Sonority and shape

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https://doi.org/10.36505/ExLing-2012/05/0018/000224

Abstract
The current study investigates whether sonority scale can linearly predict the "roundness" of a phoneme in the visual attribute. The results revealed that for vowels, it is the "roundness" feature not the sonority that predicts "roundness". But for consonants, the rank generally follows the sonority scale, except that the voiceless fricatives ranked relatively higher than voiced fricatives and voiced stops.

Key words: sonority scale, sound symbolism, kiki-bouba effect

Introduction
Sound symbolism holds that there are naturally biased mappings between phonological properties of labels and perceptual properties of their referents. A famous example is the "kiki-bouba" study by Ramachandran and Hubbard (2001). They showed that both English and Tamil speakers selected the curvy shape as "bouba" and the jagged shape as "kiki" for over 95% of the times (see Figure 1). The "kiki-bouba" effect has stimulated a growing interest in sound symbolism, and various studies have demonstrated that systematic mappings exist not only between sound and shape or size (Spair, 1929), but also between sound and colour (Wrembel & Rataj, 2008), sound and taste (Simner et al, 2010; Spence, 2012), sound and smell (Auvray & Spence, 2008), sound and spatial position (Loomis et al, 1998), etc.

 Figure 1. The visual stimuli used by Ramachandran and Hubbard.

But what exactly phonological features lead to the sound symbolic effects? It has generally been reported in the literature that vowels "o" and "u" and consonants "m", "b", "l" and "n" are associated round/big/heavy objects; vowels "e", "i" and consonants "t", "k" are associated with angular/small/light objects. But the previous classifications of the two groups of phonemes are largely inconsistent. Table 1 sampled some of the classification criteria used in previous studies.

The current study aims to provide a better classification of the "round" and "angular" phonemes in terms of their phonological features. Our hypothesis is that sonority scale linearly predicts sound symbolism. According to Parker (2002), the sonority scale in English is "Glides> Liquids> Nasals> Voiced Fricatives> Voiced Stops>Voiceless Fricatives> Voiceless Stops". Thus we predict that more sonorous sounds are perceived as more rounded in the visual attribute.

Table 1. “Round” and “Angular” sounds in previous studies

Study	“Round” sound	“Angular” sound
Klink, 2000	back vowels voiced consonants	front vowels voiceless consonants
Yorkston & Menon, 2004	low back vowels	high front vowels
Westbury, 2005	continuants	stop consonants
Abel & Glinert, 2008	voiced consonants	voiceless consonants
Peiffer-Smadja, 2010	rounded back vowels voiced continuant consonants	unrounded front vowels voiceless stop consonants
Nielsen & Rendall, 2011	sonorant consonants	strident consonants
Sweeney et al., 2012	rounded sounds	unrounded sounds

Methods

Participants: 30 Oxford University students (9 male, 21 female, mean age=21.4 years) participated in the study. The whole experiment lasts for about 20 minutes, and was approved by the Oxford University ethics review.

Stimuli: The visual stimuli included 25 different 5-point shape scales (see Figure 2). The shapes were generated by an online pattern generator (http://www.subblue.com/projects), and were all 4cm x 4cm in size, black and white in colour.

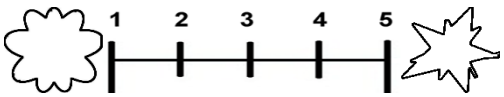

Figure 2. The visual stimuli.

The auditory stimuli consisted of 100 non-words of CV string (20 consonants x 5 vowels). The 20 consonants included glides (“w, y”), liquids (“l, r”), nasals (“m, n”), voiced fricativse (“z, f, ð, ʒ”), voiced stops (“b, d, g”), voiceless fricatives (“s, f, θ, ʃ”) and voiceless stops (“p, t, k”); the 5 vowels were “a, o, u, i, e”. The sounds were recorded in a sound proof booth by a female phonologist, who was also a native English speaker. The duration of each sound was adjusted to 1 second, and the average intensity of all the sounds was scaled to 70 decibel by Praat.

Procedure: The participants heard a CV sound and saw a scale on the screen. They then had to indicate, by pressing “1, 2, 3, 4, 5” on the keyboard, how much they thought that the sound resembled the two shapes. Each sound was repeated 3 times, giving rise to 300 trials in total. The presentation of the stimuli was randomized, as was the orientation of the scales. The participants were debriefed after the experiment and were also asked whether they had previous knowledge of sound symbolism, and

whether they found some of the non-words resembled real words and hence responded according to the semantics of the words.

Results

The average score for each sound is calculated for each participant, with larger values indicating more rounded shapes. Figure 3 shows the average roundness scores for each vowel following the sonority scale. It can be seen that there is a general decline of the scores along the sonority scale, although the scores from voiced fricatives to voiceless fricatives increased—this pattern was observed for all 5 vowels. All the relationships were confirmed via a repeated measures ANOVA and post-hoc pairwise comparisons ($p < .001$). The post-hoc comparison also revealed the 5 vowels to be significantly different from each other ($p<.001$, $SD=0.31$) except for "e" and "i" ($p=.23$, $SD=0.31$). Since the ranking of the 5 vowels is "o > u > a > e > i", it can be concluded that the "roundness" feature of the vowels, not the sonority, that correlates with sound symbolism. For consonants, the ranking is highly correlated with the sonority scale, but further examinations are needed to explain why voiceless fricatives ranked than voiced fricatives and voiced stops.

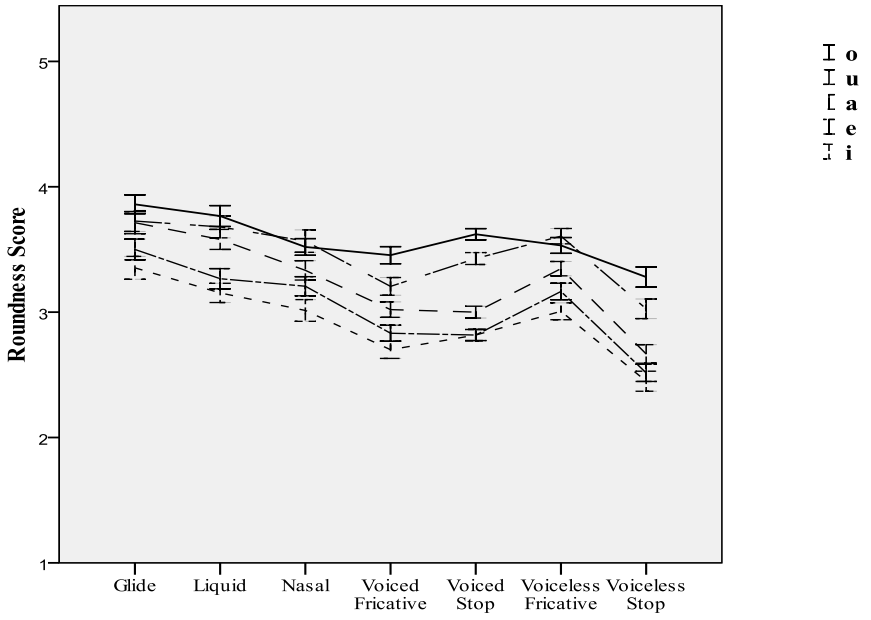

Figure 3.The average roundness score of the sounds.

Acknowledgements

This study is part of the MSc project of the first author, funded by the department of Experimental Psychology, University of Oxford and the Crossmodal Research Lab, University of Oxford.

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