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Abstract	This paper reports on an experiment which tested how sound symbolic knowledge is acquired by Japanese children. The empirical focus is associations between certain types of sounds and certain types of shapes. Köhler’s (1947) classic study has revealed that the nonce word takete is more likely to be associated with angular shapes, hereas the nonce word maluma is more likely to be associated with round shapes. Later studies generalized this finding in such a way that obstruents are associated with angular shapes, whereas sonorants are associated with round shapes. It remains to be examined, however, how the knowledge of these sound symbolic associations is acquired. The present study thus employs the preferential looking paradigm using eye-tracking technology to examine how the knowledge of these sound symbolic associations is acquired by Japanese speakers. The results show that the sound-symbolic associations at issue hold not only among adult Japanese speakers, but also among 6-year-old children who have not attended elementary school, and even more strikingly, among 2/3-year-old children.
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Acquisition of the *takete-maluma* effect by Japanese speakers*

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Abstract

This paper reports on an experiment which tested how sound symbolic knowledge is acquired by Japanese children. The empirical focus is associations between certain types of sounds and certain types of shapes. Köhler's (1947) classic study has revealed that the nonce word *takete* is more likely to be associated with angular shapes, whereas the nonce word *maluma* is more likely to be associated with round shapes. Later studies generalized this finding in such a way that obstruents are associated with angular shapes, whereas sonorants are associated with round shapes. It remains to be examined, however, how the knowledge of these sound symbolic associations is acquired. The present study thus employs the preferential looking paradigm using eye-tracking technology to examine how the knowledge of these sound symbolic associations is acquired by Japanese speakers. The results show that the sound-symbolic associations at issue hold not only among adult Japanese speakers, but also among 6-year-old children who have not attended elementary school, and even more strikingly, among 2/3-year-old children.

1. Introduction

It is generally taken for granted in modern linguistic theories that associations between sounds and meanings are arbitrary. A classic argument, which at least dates back to Locke (1689) and was reiterated by Saussure (1916), is that if the relationships between meanings and sounds were fixed, then there can be only one language. Locke (1689) states that:

> Thus we may conceive how words, which were by nature so well adapted to that purpose, came to be made use of by men as the signs of their ideas; not by any natural connexion that there is between particular articulate sounds and certain ideas, for then there would be but one language amongst all men.
>
> (Taken from An Essay Concerning Human Understanding Book III: Words, http://enlightenment.supersaturated.com/johnlocke/BOOKIIIChapterII.html)

Saussure (1916) likewise suggests:

> Since we are treating a sign as the combination in which a signal is associated with a signification, we can express this more simply as: *the linguistic sign is arbitrary*.
>
> There is no internal connexion, for example, between the idea 'sister' and the French sequence of sounds *s-ǒ-r* which acts as its signal. The same idea might as well be represented by any other sequence of sounds. This is demonstrated by differences between languages, and even by the existence of different languages.
>
> (Saussure, pp 78 of Bloomsbury Revelations edition, 2013; the emphasis in the original)

This principle of arbitrariness is discussed by Saussure as the first organizing principle of natural languages, and has had a determining influence on modern linguistic theories. It is probably safe to say that sound symbolism did not receive much serious attention in mainstream linguistic theories (though cf. Hinton et al. 1994), at least until recently.

The argument made by Locke and Saussure needs to be taken with caution, because languages use a different set of sounds, and they are susceptible to different phonotactic restrictions (i.e. how they can arrange sounds) (Shih et al. 2018; Styles & Gawne 2017). The set of denotations non-trivially differs across languages as well. For example, English does not have a lexical item to refer to "hot water," whereas Japanese lexically distinguishes "hot water" from "cold water." On the other hand, Japanese does not have a verb corresponding to the English verb "*to miss somebody*," and needs to resort to a phrasal expression to refer to that mental state ("to be sad because that person is not present"). Therefore, just because there is variation among languages does not mean that there cannot be systematic relationships between sounds and meaning.

Indeed, recent phonetic and psycholinguistic studies have shown that there are statistical tendencies for certain sounds to be associated with certain meanings. One famous example is that for speakers of many languages, [a] is felt to be larger than [i] (Jespersen 1922; Newman 1933; Sapir 1929; Shinohara & Kawahara 2016; Ultan 1978). Sapir (1929) famously says:

> English-speaking society does, for some reason or other, feel that of these two vowels, *a*, by and large, is possessed of a greater potential magnitude symbolism than the contrasted vowel *i*. The same feeling seems to be illustrated by the small number of Chinese cases. (p. 231)

Voiced obstruents in Japanese (known as *dakuon* “muddy sounds” in the Japanese literature) are also known to be associated with various types of images, such as largeness, heaviness, darkness and dirtiness (e.g. Hamano 1986; Kawahara 2017; Suzuki 1962 among many others). These sorts of associations between sounds and meanings have been referred to as “sound symbolism,” and are now actively studied in phonetics, psychology and linguistics. One crucial aspect of sound symbolic patterns is that they are *stochastic* or *probabilistic*, and almost never *deterministic* (Dingemanse 2018; Kawahara et al to appear). That is, even though [a] tends to be felt to be “bigger” than [i], it is not the case that words containing [i] always represents something small; the English word *big* is a very straightforward example.

Despite the recurrent observation that there can be systematic relationships between sounds and meanings, few researchers would argue that the relationships between sounds and meanings are completely fixed. In all incarnations of generative linguistic theories, relationships between sounds (PF) and meanings (LF) are only indirect, mediated by the syntactic component. Focus-related features may be the only exception, which are interpreted both by the phonetic component (PF) and the semantic component (LF) (Selkirk 1995). One possible reason for the reluctance to incorporate sound symbolic connections in grammatical architecture may be that generative linguistic theories usually do not accept stochastic or probabilistic tendencies as belonging to competence—it is believed that grammars should only make a dichotomous, grammatical vs. ungrammatical distinction (see e.g. Schütze 1996 and Pullum 2013 for extended discussion).[1] However, a rise of stochastic grammatical models (e.g. Boersma & Hayes 2001; Hayes & Londe 2006; Pierrehumbert 2001; Shaw & Kawahara 2018), most notably MaxEnt grammars (Goldwater & Johnson 2013; Hayes & Wilson 2008), has made it possible to model stochastic linguistic knowledge. Accordingly, there have been some proposals to incorporate (stochastic) sound symbolic knowledge in the core grammar (Kawahara et al. to appear; see also Alderete & Kochetov 2017). The key insight is that generative phonology is—and has always been—a function that maps one representation (e.g. "underlying representation") to another representation (e.g. "surface representation"), and that the same sort of function can be used to model connections between sounds and meanings.

Viewed from a more general perspective of cognitive science, sound symbolism—systematic associations between sounds and meanings—can be considered as an instance of general cross-modal perception (Spence 2011), in which sensation in one cognitive domain has systematic correspondence with sensation in another cognitive domain. Sound symbolism is systematic associations between meaning ("semantic cognition") and sounds ("auditory cognition"), but there is a priori no reason to

1 We suspect that this belief stems from what Chomsky (1957) stated in *Syntactic Structures*: "[t]he fundamental aim in the linguistic analysis of a language *L* is to separate the *grammatical* sequences which are the sentences of *L* from the *ungrammatical* sequences which are not sentences of *L* and to study the structure of the grammatical sequences" (1957: 13, the emphasis in the original). In practice, however, it is often admitted, even from the early times in the generative literature, that grammatical distinctions are finer than binary (e.g. Chomsky 1965). See Bresnan & Hay (2008), Kellar (2006), Pullum (2013), Schütze (1996), and Sorace & Kellar (2005), among others for discussion on gradience in grammar.

believe that systematic cross-modal correspondence exists only between these two domains. It is instead more natural to expect—and it has actually been empirically shown—that cross-modal perception holds across different modalities (Kawahara 2017 and Spence 2011 for recent reviews). Just to take auditory perception as an example, the McGurk effect (McGurk & MacDonald 1976) is a clear case in which auditory information is integrated with visual information; recent studies show that auditory cognition is affected by tactile sensation as well (Derrick & Gick 2013; Gick & Derrick 2009). From this perspective too, it is natural to expect that some linguistic sensations have cross-modal correspondences with sensations in other cognitive domains.

Against this theoretical background, this paper zooms in on the cross-modal perception between sounds ("auditory cognition") and shapes ("visual cognition"), which in fact has a long history of research. Köhler's (1947) classic study has shown that the nonce word *takete* is more likely to be associated with angular shapes, whereas the nonce word *maluma* is more likely to be associated with round shapes. Later studies generalized this finding in such a way that obstruents (plosives, affricates, fricatives) are associated with angular shapes, whereas sonorants (nasals, liquids, glides) are associated with round shapes (e.g. Drijvers et al. 2015; Kawahara & Shinohara 2012; Kawahara et al. 2015; Lindauer 1990; Nielsen & Rendall 2011; Shinohara et al. 2016). Since obstruents involve a rise in the intraoral air pressure, it results in aperiodic acoustic energy, which on the waveform, looks "angular", while sonorants look "round"—arguably these acoustic representations are mapped onto the different types of visual shapes (Jurafsky 2014; Kawahara & Shinohara 2012).

While there is now an extensive body of literature on sound symbolism, one important issue that is understudied within the research of sound symbolism is its acquisition, although there has been some insightful research on this topic. For instance, Maurer et al. (2006) studied the *bouba*-*kiki* effect (Ramachandran & Hubbard 2001), in which nonce words like *bouba* are associated with a round object, whereas nonce words like *kiki* are associated with an angular object. This study demonstrated that 2.5-year-old children are sensitive to sound-shape associations. It has also been shown that nonce verbs that follow sound symbolic principles are more easily learned than nonce verbs that do not, and this effect of sound symbolism has been shown to hold for Japanese children (Imai et al. 2008), as well as for English-speaking children (Kantartzis et al. 2011). Ozturk et al. (2013) demonstrated that 4-month old infants look at congruent sound-shape pairs longer than incongruent sound-shape pairs. Asano et al. (2015) demonstrated through an EEG experiment that 11-month-old infants may be sensitive to sound symbolic associations. Building on these results, Imai & Kita (2014) proposed a general hypothesis that sound symbolism may guide the language acquisition process to a non-negligible extent.

However, how the knowledge of sound symbolic patterns is acquired is still understudied, despite these recent illuminating results. We believe that it is necessary to conduct more case studies to explicate how sound symbolic knowledge is acquired. In order to contribute to filling this gap, this study reports a cross-sectional study of how the knowledge of the sound symbolic associations is acquired by Japanese speakers. Specifically, we explored how active sound symbolic principles are in (1) toddlers, who have acquired the basic grammar and a number of words but have difficulties in comprehending some constructions like passive sentences (e.g. Sugisaki 1999) and sentences with scrambling (Otsu 1994), and (2) preschoolers, whose grammatical knowledge is almost comparable to, but yet is not quite identical to, that of adults.

2. Method

The empirical target of the current study is the connection between obstruents and angular shapes on the one hand, and the connection between sonorants and round shapes on the other. In order to test how these sound symbolic associations are acquired, we tested three groups of participants: (1) twenty-nine 2/3-year-old children (2;6-3;5, mean=2;11) (2) twenty-three 6-year-old children (6;1-6;10, mean=6;6), and (3) ten adults. All the participants were from Tokyo or surrounding areas, and all the child participants were female because this experiment was conducted as a part of a larger project which required female participants.[2] We used Tobii X120 Eye Tracker, which enables us to examine the behavior of the children who are as young as 2-year-old.

The auditory stimuli that were used in the current experiment are shown in Table 1:

Table 1: The list of the stimuli

Obstruents	Sonorants
kiki	*nana*
takete	*maluma*[3]
siteki	*muyana*
kikito	*rorimu*
satake	*niyawa*
tepisi	*wamana*

In one condition, onset consonants were always obstruents; in the other condition, onsets were always sonorants. The stimuli were either disyllabic or trisyllabic. In addition to the traditional *takete-maluma* pair, some pairs were examples that were discussed by Kawahara (2017) (e.g. *rorimu* vs. *kikito*; *muyana* vs. *siteki*). No coda consonants were present in the stimuli. Vowel quality was not controlled in the current experiment.

We employed a preferential looking paradigm using an eye-tracker. The participants were presented with one auditory prompt together with a pair of angular and round

2 A related study conducted as a part of this project examined whether 6-year-old children can make use of sound symbolic knowledge to choose "correct names" for evolved vs. non-evolved Pokémon characters (Kawahara et al. 2018). This study too found that 6-year-old children have some knowledge of sound symbolism and are able to deploy that knowledge when naming new Pokémon characters.

3 This item would usually be written as *maruma* in the Japanese transcription system. However, to be consistent with the other literature on the *takete-malume* effect, we continue to use *maluma* in this paper.

figures on a computer screen, an example of which is shown in Figure 1. We used six different pairs of visual shapes, adapted from Kawahara & Shinohara (2012), itself inspired by Köhler (1947).

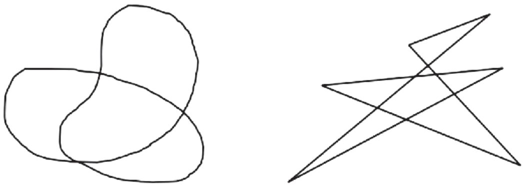

Figure 1: Visual stimulus (example)

The auditory prompt was in the form of "X *dotti* (which one), X, X" where X is one stimulus. We added *dotti* "which one" to ensure the participants knew that they were expected to look at either one of the figures. All the auditory stimuli were produced by the second author and pre-recorded. The average amplitude of all the stimuli was adjusted to 65 dB using Praat (Boersma 2001).

The time course of each trial with sample auditory stimuli and visual stimuli is shown in Figure 2.

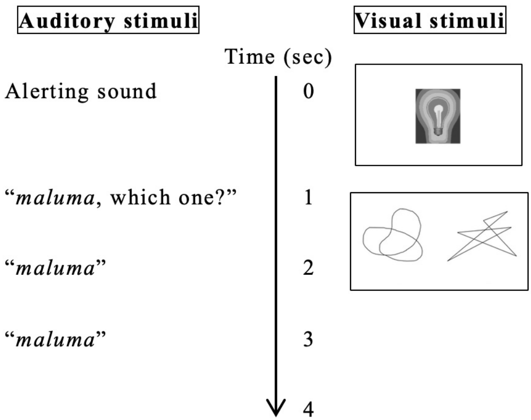

Figure 2: The structure of each trial

Each trial began with a one-second-long alerting sound along with an animated picture of a blinking light bulb, which was intended to attract the participant's gaze at the center of the monitor. After the alerting sound, a test sentence was played, and a pair of a round figure and an angular figure simultaneously appeared on the monitor. Each auditory stimulus followed the form of "X, *dotti*, X, X." Each trial took six seconds in total.

To avoid fatigue effects, the 2/3-year-old participants were divided into two groups. Children in one group were tested on 6 items (3 obstruent items and 3 sonorant items), and those in the other group were tested the other 6 items. All of the 6-year-old and adult participants were tested on all of the 12 items. The order of the trials was pseudo-randomized per participant.

3. Results and Discussion

The total fixation times during the last 3 seconds of each trial after "X *dotti*" on congruent figures (obstruents=angular; sonorants=round) and incongruent figures (obstruents=round; sonorants=angular) were calculated. The results for 2/3-year-old children, 6-year-old children, and adults are shown in the boxplots in Figures 3-5,

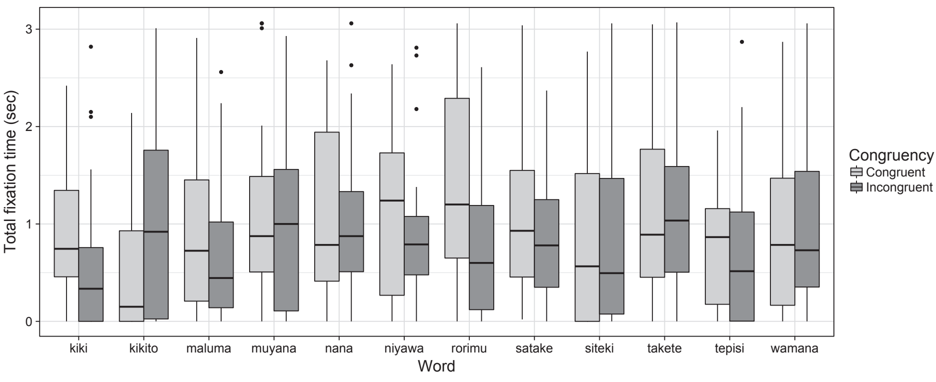

Figure 3: Boxplots of total fixation times by 2/3-year-old children

respectively. The vertical axes indicate the total fixation times in the last 3 seconds. Within each item, the left box represents the fixation time on the congruent condition, whereas the right box represents the fixation time on the incongruent condition. If sound symbolic patterns are operative, the congruent conditions should show longer fixation time than the incongruent conditions.

In all the age groups, the total fixation time is generally longer for the congruent condition than for the incongruent condition. For the 2/3-year old children (Figure 3),

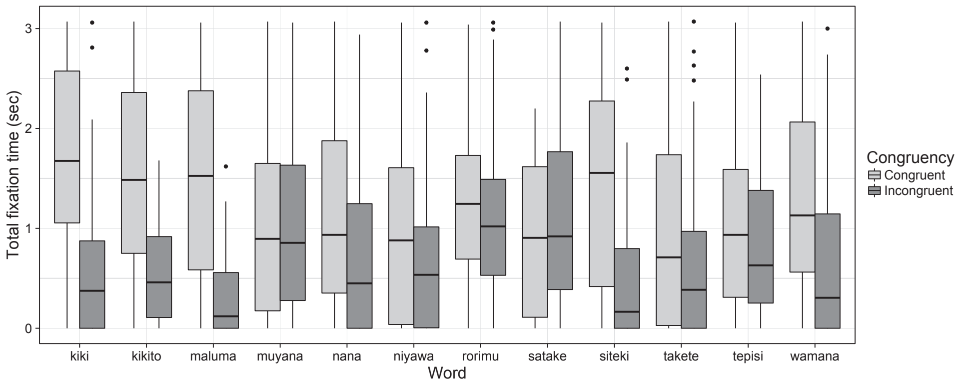

Figure 4: Boxplots of total fixation times by 6-year-old children

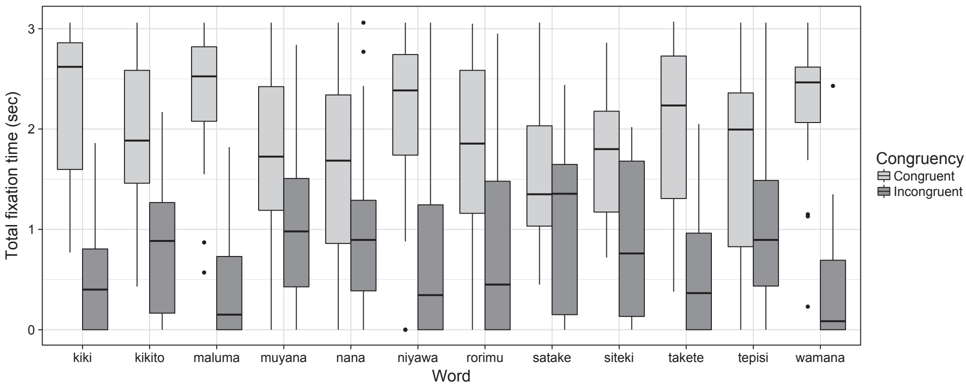

Figure 5: Boxplots of total fixation times by adults

there are some pairs that do not show substantial differences (e.g. *siteki*), but there are those which clearly do (e.g. *kiki* and *maluma*). One stimulus (*kikito*) showed very large unexpected responses for the 2/3-year old children, which was excluded from the following statistical analysis of the 2/3-year old children.[4] For 6-year-old children (Figure 4), the differences between the congruent condition and the incongruent condition are clear in the expected direction except for a few items (e.g. *muyana* and *satake*). The adults (Figure 5) showed very clear expected differences for all the test items.

The contrast between the total fixation time of the congruent figures and the incongruent ones becomes clearer as the age of groups get older. A linear mixed model with CONGRUENCY as a fixed factor and WORD and SPEAKER as random factors shows that all groups show statistical differences between congruent and incongruent conditions (2/3-year-olds: t=2.66, p<.01; 6-year-olds: t=10.22, p<.001; adults: t=15.94, p<.001).[5]

At this point, however, we would like to stay cautious about jumping to the conclusion that sound symbolic knowledge gets "sharpened" as the participants get older, because in an experimental setting like the current one, there are many factors (e.g. attention issues) that can affect the results. Though not substantiated by the current results, we still believe that it would be interesting to entertain the hypothesis that sound symbolism is innate; a baby's brain is synesthetic, possibly due to the

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4 Akio Nasu (p.c.) pointed out that the anomalous behavior of *kikito* may be attributed to its final [o]. This vowel is the most rounded vowel in Japanese (Vance 2008), and hence it would not be surprising that it invoked image of roundness for the 2/3-year-old children, whose responses may have been heavily affected by the final segment. The current experiment focused on the distinction between sonorants and obstruents within consonants; how vowels affect angular/round shape perception, and how vowels and consonants interact in sound symbolic patterns for Japanese speakers is an important topic for future research (cf. Fort et al. 2015). How these effects vary between different ages of speakers is also an interesting question, but this is also beyond the scope of the current study.

5 Once we include *kikito*, a clear outlier, the model for the 2/3-year-old children fails to reach significance (t=1.78, p=.07).

exuberant anatomical connectivity, which may be the source of sound symbolism, or cross-modal perception in general (e.g. Ramachandran & Hubbard 2001; Wager & Dobkins 2011).

4. Conclusion

We conclude from the current experimental results that Köhler's sound-symbolic associations hold not only among adult speakers of Japanese, but also among those children who have not attended elementary school, and even more strikingly, among 2/3-year-old children acquiring Japanese. The differences between the congruent condition and the incongruent condition get larger as the participants get older, which raises the possibility that knowledge of sound symbolism—or its execution—develops over the course of our lives. More research is warranted to address the possibility that sound symbolism is innate due to our synaesthetic brain.

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