, vowel x domain was not significant, $F_1(87.890, 5.493)=1.470$, $F_2(84,12)=1.538$. The visual stimuli x vowel interactions indicate sound-symbolism. The interaction between visual stimuli, audio stimuli and domain was marginally significant in participant analysis $F_1(192, 12)=1.642$, $p=.08$, $\eta_p^2=.09$ and significant in the item analysis, $F_2(84,12)=2.025$, $p<.05$, $\eta_p^2=.224$. The three-way interaction indicates the sound-symbolism differed across domains.

Because of the 3-way interaction, the mean rating scores were entered into 2 visual stimuli (abrupt, gradual) x 4 vowels (/e/, /i/, /o/, /u/) repeated measures ANOVAs for each domain (Table 5.5). The interactions between audio stimuli (/e/, /i/, /o/, /u/) and visual stimuli (abrupt, gradual) were significant for the colour (item analysis only), shape and trajectory domains (see Table 5.5).

Table 5.5. *F* values and partial eta squared (in brackets) for the 2 (visual stimuli: abrupt, gradual) x 4(vowels: /e/, /i/, /o/, /u/) ANOVAs for the main effects and interactions in the 5 domains.

	Audio stimuli		*Visual stimuli*		*Audio x Visual stimuli*	
	Participant	Item	Participant	Item	Participant	Item
Colour	1.66(.07)	1.85 (.21)	.149(.01)	.03 (.01)	2.10(.09)	3.32 * (.32)
Shape	.70(.03)	.57 (.08)	9.05**(.29)	.57 (.08)	7.80**(.26)	11.58 ** (.62)
Speed	2.95*(.12)	1.88 (.21)	26.03**(.54)	1.94 (.22)	1.23(.05)	1.33 (.16)
Emotion	1.53(.09)	4.55* (.39)	.08(.01)	.03 (.00)	1.10(.07)	.81 (.10)
Trajectory	.37(.02)	.28 (.04)	4.29*(.16)	.33 (.04)	3.464*(.14)	5.27 ** (.43)

Note: *p<.05, **p<.01. *df* in the participant analysis are 1 for audio, visual and audio x visual interactions and 22 for error. *Df* in the item analysis are 1 for audio, visual and audio x visual interactions and 7 for error.

The nature of interaction was explored by Tukey HSD post-hoc tests. The 2x4 interaction was only significant for shape and trajectory domains in the participant analysis and colour, shape and trajectory in the item analysis, and therefore only these three domains were explored further. For abrupt stimuli, /i/ was rated significantly higher than /o/ and /u/, (p<.05, shape domain, item analysis only). For gradual stimuli, /o/ and /u/ were rated significantly higher than /i/, (/o/ *ps*<.05, colour and shape domains, item analysis only; /u/, p<.05 shape domain item analysis only). For audio stimuli containing /o/ and /u/ gradual stimuli were rated higher than abrupt stimuli, ($p<.01$, shape domain).

In order to draw conclusions about the relationship between visual stimuli (abrupt, gradual) and vowels (/e/, /i/, /o/, /u/) it is important to see whether the ratings are different to neutral (2). T-tests were carried out for the colour, shape and trajectory domains in which the 2 (abrupt, gradual) x 4 (vowels) interaction was significant. The means that are significantly different from 2 are indicated on Figure 5.6, by * $p < .05$ in both participant and item analyses or $*^1$ when participant analysis $p<.05$, but item analysis not significant.

The findings from the vowels are not as consistent as those found in the consonant analysis. Only the shape and trajectory domains yielded statistically clear findings. /i/ was a better match to abrupt visual stimuli, whereas /o/ and /u/ were a better match to gradual visual stimuli. At least for /i/ and /o/, the pattern seen for the shape and trajectory domains can be a reflection of a more general phenomenon. /i/ shows the same numerical pattern across all domains and /o/ shows the same numerical pattern in four out of five domains.

Discussion

The results from this study indicate that the abrupt-gradual sound-symbolic effect appears to be domain general. In other words the sound-symbolism, which associates abrupt visual stimuli to plosive audio stimuli and gradual visual stimuli to continuant audio stimuli, is evident across four (shape, trajectory, speed and colour) of the five domains investigated.

Interestingly the relationship between gradual visual stimuli and continuant audio stimuli can be taken one step further when nasal and liquid audio stimuli are compared. The results indicate that liquid audio stimuli are a better match to gradual visual stimuli than nasal audio stimuli. This effect is significant in the shape and trajectory domains, and numerically evident in the colour and speed domains. Similarly, the relationship between abrupt visual stimuli and plosive audio stimuli can be taken one step further when voiced and voiceless audio stimuli are compared. The results indicate that voiceless audio stimuli are a better match to abrupt visual stimuli than voiced audio stimuli; this relationship is significant in the shape and trajectory domain and numerically evident in the colour and trajectory domains.

The clearest sound-symbolism for vowels was observed in the shape and trajectory domains. In the shape and trajectory domains, /i/ was rated higher for abrupt than for gradual; in contrast, /o/ and /u/ were rated higher for gradual than for abrupt. There are two possible interpretations. First, this could be an instance of magnitude sound-symbolism (Ohala, 1984; Sapir, 1929). In magnitude sound-symbolism, high front vowels such as /i/ are good match for small entities and back vowels such as /o/ and /u/ are good match for large entities. In the shape and trajectory domains, the abrupt visual stimuli had narrow and pointy, thus "small", parts and the gradual stimuli had wide and round, thus "big", parts. According to this interpretation, the sound-symbolically relevant parts of the visual stimuli were the size of the protruding parts of the shape or the trajectory. Second, the sound-symbolically relevant contrast may be abrupt vs. gradual change in a more general sense, at least for /i/ and /o/. The pattern of ratings for /i/ and /o/ are quite consistent across domains, though only shape and trajectory domains showed statistically significant evidence for sound-symbolism. According to this interpretation, the sound-symbolically relevant feature of the visual stimuli was abrupt vs. gradual change. It should also be noted that the above two interpretations are not mutually exclusive. The results may reflect both types of sound-symbolism.

Sound-symbolism for abrupt vs. gradual change was found across a number of domains. However, for the emotion domain the pattern of results did not hold. It was speculated that this is because the novel words could be referring to many aspects of the complex stories. The novel word could indeed be referring to the abruptness or gradualness of the emotion change, but it could also be referring to the emotion itself, or the positivity or negativity of the emotion among other things. Experiment 2 addressed the issue by making the key contrast between abrupt and gradual clearer.

Experiment 2

In this experiment we used a forced choice task, in which two visual stimuli, one abrupt and one gradual (with the same domain), were presented with two audio stimuli, one plosive and one continuant. The aim of this study was to investigate whether when participants were presented with stimuli simultaneously, and therefore the contrast between abrupt and gradual was more evident, participants could make the connection between abrupt to plosive and gradual to continuant audio stimuli more easily, even in the emotion domain.

Method

Participants

21 monolingual English speaking University of Birmingham students took part in this study (mean age: 19,48 range: 18-25). They were rewarded with course credits for their participation. One was removed because they had lived in France for over one year, one spoke Punjabi, one was a native Bengali speaker. This resulted in a total of 18 participants.

Materials

The materials used in this experiment were identical to those used in Experiment 1.

Procedure

The stimuli were presented in 5 blocks. Each block was made up of stimuli from a single domain (colour, shape, speed, emotion or trajectory). Each block contained a total of 16 PowerPoint slides (plus one practice trial). Each slide contained 2 visual stimuli and 2 audio stimuli. The visual stimuli consisted of one abrupt and one gradual exemplar. The audio stimuli consisted of one continuant and one plosive exemplar with the same vowel (e.g. Lororo and Dobobo). Participants had to click on an icon for each auditory stimulus individually in order to hear it. This also ensured that participants' attention could be on one stimulus at a time. Participants could hear each stimulus as many times as they needed.

The order in which the five domain sets were presented to each participant was rotated. Within each of the five domain sets, there were four counterbalancing sets. We counterbalanced the side on which the icons for audio stimuli and visual stimuli were presented. The order in which audio-visual slides were presented was also counterbalanced within each counterbalancing set.

Participants' task was to indicate which visual stimuli match which audio stimuli. Participants recorded their responses on an answer sheet. The next slide was not presented until the participant pressed the space bar on the keyboard.

Results

We examined whether the participants matched abrupt visual stimuli to plosive audio stimuli and gradual visual stimuli to continuant audio stimuli, as we found in Experiment 1. Participants' responses were coded as correct if they assigned the plosive audio stimuli to the abrupt visual stimuli and the continuant audio stimuli to the gradual visual stimuli. Responses were significantly above chance (.5) in all domains (Figure 5.7): colour: $t_1(17)=5.006$, $p<.01$, $d=1.18$,

$t_2(15)=8.08$, $p<.001$, $d= 2.02$; shape: $t(17)=3.498$, $p<.01$, $d=.082$, $t_2(15)=10.07$, $p<.001$, $d=2.52$; speed: $t(17)=5.529$, $p<.01$, $d=1.30$, $t_2(15)=6.70$, $p<.001$, $d=1.67$; emotion: $t(17)=4.58$, $p<.01$, $d=1.08$, $t_2(15)=8.00$, $p<.001$, $d=2.00$; trajectory: $t(17)=4.583$, $p<.01$, $d=1.29$, $t_2(15)=9.13$, $p<.001$, $d=2.82$. These results further support the findings from Experiment 1, that the sound-symbolism is domain general. The emotion domain was of particular interest in this experiment, as it did not follow the same pattern of results as the other four domains in Experiment 1. Results in the emotion domain in Experiment 2 follow the same pattern as the other domains, where continuant audio stimuli sound-symbolically match gradual visual stimuli and plosive audio stimuli sound-symbolically match abrupt visual stimuli.

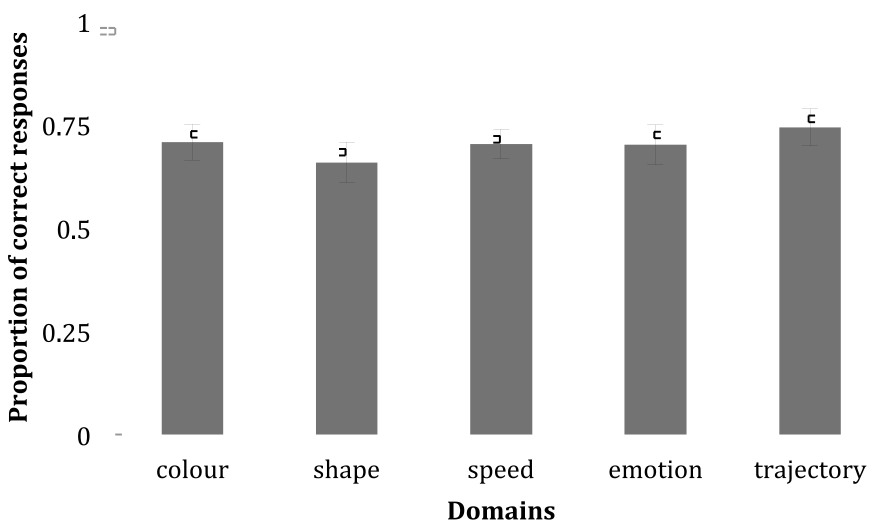

Figure 5.7. The proportion of correct responses in each domain in a forced choice task (Experiment 2). Error bars indicate standard error of the mean.

In Experiment 1, the combination of liquid audio stimuli and gradual visual stimuli were rated higher than those of nasal audio stimuli and gradual visual stimuli. Paired *t*-tests (liquid, nasal) were carried out across the five domains, with the proportion of correct responses as the dependent variable (see Figure 5.8). Participants' responses were coded as correct if they assigned the plosive audio stimuli to the abrupt visual stimuli and the continuant audio stimuli to the gradual visual stimuli. There was no significant difference in the proportion of time when liquid and nasal audio stimuli were assigned to the correct visual stimuli. There is no consistent numerical trend across the domains either.

The results failed to provide evidence for sound-symbolism of liquids vs. nasals, but this null result does not necessarily undermine the finding in Experiment 1 that liquid consonants sound-symbolically match gradual changes better than nasal consonants. In the forced choice task in Experiment 2, the correct matching can, in principle, be achieved if plosives are correctly matched to abrupt visual stimuli. The rating in Experiment 1 showed that liquid consonants and nasal consonants did not differ in the degree of mismatch with abrupt changes (liquid and nasal consonants differed only in the degree of match to gradual changes). Therefore, liquid and nasal consonants should equally support matching plosive consonants to abrupt changes. This should lead to a roughly equal proportion of correct responses for liquid and nasal consonants in the forced choice task in Experiment 2.

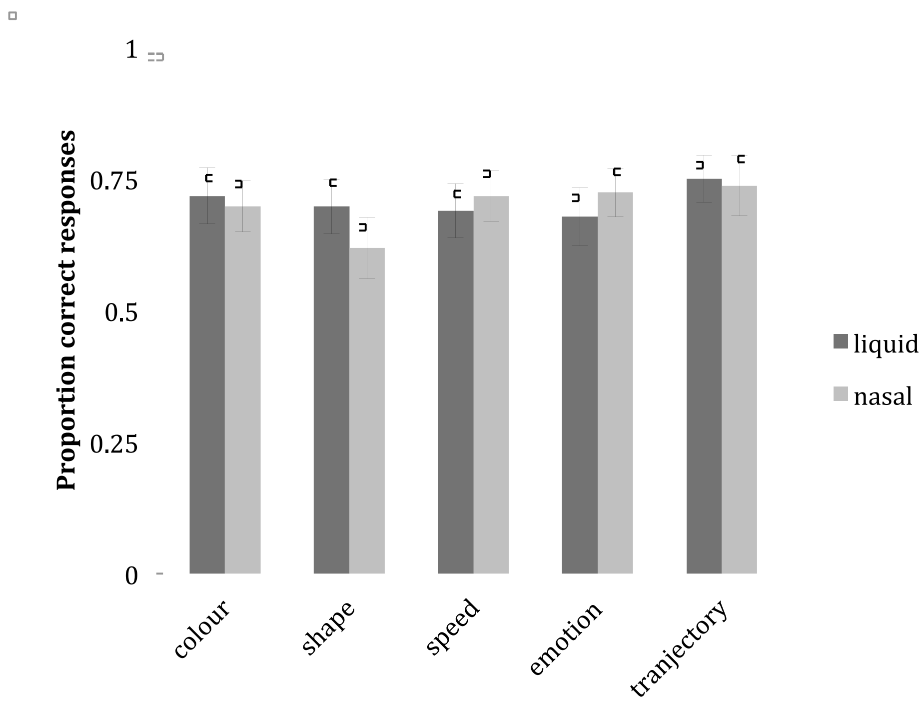

Figure 5.8. The proportion of correct responses when continuant audio stimuli were paired with liquid vs. nasals, in each domain in a forced choice task (Experiment 2). Error bars indicate standard errors of the means.

In Experiment 1 the combination of voiceless audio stimuli and abrupt visual stimuli were rated higher than those of voiced audio stimuli and abrupt visual stimuli. Paired *t*-tests (voiced, voiceless) were carried out across the five domains, with the proportion of correct responses as the dependent variable (see Figure 5.9). Participants' responses were coded as correct if they assigned the plosive audio stimuli to the abrupt visual stimuli and the continuant audio stimuli to the gradual visual stimuli. In the shape domain voiceless audio stimuli were assigned to the correct visual stimuli significantly more than voiced audio stimuli $t_1(10)= -2.695$, $p<.05$, but not for item analysis $t_2(7)=.000$, $p=1.00$. There was also a numerical trend in the same direction for all the other domains as well, except for the colour domain. These results indicate that voiceless consonants are a better sound-symbolic match to abrupt visual stimuli than voiced consonants.

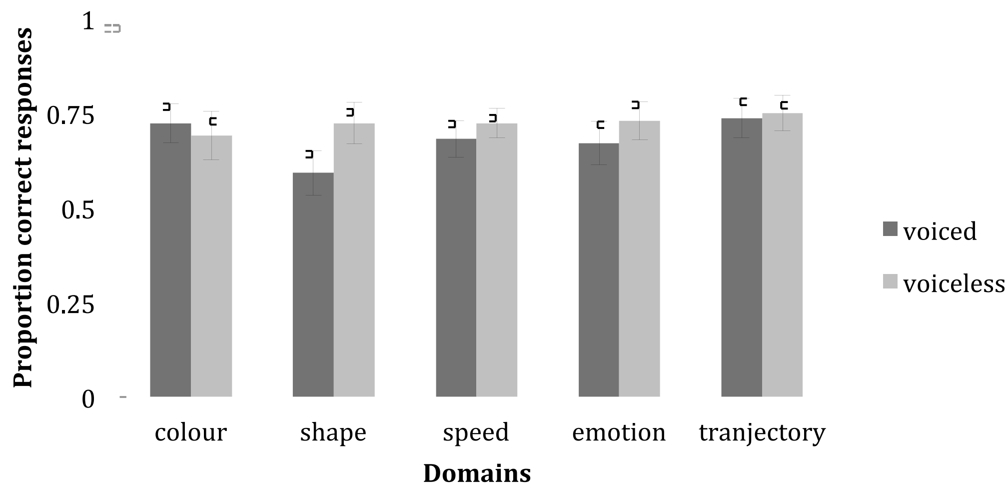

Figure 5.9. For the proportion of correct responses when the abrupt audio stimuli were voiced vs. voiceless, in each domain in a forced choice task (Experiment 2). Error bars indicate standard error of the mean.

Results from Experiment 1 showed that sound-symbolism of abruptness or gradualness is domain general in four of the five domains. Results for the emotion domain however were not clear in Experiment 1. The results from Experiment 2 supported those found in Experiment 1. Participants in Experiment 2 matched continuant audio stimuli to gradual visual stimuli above chance, they also matched plosive audio stimuli to abrupt visual stimuli above chance, and this was true in all five domains. Critically, participants also followed this pattern of results in the emotion domain.

For the nasal-liquid distinction, in Experiment 1 liquid audio stimuli had been found to be a better sound-symbolic match to gradual visual stimuli than nasal audio stimuli. Experiment 2 did not provide any further support for these findings. However, the findings from Experiment 2 are compatible with those from Experiment 1. This is because liquid and nasal audio stimuli were judged to mismatch abrupt visual stimuli to the same degree as in Experiment 1, thus the two types of audio stimuli equally support the matching of plosive audio stimuli to abrupt changes in the forced choice task in Experiment 2. This led to the comparable success rates for liquid and nasal audio stimuli in Experiment 2. In terms of the voiced-voiceless distinction, in Experiment 1 voiceless audio stimuli was found to be a better sound-symbolic match to abrupt visual stimuli, than voiced stimuli. These findings were supported, where the proportion of correct responses was higher when the plosive was voiceless than when it was voiced, in the shape domain, and numerically so for all the other domains, except the colour domain.

General Discussion

This study investigated whether sound-symbolism is domain general. More specifically, we tested whether sound-symbolism for abrupt vs. gradual changes can be found in colour, shape, speed, emotion and trajectory domains. In Experiment 1, participants gave a higher match rating to the following audio-visual pairs: (1)

abrupt visual stimuli and plosive audio stimuli pairs and (2) gradual visual stimuli and continuant audio stimuli. In contrast participants gave a lower rating to the following audio-visual pairs: (3) abrupt visual stimuli and continuant audio stimuli and (4) gradual visual stimuli and plosive audio stimuli. This pattern of results was significant in the colour, shape, speed and trajectory domains, but not in the emotion domain. We suggested that the emotion domain did not support the hypothesis because the stimuli did not contrast abruptness and gradualness clearly enough. In order to make the key contrast clear Experiment 2 was set up as a forced choice task. In Experiment 2, participants matched abrupt visual stimuli to plosive audio stimuli and matched gradual visual stimuli to continuant audio stimuli significantly above chance in all domains, including the emotion domain. That is, when the contrast between abruptness and gradualness is obvious, the predicted pattern of results was found in all domains. These findings support the hypothesis that sound-symbolism for abrupt vs. gradual changes is domain general.

We also explored if the different types of consonants within plosives (voiced vs. voiceless) and continuants (liquids vs. nasals) showed systematic match to abrupt and gradual visual stimuli. As for the voice-voiceless distinction, in Experiment 1, participants gave a higher match rating to the following audio-visual pairs: (5) abrupt visual stimuli and voiceless audio stimuli pairs and (6) gradual visual stimuli and voiced audio stimuli. In contrast participants gave a lower rating to the following: (7) abrupt visual stimuli and voiced audio stimuli and (8) gradual visual stimuli and voiceless audio stimuli. This interaction between audio stimuli and visual stimuli was significant in the shape domain, and was numerically the case in the colour and trajectory domains (thus, three out of five domains in total). In Experiment 2, participants paired audio and visual stimuli in the way consistent with (5) and (6) above (significant in the participant analysis of the shape domain, and numerically the case in all domains except for the colour domain). As for the nasal-liquid distinction, in Experiment 1, participants gave different ratings for gradual visual stimuli only. (9) When paired with gradual stimuli, liquid audio stimuli were rated higher than nasal audio stimuli. This was significant in the shape and trajectory domains, and numerically the case in the colour and speed domains (thus, four out of five domains in total). Experiment 2 did not provide further support for this pattern. However, we argued that the null result did not contradict the results from Experiment 1 because in Experiment 2 participants could, in principle, correctly respond as long as they could match the abrupt visual stimuli and plosive audio stimuli. In summary, the general picture that emerges is that the voiceless-voiced and nasal-liquid distinctions also showed domain general sound-symbolism.

The vowel results from Experiment 1 also showed some degree of domain generality. Participants gave higher match rating scores to the following: (10) abrupt visual stimuli and audio stimuli with /i/, (11) gradual visual stimuli and audio stimuli with /o/ and /u/. This was significant in the shape and trajectory domains. Numerically, (10) was the case for all domains. When the audio stimuli contained /o/, (11) was numerically the case for colour and emotion domains (thus, four out of five domains). When the audio stimuli contained /u/, (11) was not numerically consistent across other domains. That is, /i/ and /o/ showed domain general match to abruptness and gradualness respectively (but not /u/). For /i/, /o/ and /u/, the shape and trajectory domains showed the clear evidence for sound-symbolism. In both the shape and trajectory domains the visual stimuli for abruptness contained smaller parts, whilst those for gradualness contained larger parts. Previous research has shown that participants associate /i/ with small entities (Sapir, 1929; Newman; 1933) and /u, o/ with large entities (Newman, 1933). In summary, we argue that the vowel results reflect two types of sound-symbolism: abrupt-gradual across domains, and magnitude sound-symbolism for the shape and trajectory domains.

It shoud be noted that there are a large number of comparisons carried out in these Experiment 1 particularly. However, the Tukey HSD posthocs protect us from family-wise error inflations, so this is controlled for. Furthermore, both Experiment 1 and 2 show consistent results. This again indicates that the results are reliable.

The domain generality of sound-symbolism found in the current study argues against Ramachandran and Hubbard's (2005) view that sound-symbolism and adult synaesthesia share the same underlying mechanism. Based on the systematic association between shapes and sounds Ramachandran and Hubbard (2005) suggested that sound-symbolism is similar to adult synaesthesia in which stimulation in one modality (e.g. graphemes) automatically activates a second unrelated modality (e.g. colours). However, the current study found that sound-symbolism is domain general, and thus sound-symbolism and adult synaesthesia are likely to have distinct underlying mechanisms.

Further evidence in the literature supporting distinct mechanisms for sound-symbolism and adult synaesthesia. First, adult synaesthesia is specific to individuals where one synaesthete might experience the letter A as being red, while another might experience it as blue (Day, 2001). Sound-symbolism, on the other hand, is generalisable across people with different native languages (Davis, 1961), and of different ages (Davis, 1961; Imai et al., 2008; Maurer et al., 2005). Second, the domain generality of sound-symbolism can be seen in the frequent polysemy of Japanese sound-symbolic words. For example, the word "goro-goro" can indicate something rolling, a rumbling stomach, thunder and hanging around (Gomi, 1989).

The domain generality of sound-symbolism is similar to one view of cross modal mapping in infants. Very young infants just 3 weeks old were able to match intensity across two different domains, namely light and sound (Lewkowicz & Turkerwitz, 1981). Similarly, infants as young as 1 month old, who were familiarised with a soft or hard toy, showed cross-modal mapping to visual displays of the same objects (Gibson & Walker, 1984). Infants at four-month were able to match odor to objects (Fernandez & Bahrick, 1994). One interpretation of these findings is that infants are unable to distinguish between stimulation of different modalities and perceive the common feature, such as intensity, across domains ("weak form of neonatal synaesthesia"; Maurer & Mondloch, 2004). Sound-symbolism found in adults may be a remnant of this type of cross-modal mapping (Maurer & Mondloch, 2004).

Is there a unified account for the current findings that different sound distinctions mapped onto abrupt vs. gradual changes? The findings can be summarised by the position of the different sounds on the so-called sonority hierarchy in phonology. For example Burquest and Payne (1993) rank sounds as in Figure 10. Sounds associated with gradualness are more sonorous than sounds associated with abruptness: continuants (liquids = laterals, nasal) vs. plosives, liquids vs. nasals, voiced plosives vs. voiceless plosives, and /o/ (mid vowel) vs. /i/, (high vowel), respectively. Sonority hierarchies such as in Figure 5.10 are derived from patterns of historical sound change (Escure, 1977) or syllable structure (Ladefoged, 1993) in various languages. The hierarchy represents how close to a vowel or consonant prototype a sound is. The hierarchy has been characterised in terms of both acoustic and articulatory features. For example, sonorant sounds have little or no obstruction of the airflow when produced (Finch, 2000), and have the most acoustic energy (Ladefoged, 1993).

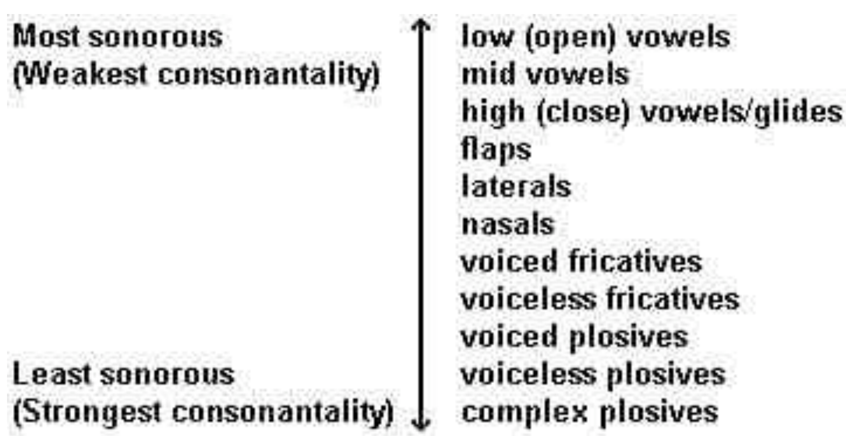

Figure 5.10. The sonority hierarchy from Burquest and Payne (1993).

It is not easy to explain the relationship between the sonority hierarchy and the abrupt-gradual contrast. For example, one might argue that plosives are associated with abrupt changes because plosives involve more abrupt airflow change when produced than continuants. However, such an account cannot explain the contrast found between /i/ and /o/. Acoustic and articulatory motivations for the sound-symbolism of abruptness and gradualness is a topic for future research.

Is the current sound-symbolism of abruptness vs. gradualness related to magnitude sound-symbolism? The sonority hierarchy can also provide a unified account for magnitude sound-symbolism. Numerous studies have found a scale of magnitude sound-symbolism in vowels (e.g. Johnson, 1967; Koriat & Levy, 1975; Newman, 1933; Sapir, 1929; Tarte, 1982). Most studies support a sound-symbolic scale of magnitude in vowels which looks similar to that proposed by Newman (1933), which places vowels in the following order of increasing magnitude: /i/, /e/, /a/, /u/, /o/. Magnitude sound-symbolism and abrupt vs. gradual sound-symbolisms are distinct and cannot be completely reduced to each other. However, they might be linked by the fact that small things tend to move abruptly, while big things tend to move more gradually in the world.

To conclude, the current study shows that sound-symbolism is domain general. Sound-symbolism refers to abstract concepts applicable across domains, such as abruptness vs. gradualness. This is at odds with the view that sound-symbolism shares the same underlying mechanisms as adult synaesthesia, in which cross-modal mapping is domain specific. Sound-symbolism may be a remnant of infant perceptual systems, which focus on common features across domains.

CONCLUSION

Summary of findings

Chapter 1

In Chapter 1 the previous literature on sound-symbolism was discussed. The chapter covered six main topics: (1) The existence of sound-symbolism, as shown by psychological research, in various domains (shape, size, action, taste and pain), (2)The universal or cross culturally recognizable aspects of sound-symbolism, (3)the potential for sound-symbolism being language specific, (4) The use of sound-symbolism in learning, (5) Three possible underlying mechanisms for comprehension of sound-symbolism (the acoustic, articulatory and orthographic theories) and(6) Brain regions involved in the processing of sound-symbolic words.

Chapter 2

Chapter 2 addressed children's sensitivity to sound symbolism. A cross-linguistic developmental study with English speaking adults, Greek speaking adults, English speaking children and Greek speaking children was carried out. The task was a forced choice task. Participants were presented with two actions and one word. One of the actions was either a universal or an English language specific sound-symbolic match to the word while the other video was a distractor. The results showed that all participants were equally sensitive to universal sound-symbolism. However, only English speaking adults, English speaking children and Greek speaking children were sensitive to English language specific sound-symbolism. These results are taken as evidence towards the idea that children are born with the ability to detect all sound-symbolic matches. However, as they learn their native language, their sensitivity is pruned or shaped to match their native language specific sound-symbolism. This is the first study to directly address how children shape their sensitivity to sound-symbolism. Although this study does not directly address how sensitivity to sound symbolism is acquired, it does show that children are sensitive to a wider range of sound symbolic links than adults. This in turn might lead us to speculate about the potential innate nature of sound symbolism. However, much research is needed with infants and neonates before such conclusions can be reached.

This study is the first to show that both universal and language specific sound symbolism may exist. Previous research has looked at the existence of universal sound symbolism (Brackbill & Little, 1957; Brown, Black, & Horowitz, 1955; Brown & Nuttall, 1959; Davis, 1961; Gebels, 1969; Imai, Kita, Nagumo & Okada, 2008; Iwasaki, Vinson, & Vigliocco, 2007a; Iwasaki, Vinson, & Vigliocco, 2007b; Tsuru & Fries, 1933). There are also however, theories that argue for a more language or culture specific sound symbolism (Taylor and Taylor; 1962; Taylor, 1963). The results of Chapter 2 showed that these two viewpoints should not be seen as either-or. Both types of sound symbolism co-exist within a speaker of a particular language.

Chapter 3

Children can use sound-symbolism to learn and generalize verbs more effectively. Chapter 3 presented a study in which English-speaking children were taught sound-symbolically matching or mismatching verb-action pairs. The results showed that children were better able to learn and generalize novel verbs when they sound-symbolically matched the action they represented. Previous research has shown that children are sensitive to sound symbolism (Maurer, Pathman & Mondloch, 2006). However, this was the first study to show that English-speaking children can use Japanese-type sound symbolism in word learning.

The results of this study raised the question as to how exactly sound symbolism helps children learn verbs more effectively. What children seem to find difficult when learning novel words is separating the action from the actor. We suggested that sound symbolism helps children focus on the relevant part of the scene, by highlighting the action as the referent of the verb and therefore help them learn the verb more effectively.

This study also contributed to the ever-expanding discussion of the role of sound symbolism in the evolution of language. Previous discussions have suggested that sound symbolism may have played a vital role in the evolution of language (Kita, 2008; Kita, Kantartzis, & Imai, 2010; Ramachandran & Hubbard, 2001). More specifically this study and others have shown that sound symbolism can facilitate dissemination of language from one speaker to another (e.g., from an adult to a child) (Imai et al., 2008; Kantartzis, Imai, & Kita, 2011). Furthermore, this study showed that universal sound symbolism facilitated word learning in children learning English. Unlike Japanese, English does not have a large sound symbolic lexicon; thus, sound symbolic bootstrapping is not as useful when learning English. However, sound symbolism facilitated word learning for children learning both English (Kantartzis, Imai, & Kita, 2011) and Japanese (Imai et al., 2008) to a similar degree. This suggests that the ability to use sound symbolism for word learning may be an evolutionary vestige that all children are biologically endowed, regardless of the language they happen to receive as an input.

Chapter 4

Children can use sound-symbolism to learn and store novel verbs in such a way that makes them generalisable the following day. Chapter 4 presented a verb learning study which showed that (1) children are able to retain, identify and store the novel sound-symbolically matching verb in such a way that made it generalisable one day later. (2) Sound-symbolism helps children accept the correct action as the referent of a verb, but sound-symbolism does not help children reject the incorrect action as the referent of a verb.

Previous research has shown that children can use sound symbolism to learn novel verbs more effectively (Imai et al., 2008; Kantartzis et al., 2011). However, both these studies looked at the immediate recall of the novel verbs. In other words the testing session immediately followed the training session. It is therefore not clear whether children are able to retain the memory of the novel verb, or whether sound symbolism only has a short-term facilitation effect. Using the 1-day delay paradigm, we tested this. The results showed that sound symbolism helped children identify and store the semantic representation of the novel verbs in such a way that they are generalizable to a new scene the following day.

Furthermore, the paradigm used in the experiment present in Chapter 4 gave us further insight into the type of help sound symbolism provides in word learning. Previous studies with two-way forced choice responses (Imai et al., 2008; Kantartzis et al., 2011) could not tell us if sound symbolism was helping the children accept the correct action as the referent of the verb or reject the incorrect action, or both. Using the yes-no response paradigm in Chapter 4 it was found that sound symbolism helped children accept the correct action as the referent of the verb, but did not help them reject the incorrect action.

Chapter 5

Sound-symbolism is domain general. In Chapter 5 two empirical studies were presented in which participants were presented with novel word-object pairs and asked to rate the degree of match between them (Study 1) and participants were presented with novel word-object pairs and asked to match them up (Study 2). The words contained either continuant or plosive consonants. The objects depicted a gradual or abrupt change in one of five domains (shape, colour, speed, trajectory or emotion). The main result was that words containing plosives were matched to abrupt change and words containing continuants were matched to gradual change in all the domains.

A recurring question in the field of sound symbolism is why words are sound symbolic. What makes them sound symbolic? There is a large body of literature showing that the world *maluma* for example matches a rounded object (Holland & Wertheimer, 1964; Köhler, 1947). However it is not clear what aspects of *maluma* matches the rounded object. Is it the 'm' sound or the 'u' sound, or is it the exact combination of sounds in the word? Could we create a new word that would be an even better match to a rounded object, or is maluma the optimum match? All these questions remain unanswered but are critical to understanding the field of sound symbolism. The experiments presented in Chapter 5 bring us one step closer to understanding the nature of sound symbolism and how words become sound symbolic. For example, it showed that continuant consonants are a better match to gradual changes, whereas plosive consonants are a better match to abrupt changes.

Limitations

There are a number of limitations to the research carried out in this thesis. In terms of the sensitivity to sound-symbolism, it is shown that infants have an increased sensitivity to sound-symbolism, which is reshaped or pruned as the children learn their native language. However, this was only shown in the motion or action domain. Previous research has shown that children as young as 2-years-old are sensitive to sound symbolism in the shape domain. It is not clear whether sensitivity to sound-symbolism in the shape domain (or in other domains such as size, pain and so on) develops in the same way as in the motion domain. Research into different domains of sound symbolism needs to be done before any general statements about children's sensitivity to all sound symbolism can be made.

An analogy was drawn between the acquisition of sound symbolism and the acquisition of phonology, but not all consequences of the analogy have been empirically tested. The study presented in Chapter 2 showed that the Greek-speaking children are sensitive to more sound symbolism than the Greek adults, just as young infants are sensitive to more sound contrasts than adults (Werker & Tees, 1983). The ability to discriminate sounds in languages of the world is believed to be innate (Kuhl et al., 2006); thus, if the above analogy between development of sound symbolism and phonology is correct, then the sensitivity to sound symbolism should also be innate. However, more research must be done to substantiate such a claim.

It is not clear how the use of sound-symbolism in word learning would be useful in a 'real world' context. Children can use sound-symbolism to learn novel sound-symbolic words more effectively (Imai et al., 2008; Kantartzis et al.,2011). However, there are a number of questions that still need to be answered. Firstly, is sound symbolism a critical component of word learning? Second, at what point in word learning is sound symbolism critical? Although empirical evidence is sparse, parents tend to use onomatopoeic words with very young infant (see Fernald & Morikawa, 1993; for a discussion of mothers' use of onomatopoeic words). This may be part of the word learning process, at which stage sound symbolism might also be useful. It may be the case that sound symbolism is only critical in the initial stages of word-object association. This is supported by the observation that second language learners of Japanese find it difficult to learn Japanese sound symbolic words ("mimetics ")(Hamano, 1998). Research looking at using sound symbolism in word learning at different ages, will help us gain a clearer picture of the role of sound symbolism in word learning.

Finally, it might still be asked how the word *choka-choka* for example would be useful for a child to learn. Many of the studies on sound symbolism use non-words that do not have the typical shape for the language the child is learning (e.g., English). Studies on sound symbolism with more realistic words (with typical word forms for English for English speaking children) are missing in the literature. Future studies in the area of sound symbolism should begin looking at how these non-words can be adapted to make them more typical to the child's mother tongue. This will be particularly important if people want to use sound symbolism as a tool for helping children with language delays.

It is still not clear how sound-symbolic words are formed. Chapter 5 of the current thesis looks in some detail at which exact part of a word makes it sound-symbolic, for example continuant-plosives, voiced-voiceless, nasal-liquids, vowels. However, there is still much research needed looking at exactly how sound-symbolic words are constructed and what exactly it is about a sound-symbolic word that makes it sound-symbolic. Things such as intonation, fundamental frequency, speed, consonants, vowels etc. may all play a role (e.g., Nygaard, Herod, & Namy, 2009; Shintel, Nusbaum, & Okrent, 2006; Shintel & Nusbaum, 2007). It is vital these factors are also investigated systematically and thoroughly before sound-symbolism can be understood fully. It would be useful if we could arrive at a stage where not only do we understand why a word is sound symbolic, but also how to create and manipulate sound symbolism to give intended semantic connotation to a word.

Implications

Sound-symbolism may have played a pivotal role in the evolution of language. Implications about the role of sound-symbolism in the evolution of language have been discussed in the literature (Imai, et al., 2008; Kantartzis et al., 2011; Maurer et al., 2006; Ramachandran & Hubbard, 2005). In this thesis it was shown that young children are sensitive to more sound-symbolism than adults (Chapter 2), and that sound-symbolism can be used to make word learning more effective (Chapter 3 & 4). Showing that sound-symbolism is available to young children and that it has a functional role in language adds to the argument linking sound-symbolism to the evolution of language.

The experiment presented in Chapter 2 showed that children are sensitive to a wider range of sound symbolism than adults. These findings indicate that sound symbolism is probably not learnt, because if this were the case, adults who are more proficient with language should be more sensitive than children. Therefore, it could be suggested that children are born with a heightened sensitivity to sound symbolism. However, to say that sound symbolism is innate is too strong a statement at the moment, and much more research must be carried out before such an argument can be made. This study has however, opened a gateway for many more studies looking specifically at how sound symbolism is acquired.

Sound-symbolism is domain general. Previous research in the field of sound-symbolism has often focused on one domain: size (Sapir, 1929, Newman 1933), shape (Köhler, 1929/1947; Maurer et al., 2006 Westbury, 2004), action/motion (Imai et al., 2010; Kantartzis et al., 2011), pain (Iwasaki, Vinson, & Vigliocco, 2007a) and taste (Cuskley et al., 2010). However, the current thesis has shown that sound-symbolism is domain general. One property of sound-symbolism, abruptness or gradualness of change in this case, can be extended to a number of domains. This indicates that sound-symbolism may indicate relatively abstract properties and such properties (e.g., abruptness) may be extendable across a number of domains. However, it is still not clear whether this is true of all types of sound-symbolism. For example, the sound-symbolism of sweetness (Cuskley et al., 2010) may only be applicable to one specific domain that is taste. The distinction between domain-generality vs. specificity may be similar to the philosophical distinction between primary and secondary properties (See Locke, 1690; for discussion of primary and secondary properties). Primary properties express qualities in any domain, whereas secondary properties can only express properties in one domain.

Future directions

There are number of future directions the research from this thesis could take. Initially it is interesting to look at whether young infants are sensitive to sound-symbolism. If infants as young at 8 or 10 months old are able to detect sound-symbolism then this is further evidence towards innateness of sound symbolism and hence the role sound-symbolism played in the evolution of language.

If sound symbolism is linked to the evolution of language, then infants might be able to use sound symbolism at the initial stages of word learning. Theories linking sound symbolism to the evolution of language speculate that sound symbolism might be the link between iconic (onomatopoeia) and arbitrary (the majority of spoken language today) sign (Kita, Kantartzis & Imai, 2010; Kita, Özyürek, Allen & Ishizuka. 2010). Sound symbolism by virtue of its nature could act as a link between iconic signs ('bang' for a loud noise) and arbitrary sign (the word 'loud'). If this is the case then very young infants might be able to use sound symbolism to make the first steps to understanding the arbitrary sign. What is often difficult in word learning is understanding that a sound relates to an object in the world. Sound symbolism creates a natural link between the sound and referent. Therefore, highlighting the relevant part of the world and making the word-learning task easier for the infant. Therefore, it would be interesting to look at whether young infants can use sound symbolism to make word-object associations.

Moreover, if infants can use sound-symbolism to learn words more effectively then it is interesting to look at clinical applications of sound-symbolism. In Japan mimetics are sometimes used to help children who are delayed in language development (M. Imai, personal communication, November 19, 2009). As discussed above, often the problem children have in word learning is understanding which part of the world a word is referring to. In verb learning for example, children often find it hard to separate the action from the agent (Imai et al., 2005). In the current thesis it was shown that sound symbolism helped children learn verbs more effectively, enabling the children to generalize the novel verbs. It is speculated that sound symbolism helped children by highlighting the relevant part of the world. This property of sound symbolism, its ability to highlight the relevant part of the world or scene, might be a useful tool for children who are delayed in language development. Sound symbolism may be a tool that can be utilized to make the word-learning task easier. However, further research is needed before using sound-symbolism for word learning can be used in a clinical setting.

The domain generality hypothesis of sound-symbolism can be further investigated. So far abrupt or gradual change has been shown to be a domain general property of sound-symbolism. However, it may be the case that all sound-symbolism is domain general or conversely it may be the case that this is the only example of domain general sound-symbolism. It is therefore important to investigate this further.

Furthermore, it is also an important question as to whether or not domain generality holds cross-linguistically. Running the experiments presented in Chapter 5 with speakers of different languages is also an important next step. Within the field of sound symbolism and language in general, it is important to ensure that effects found are not specific to English speakers but can be seen of speakers of a variety of languages.

There still remains a question about the fundamental difference between understanding and producing sound-symbolic words. One key difference between native sound-symbolism and so-called universal sound-symbolism is people's ability to produce sound-symbolic words. When presented with the word *jiraka-biraka*, and told it means spinning, then you may be able to intuitively see the connection.

However, if somebody who does not know Basque is asked to produce a novel word for spinning it is incredibly unlikely that you would come up with the word *jiraka-biraka*. The word *jiraka-biraka* must therefore be a combination of universal and language-specific elements; but you can only guess the universal part. Furthermore, there are multiple ways in which the concept of spinning can be expressed in terms of sound-symbolism. It is interesting to investigate why there seems to be a difference in people's ability to understand and produce sound-symbolic words. Understanding this difference may be the link to understanding how sound-symbolism in perceived, but also what the role of sound-symbolism is in language.

Conclusions

In summary this thesis adds to the growing body of research looking at the nature of sound-symbolism. The take home points are (1) children are sensitive to sound-symbolism at a young age, and their sensitivity is shaped and/or pruned when they learn their native language. (2) Both universal and language-specific sound-symbolism exists. (3) English speaking children can use sound-symbolism to help them learn verbs more effectively. (4) Sound-symbolism helps children identify and store novel verbs in such a way that makes them generalisable the following day. (5) Sound-symbolism is domain general.

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Appendix A

Script used for training and testing children in Chapter 4 "Sound-symbolism facilitates long-term retention of the semantic representation of novel verbs in three year olds", Experiment 1.

Day 1: Training day
“Look! This is Ellie! She is here to learn some new words with you!”

“You are both going to see some videos on the screen and I am going to say some words, I want you to pay attention to them.”

Practice trials commence, followed by the experiment proper. The puppet Ellie is placed so that she is not directly looking at the laptop screen.

Once training is over:
“Well done! Do you think Ellie was paying attention?”
Depending on children response, if yes:
“you are right, I think she wasn't paying attention”
If no:
“Well, I think she wasn't paying attention.“
“OK, Im going to come back tomorrow and we are going to see how much Ellie remembers, OK?”

Day 2: Test day
“Do you know what Ellie told me when we got home yesterday? She told me that she wasn't paying attention yesterday. Do you know what that means? I think it means she might not remember all the words we learnt yesterday.”

“I’m going to show you some videos and Ellie is going to tell me what she sees in the videos, and we are going to tell her if she is right or wrong. If she is right, what to we say? We say YES! Ellie you are right! And if she is wrong, what do we say? We say, NO! Ellie you are wrong!”

“Ellie thinks he/she is doing X, X, X. Is he/she doing X?”

Appendix B

Script used for training and testing children in Chapter 4 “Sound-symbolism facilitates long-term retention of the semantic representation of novel verbs in three year olds”, Experiment 2.

Day 1: Training day
“Look! This is Ellie! She is here to look at some new videos with you!”

“You are both going to see some videos on the screen, I want to to pay attention to them.”

Practice trials commence, followed by the experiment proper. The puppet Ellie is placed so that she is not directly looking at the laptop screen.

Once training is over:
“Well done! Do you think Ellie was paying attention?”
Depending on children response, if yes:
“you are right, I think she wasn't paying attention”
If no:
“Well, I think she wasn't paying attention.“
“OK, Im going to come back tomorrow and we are going to see how much Ellie remembers, OK?”

Day 2: Test day
“Do you know what Ellie told me when we got home yesterday? She told me that she wasn't paying attention yesterday. Do you know what that means? I think it means she might not remember all the videos we say yesterday.”

“Im going to show you some videos and Ellie is going to tell me if she thinks we saw them yesterday, and we are going to tell her if she is right or wrong. If she is right, what to we say? We say YES! Ellie you are right! And if she is wrong, what do we say? We say, NO! Ellie you are wrong!”

“Ellie thinks he/she say this video yesterday. Did you see this video yesterday?”

Appendix C

List of colours used in colour domain in Chapter 5, “Sound-symbolism is domain general.”

Set	Colour 1	Colour 2
1	Blue	Yellow
2	Light blue	Light orange
3	Light green	Dark orange
4	Pastel blue	red
5	Green (yellow base)	Burgundy
6	Green	Pink (fuchsia)
7	Green (olive)	Mauve
8	Yellow	Blue
9	Orange (light)	Sky blue
10	Orange	Turquoise (light)
11	Red	Blue (Pastel)
12	Boudreaux	Green (light)

Appendix D

List of shapes used in shape domain, in Chapter 5: “Sound-symbolism is domain general.”

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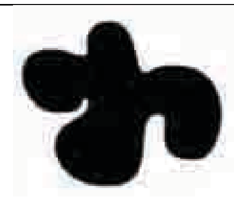
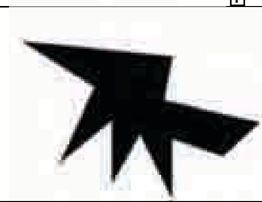
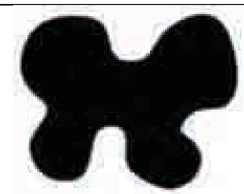
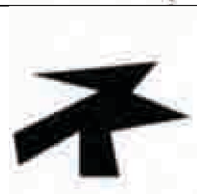
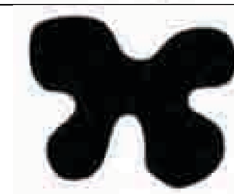
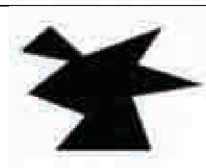
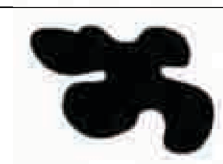
(		
N		
k		
,		
9		
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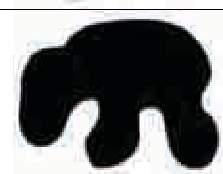
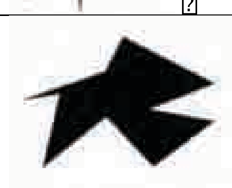
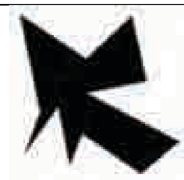
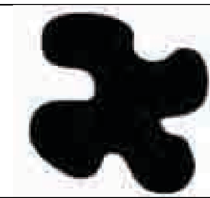
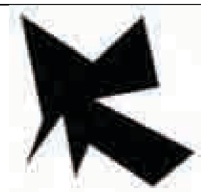
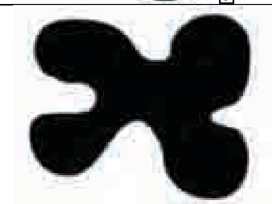
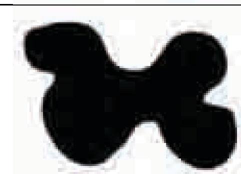
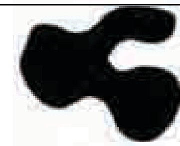
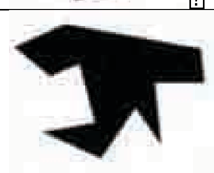
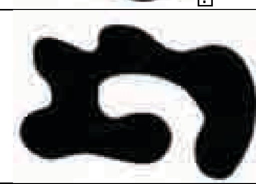
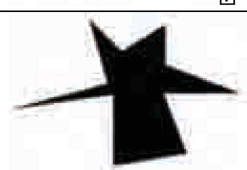
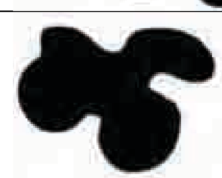
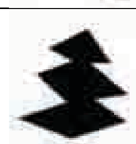
)		
M		

'		
(”		
((		
(N		
(k		
(,		
(9		
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Appendix E

Stories used in the emotion domain, Chapter 5: “Sound-symbolism is domain general.”

Set	Abrupt	Gradual
1	You get a gift you really like. You immediately feel very happy.	You are at your friend's wedding. All your friends are there and you are enjoying yourself. As the day goes by you get happier and happier until you are very happy.
2	When you are trying to pay in a shop, someone snatches your wallet away and runs away. You immediately feel very angry.	Over time you realize a friend is taking money from you. Over time you get angrier and angrier, until you are very angry.
3	You are at home alone at night and suddenly you hear some noises. You immediately feel very scared.	You and your friends are telling scary stories in the dark. You slowly become more and more scared, until you are very scared.
4	One day, your child tells you he is leaving home to work in a different town. You immediately feel very sad.	You know the time is approaching for your child to leave home. As the time goes by, you feel sadder and sadder until you are very sad.
5	You are walking in the woods and you hear someone behind you. You suddenly feel very scared.	You are walking in the woods, and you begin to realize you are lost. You get more and more scared, until you are very scared.
6	One day, you are told that your friend is going to move to a town far away. You immediately feel very sad.	As you get older, your friends start to leave your town/As more and more leave you become sadder and sadder, until you are very sad.
7	You buy some food. When you go home you see that the shopkeeper has given	While shopping you buy tomatoes from one shop. As you walk past other

	you rotten food. You immediately feel very angry.	shops you see they are cheaper, and start to realize you were charged too much. As you look at more shops, you get angrier and angrier, until you are very angry
8	Your parents praise you for your hard work. You immediately feel very happy.	You are working hard around the house helping your parents. You see that they are pleased with what you are doing. As the day goes on you get happier and happier, until you are very happy
9	You hear a song you like and immediately feel very happy.	You hear a new song. As the song plays you begin to get happier and happier. At the end of the song you are very happy.
10	You break something your mother loves very much. You know she will be angry when she finds out. You immediately feel very scared.	You break something your father loves very much. You know he will find out when he gets back from work. As the day goes by you get more and more scared, until you are very scared.
11	Your friend tells your secret to someone else. You immediately feel very angry.	You realize that over time your friend has been telling some of your secrets to other people. The more you find out, you become more and more angry, until you are very angry.
12	One day, you are told you have to leave the town you live in, within the next week. You immediately feel very sad.	You know the time to leave your town is approaching. As time goes by you feel sadder and sadder, until you are very

		sad.
13	You run into a friend you haven't seen in a while. You immediately feel very happy.	You are having a nice day with your family. As the day goes by you become happier and happier. By the end of the day you are very happy.
14	It becomes suddenly clear that your friend has lied to you. You immediately feel very angry.	In the last few days, you start to wonder if you friends have lied to you. As it becomes clearer and clearer that they have, you get more and more angry, until you are very angry .
15	You see a snake in your house. You immediately feel very scared.	You think you can hear a snake in your house. As the time goes by you keep hearing it. The more you hear the more and more scared you get, until you are very scared .
16	You come home and find your pet has died. You immediately feel very sad.	You find out your pet is ill, and is dying. As it gets more ill, you get sadder and sadder, until you are very sad.