Sound Symbolic Relationship between Onomatopoeia and Emotional Evaluations in Taste

Tatsuki Kagitani (k1330014@edu.hc.uec.ac.jp)
Department of Informatics and Engineering, The University of Electro-Communications
1-5-1, Chofugaoka, Chofushi, Tokyo 182-8585, Japan

Mao Goto (g1010060@edu.cc.uec.ac.jp)
Department of Informatics and Engineering, The University of Electro-Communications
1-5-1, Chofugaoka, Chofushi, Tokyo 182-8585, Japan

Junji Watanabe (watanabe.junji@lab.ntt.co.jp)
NTT Communication Science Laboratories, Nippon Telegraph and Telephone Corporation
3-1, Morinosato-Wakamiya, Atsugi, Kanagawa, 243-0198 Japan

Maki Sakamoto (sakamoto@inf.uec.ac.jp)
Department of Informatics and Engineering, The University of Electro-Communications
1-5-1, Chofugaoka, Chofushi, Tokyo 182-8585, Japan

Abstract

Many languages have a word class whose speech sounds are linked to sensory experiences (sound symbolism). Here we investigated sound symbolism in taste. Specifically, we performed psychological experiments to study the relationship between phonemes of Japanese sound symbolic words and emotional evaluations of objects in taste. In the experiment, when participants drank something, they were asked to express the taste sensation using Japanese sound symbolic words and then rate the comfort of the object with the semantic differential (SD) method. This experiment was aimed at specifying the systematic association between phonemes of Japanese onomatopoeic words and taste-emotion evaluations. Our results showed the existence of unique associations between the phonemes of the words for expressing the sensation and the evaluations of comfort/discomfort in taste and showed the possibility to clarify taste categories using sound symbolic method. As previous studies have suggested, onomatopoeic words expressing food texture are more easily used for emotional evaluations in taste than those expressing taste itself. However, we found a strong association between phonemes and SD scales related to taste such as “sweet”, “bitter”, and “salty”. Therefore, we showed that sound symbolic words could be important indexes in investigating various level of perceptual dimension of taste including emotional evaluations like comfort/discomfort.

Keywords: Sound symbolism; Taste; Texture; Emotional evaluation; Onomatopoeia

Introduction

Humans can perceive and differentiate tastes in foods and drinks. Although humans can richly perceive variations of taste, the relationships among taste categories are not clearly generalized. Humans categorize sensory inputs using words, and words are an important index in investigating such sensory categories. Although the relationship between the sound of a word and its meaning has long been considered to be arbitrary (e.g., Saussure, 1916), the existence of synesthetic associations between sounds and sensory experiences (sound symbolism) has been demonstrated over the decades (e.g., Jespersen, 1922; Köhler, 1929; Newman, 1933; Sapir, 1929; Taylor, 1963; Werner & Wapner, 1952; Wertheimer, 1958, for early studies) and, to varying extent in a wide variety of languages (e.g., Brown, Black, & Horowitz, 1955; Davis, 1961; Emeneau, 1969; Hinton, Nichols, & Ohala, 1994; Klank, Huang, & Johnson, 1971; Nuckrolls, 1999; Voeltz & Kilian-Hatz, 2001). The characteristics and universality of such sensory-sound correspondence have been studied to provide a clue for understanding the development of language abilities (Imai, Kita, Nagumo, & Okada, 2008; Kantartzis, Imai, & Kita, 2011; Maurer, Pathman, & Mondloch, 2006; Westbury, 2004) and language evolution (Ohala, 1997; Ramachandran & Hubbard, 2001).

It is also known that the sensory-sound correspondence can be found not only in words referring to visual shapes, which was demonstrated in the landmark studies, which identified “mal/mil” and “bouba/kiki” for round and sharp shapes, respectively, but also in those referring to tactile, smell, and taste sensations.

Japanese is known to have a large number of onomatopoeic words to express sensory experiences. Taste sensation is one of those frequently expressed by onomatopoeia in Japanese. Thus, in this paper we investigate the sound symbolic associations between phonemes of Japanese onomatopoeia for expressing taste sensations and subjective evaluations of comfort/discomfort for objects in taste.

Watanabe et al. (2012) investigated sound symbolic associations between phonemes of Japanese onomatopoeia for expressing tactile sensations and subjective evaluations of comfort/discomfort for touched objects. Fifteen naïve participants, aged between 19 and 26, ten males and five females, reported an onomatopoeic word to express the

tactile feeling while touching one of 120 tactile substances, and evaluated the comfort/discomfort of the touched material on a seven-point scale (Very comfortable +3, Comfortable +2, Slightly comfortable +1, Neither 0, and three levels, -1 to -3, for uncomfortable feeling) while touching it. The results produced 1800 sets of onomatopoeic words and subjective evaluations of comfort level (120 substances x 15 participants). In 87.1% of all trials (1569 cases), the onomatopoeic word had a two-mora repetition form (e.g. "sara-sara"). Therefore, they analyzed the relationship between the phonemes of onomatopoeic words in two-mora repetitions form and evaluations of comfort/discomfort using the 1569 instances. The average of the ratings obtained across the 1569 cases was 0.08. This value suggests that half of trials yielded a rating in a comfortable level, and the other half a rating in an uncomfortable level (nonbiased for participant's response opportunities). The averages of ratings across trials in which the same phonemes were used in the first syllable were statistically compared with the average of the 1569 cases (0.08) (t-test comparing the average with constant value). As for the vowels, they reported that only /u/ had a statistically significant relationship to comfort. Vowels /i/ and /e/ were not used often, but they were deeply related to discomfort (/i/ was marginally significant, and /e/ was significant). Among the consonants, /m/, /h/, and /s/ were related to comfort, while /g/, /z/, /j/, /b/, and /n/ were significantly related to discomfort.

Inspired by this previous study, we here investigate sound symbolism in taste. Specifically, we perform psychological experiments to explore the relationship between phonemes of Japanese sound symbolic words and emotional evaluations of objects in taste. The purpose of the experiments is to specify the association between phonemes of Japanese onomatopoeic words and taste-emotion evaluations. We compare the results obtained from our experiments with those of our previous experiment where participants expressed the sensation obtained from touched substances using Japanese sound symbolic words and evaluated the comfort of tactile sensation. In the analysis of sound symbolism in taste, we carefully consider two things in performing a psychophysical experiment. When we taste something, not only taste itself but also texture plays an important role. We say, for example, "this is "huwa-huwa" and tasty" or "this tastes bad and "neba-neba". "Huwa-huwa" is an expression for comfortable touch, while "neba-neba" is an expression for uncomfortable touch. Food texture is a kind of tactile sensation of food or drink in your mouth going down your throat.

In the analysis, we therefore elucidate the relationship between the phonemes of onomatopoeic words and evaluations of comfort/discomfort using substances which are the same in taste but different in texture. The previous study of the sound symbolism in tactile sensation showed that the sound of onomatopoeia is related to comfort/discomfort significantly. We compare the previous results with those obtained in the present experiment using substances with different food texture. We compare the results obtained from the substances different only in texture with those obtained from those different only in taste.

Method

For the purposes described in the above, we performed a psychophysical experiment. After participants had tasted various drinks different in taste or in texture, participants were asked to respond with onomatopoeia associated with the sensation and rate how much they liked the taste or texture of the object, hereafter 'comfort/discomfort, using the SD method.

Participants

Twenty naïve participants (seventeen males and three females), aged between 20 and 40 years old, took part in the experiments. The participant was not informed of the purpose of the experiment, and they had no known abnormalities in speech or in their ability to discern texture. They visited a laboratory at the University of Electro-Communications to conduct trials.

Substances

We chose drinks as substances in our experiment because the taste and texture of drinks can be more easily controlled than those of foods. We searched for drinks with various tastes and textures and decided to use cola, sports drink, coffee, milk, green tea, and vegetable juice from a basic drink product category. We altered the taste of the six basic drinks by adding soy sauce in order to analyze the relationship between the phonemes of onomatopoeic words and evaluations of comfort/discomfort among substances which are the same in texture but different in taste. On the other hand, we altered their texture by adding water or carbonated water in order to analyze the relationship between the phonemes of onomatopoeic words and evaluations of comfort/discomfort among materials that are the same in taste but different in texture. The materials prepared for the experiment are listed in Table 1. For the taste and texture alternations, 10 ml of soy sauce was mixed with 100 ml of the basic drinks, and 100 ml of water or carbonated water was mixed with 100 ml of the basic drinks.

Semantic differential scales

Hayakawa et al. (2005) collected 445 Japanese words which are used to express food texture. We excluded onomatopoeia from 445 words because our objective was to analyze onomatopoeia obtained from the experiment. As a result, 132 words were selected as candidates for use as SD scales ("sparkling - still", "thick – thin", and "smooth – rough", and "good texture – bad texture"). Then, referring to the "Word list by semantic principles" collected by the National Institute for Japanese Language (Bunruigoihyo, 1964), we selected four pairs of adjective as SD scales related to texture, namely "sparkling - still", "thick – thin", and "smooth – rough", and "good texture –bad texture".

Referring again to the “Word list by semantic principles”, we selected five pairs of adjectives as SD scales related to taste, namely "sweet – not sweet", "bitter – not bitter", "salty – not salty", "sour – not sour", and "hot – not hot". Furthermore, we added "comfortable – uncomfortable” as a highly emotional scale. For all ten SD scales, the ratings were made on a 7-point scale ranging from -3 through 0 to +3.

Procedure

Participants, blindfolded, sat on a chair and drank 24 substances one by one in sips (15 ml.). After they had drunk one of the substances, participants were asked to drink water to clean their mouths and throats. Half of the participants first reported as many onomatopoeic words as they liked to express how they felt while drinking each of the 24 substances. Then, they rated ten SD scales. The other half of the participants first rated ten SD scales. Then, they reported as many onomatopoeic words as they liked to express how they felt while drinking one of the 24 substances. This is because onomatopoeia association may affect the evaluation by SD scales or evaluation by SD scales may affect onomatopoeia association. In the experiments, the experimenter prepared each substance right before the participants drank it. The substances were presented in a random order

Table 1: Substances to be used for the experiment

No.	Substances	Mixing ratio
1	Cola	
2	Coffee	
3	Milk	
4	Green tea	
5	Vegetable juice	
6	Sports drink	
7	Cola + soy sauce	10 ml of soy sauce for 100 ml of commercial drink
8	Coffee + soy sauce	
9	Milk + soy sauce	
10	Green tea + soy sauce	
11	Vegetable juice + soy sauce	
12	Sports drink + soy sauce	
13	Cola + water	100 ml of water for 100 ml of commercial drink
14	Coffee + water	
15	Milk + water	
16	Green tea + water	
17	Vegetable juice + water	
18	Sports drink + water	
19	Cola + carbonated water	100 ml of carbonated water for 100 ml of commercial drink
20	Coffee + carbonated water	
21	Milk + carbonated water	
22	Green tea + carbonated water	
23	Vegetable juice + carbonated water	
24	Sports drink + carbonated water	

Results

Phonemes associated with comfort/discomfort

The results produced 740 sets of onomatopoeic words and subjective evaluations of comfort level (24 substances x 20 participants). In 94.3% of all the trials (480 cases), the onomatopoeic words had a two-mora repetition form (e.g. "sara-sara"). We therefore analyzed the relationship between phonemes of onomatopoeic words in two-mora repetitions form and evaluations of comfort/discomfort using the 480 instances. The average of the ratings obtained across the 480 cases was -0.42. This value suggests that a number of trials yielded a rating in an uncomfortable level (nonbiased for participant’s response opportunities).

We took particular note of the vowels and consonants of the first syllable, which show strong sound symbolic associations (Hamano, 1998). The averages of ratings across trials in which the same phonemes were used in the first syllable were statistically compared with the average of the 420 cases (-0.42) (t-test comparing the average with constant value). Of the vowels, as shown in Table 2, only /a/ had a statistically significant relationship to comfort. Vowels /i/ was deeply related to discomfort (/i/ was marginally significant). Among the consonants, /sy/, /h/, and /s/ were related to comfort, while /g/, /z/, /b/, /d/, /n/and Ø were significantly related to discomfort.

We compared the results of our study with those of our previous study (Watanabe et al. 2012) for the tactile sensation as shown in the column of “Touch” in Table 2. The results of taste and touch are the same in the relationship of /s/ and /h/ with comfort evaluation and /i/, /z/, /b/ and /g/ with discomfort evaluation. On the other hand, only for the results of this study, /a/ and /sh/ are significantly related to comfort and /d/ and /Ø/are significantly related to discomfort. Although the results of this study are partly different in the kind of phonemes related to comfort/discomfort from those for touch, the number of phonemes related to comfort/discomfort is the same. Therefore, the evaluation of comfort/discomfort of drinks is associated with phonemes of onomatopoeic words expressing how they felt while drinking in the same way as the results of our previous study of touch.

Then, we compared the results obtained from the substances different only in texture with those obtained from the substances different only in taste, as shown in Table 3. /a/ and /s/ had a statistically significant relationship to comfort for the substances different only in taste as well as those different only in texture, while /sh/ is significantly related to comfort only for the substances different in taste and /h/ is significantly associated with comfort only for the substances different only in texture. On the other hand, /b/, /g/, /i/, and /z/ had a statistically significant relationship to discomfort for the substances different only in taste as well as those different only in texture, while /d/, /e, and /Ø/ are significantly related to discomfort for the substances different only in taste.

Table 2: Numbers (Num.) and average of ratings (Ave.) of the first vowel and consonant. Only phonemes whose numbers were more than 7 (1 % of 740 cases) are listed. P-values of statistical analysis to the overall average (-0.42) are also shown (*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$). Red and blue shading indicate that the phoneme is significantly different in positive and negative values, respectively.

	Results of this study			Touch		Results of this study			Touch
	Num.	Ave.	*p* value			Num.	Ave.	*p* value	
/s/	144	1.17	0.00***	Comfort	/m/	23	-0.83	0.36	Comfort
/h/	31	0.52	0.01*	Comfort	/n/	58	-0.83	0.15	Discomfort
/a/	131	0.41	0.00***		/e/	27	-0.96	0.18	Discomfort
/sy/	84	0.29	0.00**		/i/	94	-1.22	0.00***	Discomfort
/p/	44	0.16	0.07		/d/	39	-1.51	0.00**	
/k/	28	-0.11	0.43		/z/	35	-1.54	0.00**	Discomfort
/u/	362	-0.35	0.59	Comfort	ø	28	-1.96	0.00***	
/t/	59	-0.56	0.63		/b/	45	-2.00	0.00***	Discomfort
/zy/	37	-0.70	0.42		/g/	59	-2.22	0.00***	Discomfort
/o/	126	-0.79	0.07						

Table 3: Numbers (Num.) and average of ratings (Ave.) of the first vowel and consonant for taste and texture. Only phonemes whose numbers were more than 7 (1 % of 740 cases) are listed. P-values of statistical analysis to the overall average (taste:-0.48, texture:-0.36) are also shown (*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$). Red and blue shading indicate that the phoneme is significantly different in positive and negative values, respectively.

taste				Touch	texture				Touch
	Num.	Ave.	*p* value			Num.	Ave.	*p* value	
/a/	51	0.58	0.00**		/a/	80	0.30	0.00**	
/b/	27	-2.11	0.00***	Discomfort	/b/	18	-1.83	0.00***	Discomfort
/d/	28	-1.67	0.00**		/d/	11	-1.09	0.20	
/e/	19	-1.5	0.03*	Discomfort	/e/	8	0.50	0.19	Discomfort
/g/	39	-2.35	0.00***	Discomfort	/g/	20	-1.95	0.00***	Discomfort
/h/	16	0.37	0.13	Comfort	/h/	14	0.71	0.03*	Comfort
/i/	42	-1.38	0.01*	Discomfort	/i/	52	-1.09	0.00**	Discomfort
/k/	16	0	0.40		/k/	12	-0.25	0.83	
/m/	16	-0.75	0.64	Comfort					
/n/	33	-0.69	0.60		/n/	25	-1.00	0.09	
/o/	87	-0.79	0.25		/o/	39	-0.76	0.19	
/p/	15	0.33	0.17		/p/	29	0.06	0.22	
/s/	58	1.86	0.00***	Comfort	/s/	86	0.70	0.00***	Comfort
/sy/	24	1.2	0.00***		/sy/	60	-0.08	0.28	
/t/	32	-0.5	0.97		/t/	27	-0.62	0.46	
/u/	172	-0.3	0.40	Comfort	/u/	190	-0.38	0.86	Comfort
/z/	13	-1.92	0.02*	Discomfort	/z/	22	-1.31	0.01*	Discomfort
/zy/	19	-0.52	0.93		/zy/	18	-0.88	0.23	
ø	21	-2	0.00**						

Phonemes associated with other evaluations

We compared the average of ratings of phonemes obtained from experiments for each SD scale, as shown in Table 4. The evaluations of “sparkling”, “smooth”, “good texture” and “comfortable” are the most frequently categorized into phonemes of onomatopoeic words. Ten or eleven phonemes are significantly related to these scales. Since these scales are texture scales, evaluations of texture might be easily associated with phonemes of onomatopoeic words. The positive or negative evaluations of “sparkling” and “smooth” have a statistically significant relationship to /s/,

/sy/, /n/, /p/, /d/, /Ø/, /m/ and /o/. The evaluations of “thick” and “salty” are the second most frequently categorized into phonemes of onomatopoeic words. Eight phonemes are significantly related to these scales. The positive or negative evaluations of “thick” and “salty” have a statistically significant relationship to /s/, /sh/, /d/, and /a/. As for the phonemes related to “thick-thin”, /n/, /d/, /m/, and /o/ are significantly related to “thick” (e.g., “neba-neba” meaning sticky, "doro-doro" meaning muddy), while /s/, /sy/, /a/, and /i/ are significantly related to “thin” (e.g., "sara-sara" meaning smooth). The evaluations of “sweet”, “bitter”, “sour”, and “hot” are not easily symbolized by phonemes of onomatopoeic words. Only five or six phonemes are significantly related to these scales. Since these scales are specific for taste, evaluations of taste might be not so easily associated with phonemes of onomatopoeic words as evaluations of texture. However, we found a strong association between phonemes and some SD scales related to taste. For example, vowels and consonants /n/, /i/, and /o/ were significantly related to “bitter-not bitter”. The vowel /i/ was significantly related to “sweet-not sweet”. Furthermore, the consonants /s/, /g/ were significantly related to “salty-not salty”. This means that evaluations of taste can be symbolized by phonemes of Japanese onomatopoeic words, although previous studies (e.g. Yamanashi, 1988) have suggested that, unlike touch, taste is not expressed by onomatopoeic words.

Discussion

Humans categorize sensory inputs using words, and words are important indexes in investigating such sensory categories. Previous studies of tactile sensations identified major factors in tactile perception and established standards of classification based on physical properties of substances or in terms of sets of adjectives (e.g., Tiest, & Kappers, 2006). However, the previous methods using adjectives have limitations. If adjective labels that represent a certain perceptual dimension are not involved, the perceptual dimension would never be extracted. Therefore, it is debatable whether the pairs of adjectives are capable of richly expressing variations of tactile sensations including emotional evaluations like comfort/discomfort. Watanabe et al. (2012) proposed a new method using sound symbolic associations between phonemes of Japanese onomatopoeia for expressing tactile sensations and subjective evaluations of comfort/discomfort for touched objects. They identified phonemes associated with comfort and discomfort respectively. In the same way as tactile perception, humans can richly perceive variations of taste. However, the relationships among taste categories have not been clearly described. Using the method proposed by Watanabe et al. (2012), we found /a/, /sy/, /h/, and /s/ had a statistically significant relationship to comfort and /i/, /g/, /z/, /b/, /d/, /n/, and /Ø/ were significantly related to discomfort and showed the possibility to clarify taste categories using sound symbolic method.

Table 4: Averages of ratings for combinations of SD scales and first consonant which are listed in Table 1. Only phonemes whose numbers were more than 7 (1 % of 740 cases) are listed. P-values of statistical analysis to the average of each scales are also shown (*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$). Red and blue shading indicate that the phoneme is significantly different in positive and negative values, respectively.

	sweet	bitter	sour	salty	hot	thick	sparkling	smooth	good texture	Comfortable
Ave.	1.99	1.69	1.63	1.82	0.78	1.75	1.79	-0.09	-0.31	-0.42
/s/			-1.11**	-0.77***	-0.45*	-0.81***	-1.08***	1.31***	1.22***	1.17***
/sy/	2.52*		-1.22*	-1.07**		-0.81***	4.23***	0.83***	0.38***	0.28**
/g/	-1.32*			3.33***	1.27*			-1.61***	-1.59***	-2.22***
/t/		-1.16*								
/n/		2.62***				2.91***	-0.84**	-0.60*		
/b/					-0.28*			-1.2***	-1.71***	-2.00***
/p/					1.22*		3.70***	0.63**		
/d/			2.43**	2.71*		3.79***	-0.64**	-1.53***	-1.33***	-1.51**
/zy/	2.83*						3.75***			
/z/		2.54**	2.4*	2.68*					-1.25**	-1.54**
/h/										0.51*
Ø	-1.28*			2.75*			-0.64**	-1.35***		-1.96***
/m/						3.69***	-0.26**	-1.00*		
/a/		-1.32*		-1.31**		-1.07***		0.64***	0.40***	0.41***
/e/			2.55*	2.66*	1.66**		-0.88*		-1.25**	
/i/	-1.26***	2.82***			-0.40*	-1.30*			-0.94**	-1.22***
/o/		-1.03***				2.83***	-0.75***	-0.90***	-1.73*	
/u/							2.12*			

Previous studies (e.g. Yamanashi, 1988) have suggested that, unlike touch, taste is not expressed by onomatopoeic words and, if any, onomatopoeic words used for taste are expressing food texture, which is a kind of tactile perception. Our results showed that the SD scales related to texture such as “sparkling”, “smooth”, “good texture” and “comfortable” were the most frequently categorized into phonemes of onomatopoeic words. Therefore, as previous studies have suggested, onomatopoeic words expressing food texture are more easily used for emotional evaluations in taste than those expressing taste itself. However, we found a strong association between phonemes and some SD scales related to taste itself. For example, vowels and consonants /n/, /i/, and /o/ were significantly related to “bitter-not bitter”. The vowel /i/ was significantly related to “sweet-not sweet”. Furthermore, the consonants /s/, /g/ were significantly related to “salty-not salty”. This means that evaluations of taste can be symbolized by phonemes of Japanese onomatopoeic words. We therefore showed that sound symbolic words could be important indexes in investigating various level of perceptual dimension of taste including emotional evaluations like comfort/discomfort.

Conclusion

This study investigated sound symbolism in taste through psychological experiments and showed that sound symbolic words could be important indexes in investigating various level of perceptual dimension of taste including emotional evaluations like comfort/discomfort. Since sound symbolism is observed in languages of the world, whether the findings of this study are universal or not is an issue awaiting further investigation.

Acknowledgement

This work was supported by Grant-in-Aid for Scientific Research on Innovative Areas "Shitsukan" (No. 23135510 and 25135713) from MEXT, Japan.

References

Brown, R. W., Black, A. H., & Horowitz, A. E. (1955). Phonetic symbolism in natural languages. *The Journal of Abnormal and Social Psychology*, 50, 388-393.

Bunruigoihyo. (1964). Bunruigohyo. *Shuei publisher (In Japanese)*.

Davis, R. (1961). The fitness of names to drawings: A cross-cultural study in Tanganyika. *British Journal of Psychology*, 52, 259-268.

Emeneau, M. B. (1969). Onomatopoetics in the Indian linguistic area. *Language*, 45, 274-299.

Hamano, S. (1998). *The sound symbolic system of Japanese*. Stanford, CA: CSLI Publications; Tokyo: Kuroshio.

Hayakawa, F. Ioku, K. Akuzawa, S, Saito M. Nishinari, K. Yamano, Y. & Kohyama K. (2005). Collection of Japanese Texture Terms. Nippon Shokuhin Kagaku Kogaku Kaishi, 52, 337-346.

Hinton, L., Nichols, J., & Ohala, J. (Eds.). (1994). *Sound symbolism.* Cambridge, UK: Cambridge University Press.

Imai, M. Kita, S., Nagumo, M., & Okada, H. (2008). Sounds Symbolism between a word and an action facilitates early verb learning. Cognition, 109, 54-65

Jespersen, O. (1922). The symbolic value of the vowel i. *Philologica*, 1, 1-19.

Kantartzis, K., Imai, M., & Kita, S. (2011). Japanese Sound Symbolism Facilitates Word Learning in English Speaking Children. *Cognitive Science*, 35, 575-586

Klank, L. J. K., Huang, Y. H., & Johnson, R. C. (1971). Determinants of success in matching word pairs in tests of phonetic symbolism. *Journal of Verbal Learning and Verbal Behavior*, 10, 140–148.

Köhler, W. (1929) Gestalt Psychology. NewYork: Liveright Publishing Corporation.

Maurer, D., Pathman, T., 7 Mondloch, C. J. (2006). The shape of boubas: Sound-shape correspondences in toddlers and adults. Developmental Science, 9, 316-322.

Newman, S. S. (1933). Further experiments in phonetic symbolism. The American Journal of Psychology, 45, 53-75.

Nuckrolls, J. (1999). The case for sound symbolism. *Annual Review of Anthropology*, 28, 225-252.

Ohala, J. J. (1997). Sound Symbolism. Proceedings of 4th Seoul International Conference on Linguistics (pp. 98-103).

Ramachandran, V. S., & Hubbard, E. M. (2001). Synaesthesia- a window into perception, thought, and language. Journal of Consciousness Studies, 8, 3-34.

Sapir, E. (1929). A study of phonetic symbolism. Journal of Experimental Psychology. 12, 225-239.

Saussure, Ferdinand de (1916). Nature of the Linguistics Sign, in: Charles Bally & Albert Sechehaye (Ed.). *Cours de linguistique générale, McGraw Hill Education.* ISBN 0-07-016524-6.

Taylor, I. K. (1963). Phonetic symbolism re-examined. *Psychological Bulletin*, 60, 200-209.

Tiest, W. M. B., & Kappers, A. M. L. (2006). Analysis of haptic perception of materials by multidimensional scaling and physical measurements of roughness and compressibility. Acta Psychologica, 121, 1-20.

Voeltz, F. K. E., & Kilian-Hatz, C. (Eds.). (2001). *Ideophones*. Amsterdam: John Benjamins.

Watanabe, J. & Sakamoto, M. (2012). Sound Symbolic Relationship between Onomatopoeia and Emotional Evaluations in Taste. *Proceedings of the 34th Annual Meeting of the Cognitive Science Society(CogSci2012)*, 2517-2522.

Werner, H., & Wapner, S. (1952). Toward a general theory of perception. *Psychological Review*, 59, 324-38.

Wertheimer, M. (1958). The relation between the sound of a word and its meaning. *The American Journal of Psychology*, 71, 412-415.

Westbury, C. (2004). Implicit sound symbolism in lexical access: Evidence from an interference task. Brain and Language, 93, 10-19.

Yamanashi, M. (1988). *Metaphor and understanding.* Tokyo: University of Tokyo Press.