DEAF AND HARD-OF-HEARING PEOPLE CAN DETECT SOUND SYMBOLISM: IMPLICATIONS FOR THE ARTICULATORY ORIGIN OF WORD MEANING

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Uncovering the relation between form and meaning of words is important for understanding the nature and evolution of language. Where does the sound-meaning relationship of a word come from? In a long tradition of linguistics, it has been assumed that language-specific conventions create arbitrary association between linguistic forms and meanings (Hockett, 1960; de Saussure, 1916). However, words that sound like what they mean have also been recognized, and this intrinsic link is called sound symbolism (Köhler, 1929). Does one need to be able to hear sound to detect sound symbolism? Here, we show that one does not need to. Deaf-and-Hard-of-Hearing (DHH) participants, even those with profound hearing loss, could judge the sound symbolic match between shapes and words just as well as hearing participants do, as long as DHH participants could move their tongue freely. This indicates that people can detect sound symbolism via inherent resemblance between articulatory movements and the meanings. This further suggests that linguistic symbols can emerge through iconic mapping between oral gesture and sensory experience of the world.

1. Introduction

Uncovering the relation between form and meaning of words is important for understanding the nature and evolution of language. Form and meaning of words are associated not only by language-specific arbitrary conventions (de Saussure, 1916), but also by an intrinsic link, called sound symbolism (Köhler, 1929), which reflects perceived resemblance between sound and properties of referents. One may assume that the hearing ability is indispensable to sense sound symbolism. However, if sound symbolism is originated from articulatory gesture—mimicry of things or events by mouth—people may be able to detect sound-meaning match without the function of hearing. We propose *the articulatory origin of sound symbolism hypothesis*. We examined this hypothesis by testing whether Deaf or Hard of Hearing (DHH) people can detect sound symbolism.

2. Experiment 1.

2.1. Participants and Stimuli

Thirty-four DHH individuals, all with congenital and profound hearing loss (minimum dB = 103), and 36 individuals with typical hearing participated in the study. Participants received a 2-page booklet. On each page, either a spiky-shaped figure or a round-shaped figure was depicted at the top, below which 38 novel words were listed orthographically. A total of 38 novel words were created. Previous findings (Köhler, 1929) indicate that, among these segments, sonorant consonants (/m, n, j, ɾ/), bilabials consonants (/b, p/), and non-front vowels (/a, o, ɯ/) are likely to be associated with round shapes, whereas non-labial obstruents (/d, t, ɡ, k, z, s, ʑ, ɕ, tɕ, dʑ/) and front vowels (/i, e/) are good candidates for spiky shape sound symbolism (D'Onofrio, 2014; Nielsen & Rendall, 2011). These consonants and vowels were combined to form words with the /CVCV/ structure. The participants were instructed to judge whether each word matched the figure in three degrees: *good match*, *neutral*, and *mismatch*.

2.2. Results

For each word-shape combination, we calculated the proportion of participants in each group who gave "good match" judgment (Figure 1). In Figure 1, the words were shown from the highest to the lowest acceptance (i.e., judgements of *good match*) by the hearing group for the round and spiky shapes. The distribution of match scores across items (word-shape combinations) was highly similar between the two groups: by-item correlations between the two groups (N = 38) were very high: r = .893 for the round figure (Figure 1a) and r = .832 for the spiky figure (Figure 1b). When both figures combined, r = .862, all ps < .001 (Figure 2). We split the DHH participants into two groups according to the severity of hearing loss to see whether DHH people's judgements would differ depending on their hearing level. Even the severest group showed high correlations, which did not statistically differ from those shown by the milder group.

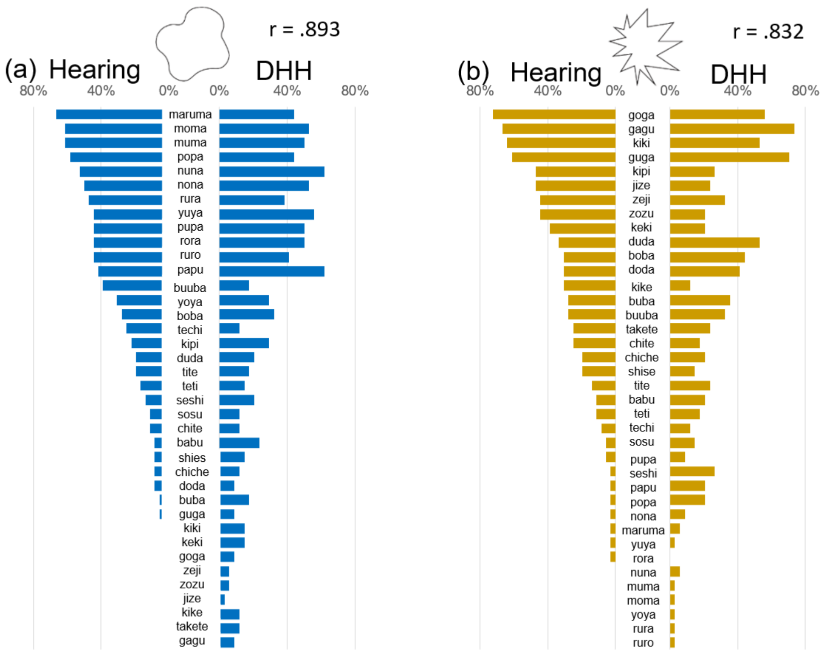

Figure 1. The percentage of participants in the hearing group and those in the DHH (Deaf and Hard of Hearing) group who judged the novel words to be good sound symbolic match with the shapes, in Experiment 1. The words are arranged in the descending order of the percentages for the hearing group.

A closer examination of Figures 1(a)(b) indicates that words that were judged good matching for the round shape tend to start with sonorant sounds, and those judged good matching for the spiky shape tend to start with obstruent sounds.

In Figure 2, the 38 words are plotted along the proportion of good-match judgements by the hearing (Y Axis) and the DHH group (X Axis). Here, the words starting with sonorant sounds are represented in green, and those starting with obstruent words are shown in red; values for the round shape and the spiky shape are represented in a circle and a triangle, respectively. Here, it is clear that the sonorant-round shape and obstruent-spiky shape combinations received high values, while the sonorant-spiky shape and obstruent-round shape combinations received low values in both groups.

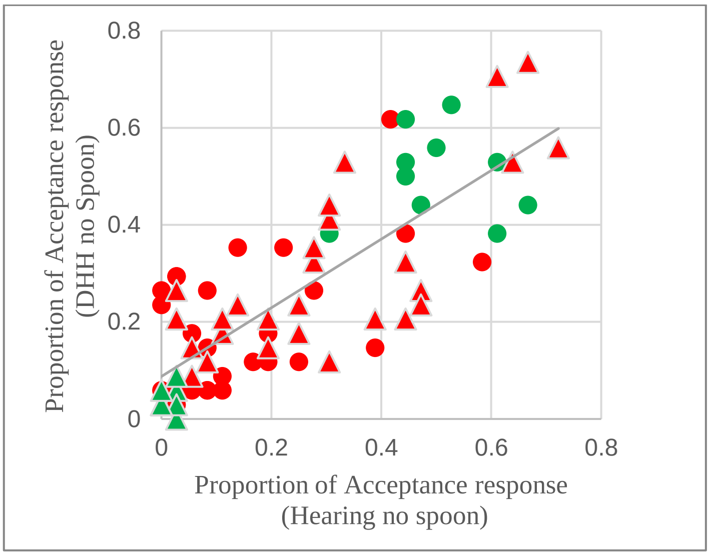

Figure 2. Plots of the 38 items along the proportion of good match judgements by the hearing group (X Axis) and by the DHH group (Y Axis).

2.3. Discussion

The results supported *the articulatory origin of sound symbolism hypothesis* in that DHH people show judgements of sound-shape correspondences that are highly similar to those by hearing people. In both groups, participants judged sonorant-round shape and obstruent-spiky shape to be good matches, while the reverse combinations to be poor matches.

3. Experiment 2.

Experiment 2 examined whether disturbance of articulatory movements changes the judgements of sound-meaning correspondence both for hearing and DHH participants. In Experiment 2, participants placed a spoon on the tongue and closed the lips to hold the spoon, hence movement within the oral cavity and lips was generally restricted.

3.1. Participants and Stimuli

Sixteen DHH students, all with congenital hearing loss, and 61 university students with typical hearing, participated. None of the participants took part in Experiment 1. The stimuli and the procedure were identical to Experiment 1, except that the participants were asked to hold a spoon with their mouth: they put the spoon in the oral cavity with the concave part of the spoon facing down, and placed the concave part on the tongue, and closed the lips to stabilize the handle of the spoon.

3.2. Results

3.2.1. By-item correlation analyses

As in Experiment 1, a by-item correlation analysis was conducted. For the DHH group, the correlation coefficient between the baseline case (no-spoon in the hearing group, Experiment 1) and the *spoon on-tongue* case (Experiment 2) was $r = .639$, $p < .001$.This value was significantly lower than that between the two groups in the no-spoon case in Experiment 1. For the hearing group, the correlation coefficient between the baseline and the *on-tongue* case was still very high ($r = .913$, $p < .001$). The correlation coefficient in the *on-tongue* condition was significantly lower in the DHH group than in the hearing group (Meng's $z = 5.71$, $p = .000$). The correlation analyses thus endorsed the view that oral movement plays a critical role in sensitivity of sound symbolism.

3.2.2. Model analysis

The results of Experiment 1 suggested that the sonorant sounds and the obstruent sounds play a prominent role for the shape sound symbolism. Figure 3 shows the proportion of acceptance of words as good-matching in each of the sound/condition/group combinations for each shape. A mixed-effect logistic regression analysis was conducted to predict the participants' judgement (1:*good-match*/0: other responses), specifying Group (DHH:-0.5/Hearing: 0.5), Condition (articulation free:-0.5/articulation disturbed:0.5), shape (spiky:-0.5/round:0.5), sound (sonorant:-0.5/obstruent:0.5), and their interactions as fixed-effects. The participants are specified as random effects.

From the pattern shown in Figure 3, the interactions involving Sound x Shape strongly predict the proportion of good-match judgements.

The Shape x Sound interaction was highly significant, $z = -21.32$, $p = .000$. Also significant was two 3-way interactions: Condition x Shape x Sound interaction, $z = 3.08$, $p = .002$, and Group x Shape x Sound interaction, $z = -3.74$, $p = .000$. The effect of Condition was modified by Shape x Sound interaction in such a way that disturbance of articulation decreased the sense of good match for the round-sonorant combination but not so much for the obstruent-spiky combination. Likewise, the effect of Group was modified by the Shape x Sound interaction: the decrease of acceptance in round-sonorant combination was larger for the DHH group than for the Hearing group. However, the 4-way interaction effect was not significant.

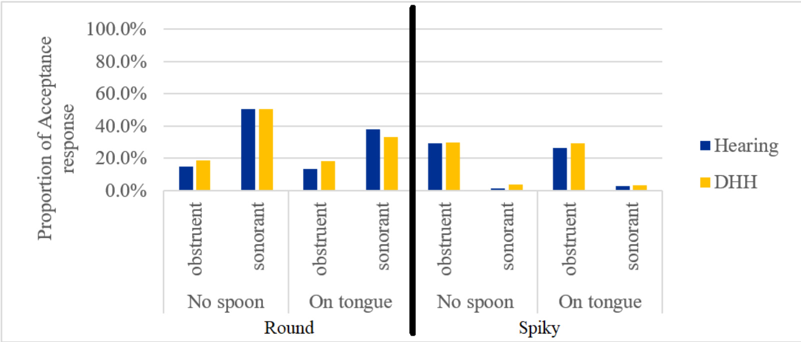

Figure 3. The proportion of acceptance of words as good-matching in each sound/condition/group combination for the Round shape (right panel) and for the Spiky shape (left panel).

3.3. Discussion

The results strengthened the articulation origin of sound symbolism theory in that disturbance of articulatory movements affected sensitivity to sound symbolism. DHH individuals were affected by the disturbance of articulation more strongly than individuals with typical hearing and that the decrease of sensitivity to sound-shape correspondence mostly came from the sonorant sound-round shape correspondence, but not so much from the obstruent sound-spiky shape correspondence. The last result suggests that the mechanism of sound symbolism sensitivity is complex and that different mechanism may underlie for round shapes and spiky shapes (cf., Fort et al., 2018; Yang et al., 2019).

4. General Discussion

The results of the two experiments supported *the articulatory origin of sound symbolism hypothesis.* Our finding offers great insights into a key question in the literature of sound symbolism, i.e., whether sound symbolism arises from articulation (Sapir, 1929; Ramachandran & Hubbard, 2001; Margiotoudi & Pulvermüller, 2020). It is remarkable that Deaf and Hard-of-Hearing individuals can sense sound symbolism by mapping oral movements to the meanings. This strongly suggests that oral movements are crucial for sound symbolism detection. Furthermore, this fact highlights the view that sound symbolism is truly a multi-modal phenomenon, and not just the correspondence between audition and other sensory modalities (Perniss & Vigliocco, 2014; Pearlman et al., 2021). However, the current data do not rule out the possibility that hearing people recruit the acoustic information in addition to articulatory movements.

The current results have profound implications for theories of language evolution. Hand gesture is a prime candidate for how an open-ended shared lexicon emerged in early stages of language evolution (Stokoe, 2002; Arbib, 2005) because people can move their hands in a way that can iconically map to entities in the world such as events and objects(Goldin-Meadow et al., 1996; Ortega & Özyürek, 2020). The hand-gesture origin theories of language evolution maintain that hand movements have unique advantage over the movement of articulatory organs when it comes to iconically representing entities in the world(Stokoe, 2002; Arbib, 2005). However, the current result questions such assumption, and suggests that both hand movements and articulatory movements can be the basis of iconic meaning, offering a possible account for why language evolved in speech modality as well as in manual modality.

The current study has some limitations. First, because we presented the novel words orthographically, the possibility that DHH people's sensitivity may come from resemblance between the visual shape and shapes of letters. Although it is difficult to completely rule out the influence of letter symbolism, the results of Experiment 2 convincingly demonstrated that articulatory movements are critical for detecting sound-meaning correspondences (also see Cwiek et al, 2022 for the view that letter symbolism is minimum). Another limitation is that the spoon manipulation in Experiment 2 affected only the round shape-sonorant sound. Although this result suggests that different mechanism may underlie sound symbolism for round shapes and spiky shapes (cf. Fort et al., 2018, Yang et al., 2019), we cannot draw a conclusion concerning this issue, as our stimuli were not designed to address this issue.

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