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Pathak, Abhishek; Calvert, Gemma A.; Motoki, Kosuke

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LONG VOWELS AND TASTE EXPECTATION

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Abhishek Pathak¹, Gemma Anne Calvert² and Kosuke Motoki³

¹School of Business, University of Dundee, UK

²Nanyang Business School, Nanyang Technological University, Singapore

³Department of Food Management, Miyagi University, Japan

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Abstract

A growing body of research has demonstrated the existence of cross modal correspondences that involve tastes and sounds. For example, front vowels (e.g., /i/) and voiceless consonants (e.g., /f/) are more matched with sweetness than back vowels (e.g., /u/) and voiced consonants (e.g., /b/). However, research on taste-sound correspondences so far has focused mainly on the vowel position (e.g., front vs. back) and/or consonant types (i.e., voiced vs. voiceless). The literature on onomatopoeia and phonaesthetics suggests that vowel length (e.g. /e/ in *sweeet* vs *sweet*) can be used to convey pleasure or euphony (e.g. sweetness) and displeasure (e.g., bitterness). This paper explores the linkages between vowel length and taste attributes. Specifically, this paper investigated the link between long (vs. short) vowel sounds and sweetness. In three studies, we demonstrate that people expect words containing long vowels (e.g., Monef [Məʊni:f]) to connote sweeter tastes than words containing short vowels (e.g., Monef [Mɒnef]). Our findings reveal the importance of vowel length in taste-sound associations, and show its linkage with the taste continuum.

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1. Introduction

In a seminal paper, Fónagy (1963) showed for the first time the cross modal linkages between sounds (within the linguistic correspondences) and taste (e.g., /u/ with bitter and /i/ with sweet tastes). Prior to that, other research had reported similar cross modal audio-visual linkages between shapes and speech sounds (e.g., /maluma/ with rounded shapes and /takete/ with pointy shapes). Since then, these findings have been extensively replicated across languages and age groups. More recently, cross-modal linkages have been demonstrated between taste and music or musical notes and taste and vowels or consonants (e.g., Knöferle & Spence, 2012; Motoki et al., 2020; Pathak & Calvert, 2020).

Although a significant amount of work has been done in this field (i.e. cross modal linkages between speech and taste), most research to date has differentiated the vowel sounds mostly on the articulatory position of the tongue alone (i.e. the *vowel position*) (e.g., Motoki et al., 2020; Spence & Gallace, 2011). To explain this in non-linguistic terms, vowels are speech sounds which are produced from, 1) the movement of air within the oral cavity and 2), the vibration of vocal cords. Further, the vowels are classified depending on the position of tongue while the vowel sound is uttered. Based on the tongue position, vowels can be front, central and back vowels (i.e. based on the horizontal aspect of tongue position) or high, mid and low vowels (i.e. based on the vertical aspect of the tongue position). However, each vowel (/a/, /e/, /i/, /o/, /u/) also has a corresponding long vowel sound (e.g. /e/ in *fed* vs. *feed*) and to date, research exploring the cross modal taste linkages between long (vs. short) vowel sounds and product attributes, is rather rare.

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If a hypothetical ice-cream **Frish** (vs. **Frosh**) is perceived as creamier (vs. less creamy) due to the differences in the vowel position alone [i.e. front vs. back vowel, as suggested by Yorkston and Menon (2004)], will the same be true for, 1) **Frish** vs. **Fraishe** (pronounced as **Fry-sh** (as in **rice**) i.e. with the corresponding long vowel sound of the vowel /i/) or, 2) **Frish** vs. **Froash** (pronounced as **Froa-sh** (as in **boat**) i.e. with the corresponding long vowel sound of the vowel /o/) or 3) **Fraishe** vs. **Froash** (both with the long vowels sounds)? The current literature does not differentiate between these, as position-wise they appear to arise from the same position within the oral cavity, however, length-wise they are clearly distinct. Moreover, many researchers in this field have used visual stimuli, (e.g., **Frish** vs. **Frosh**) and in the presentation of such non-words as stimuli, there is always a confound whether the participant is reading the non-word with a corresponding long or short vowel sound (e.g., **Fri-sh** might have been read by a respondent as **Fry-she**). This is an interesting new question and the current paper explores this in the context of taste attributes and long (vs. short) vowel sounds.

2. Theoretical background

Why should long versus short vowel sounds evoke different taste expectations? We propose to link the euphonious nature of long vowels, onomatopoeia in languages and the transitivity hypothesis to explain these distinctive sound-taste associations. All languages contain speech sounds that are euphonic (vs. cacophonic) (e.g., Tambovtsev, 2010). Euphonic sounds create a melodious and pleasing effect (e.g., liquid sounds such as /r/, /l/), whereas cacophonic sounds (e.g., /kr/, /sh/ in the word /mash/ and /crash/) confer harsh intonations (Nielsen & Rendall, 2011). Spectral differences in their respective frequencies have been suggested as the reason behind harsh and jagged (vs. smooth and rounded) perception of these sounds (e.g., (Fort,

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Martin & Peperkamp, 2015; Nielsen & Rendall, 2011). In fact, extending this finding to the well-known bouba-kiki phenomenon, research now suggests an effect of the type of consonant (i.e. euphony (/m/, /l/) vs. cacophony (/g/, /k/)) on the shape-sound correspondence (e.g., Fort, Martin & Peperkamp, 2015). Euphony has traditionally been used by poets and writers to enhance the melody in their creations. Poets are known to use tools such as alliteration, repetition, assonance, rhyming and euphony to please their readers, and one of the frequently used tools by them to enhance euphony, is the use of long vowels (Tambovtsev, 2010). For example, observe the use of poetic tools in the lines of Lord Tennyson, (a poet known to have mastery over euphony),

“Dark faces pale against that rosy flame /The mild-eyed melancholy Lotos-eaters came”

Most words in these lines consist of a long vowel sound, together with soft sounds (/m/, /l/) and repetition and rhyming. Long vowels are considered to be particularly euphonic not only in English but across languages. Though research linking long vowels with the sensory domain is rare, there is some indirect evidence linking long vowels with softness and roundedness (Fujiwara et al., 2004). These authors demonstrated that long vowels are negatively correlated with sharpness (or in other words, are considered soft and rounded, dimensions which are often linked to sweet tastes) (Velasco, Woods, Marks, Cheok, & Spence, 2016) .

While explaining sound-meaning associations, two views are widely held. One suggests that sounds of a word and its meaning are totally arbitrary and the other (i.e. onomatopoeia) suggests that sounds *do* convey what they mean (e.g., ‘Noise of crunchy bones goes *crackety-crack* for miles around’ by Roald Dahl) (see Lockwood & Dingemanse, 2015 for a review). Onomatopoeia has been shown to be quite common in some languages (e.g., Japanese). Research

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suggests that onomatopoeia not only imitates sounds with meanings (e.g., woof-woof with barking of a dog) and expressions (e.g., faster speech for faster objects), but also extends to a lexical level (Wharton, 2009). For example, if someone wants to create a novel word for saying /mother/, then it is likely that he/she will use soft sounds (e.g., /m/, /n/, /l/, /r/ or soft vowel sounds) in the new word to link these concepts.

Similarly, consumers have been shown to link stimuli presented in one sensory pathway, with related similar attributes in different sensory pathway(s) (e.g., pitch of a music (auditory) with olfaction (e.g., sweet smell or music); thermal attributes with olfaction (e.g., menthol with 'coolness' of the smell, i.e. linking trigeminal attributes with the thermal ones) and taste with angularity or roundedness) (Deroy, Crisinel, & Spence, 2013). In cross modal correspondences, people often relate two independent stimuli together, if those stimuli are connected with another common stimuli (transitivity hypothesis). For example, if soft sounds are linked with roundedness and round objects are linked with sweet tastes, then sweet tastes get linked with roundedness (Deroy, Crisinel, & Spence, 2013). Extending these findings to the current paper, we hypothesized that long vowels are considered pleasant and euphonic (compared to short vowels) and sweet taste is considered pleasant, therefore consumers would tend to link long (vs. short) vowel sounds more with sweet (vs. non-sweet) tastes. In particular, we show that because long vowel sounds are particularly pleasing, their inclusion in hypothetical words would evoke expectations of sweetness (compared to words containing short vowel sounds).

3. Method and overview of studies

A total of ten bi-syllabic word pairs were created as stimuli (Appendix 1). All stimuli were created using twelve consonants (/k/, /n/, /z/, /g/, /l/, /r/, /h/, /m/, /v/, /p/, /t/, /f/, /r/) and five

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vowels (/a/, /e/, /i/, /o/, /u/). Each word pair differed only in the type of the vowel used i.e. short vs. long. For example, the stimulus Gelin (IPA notation: gelɪn; /e/ as in fed and ɪ as in hit) was created using only short vowels /e/ and /ɪ/. Similarly, its long vowel counterpart (IPA notation: gi:lɑːm; i: as in feed and ɑ: as in mite) was created with corresponding long vowels, /i:/ and /ɑ:/. Consonants /s/, /b/ and /r/ were not used in a sequence in any stimuli (e.g., /s-w-t/ or /b-t-r/), as such a sequence might evoke the semantic association of sweet or bitter tastes. Stimuli were then converted to an auditory format, in an American accent, using Google's text to speech conversion (stimuli can be accessed at the Open Science platform at <https://osf.io/ab5h6/>). Both studies were designed on the Inquisit 6 platform (Millisecond.com) and participants were native English speakers recruited from the USA through Amazon Mechanical Turk. Participants could take part in only one study related to the current paper and in both the studies, audio checks were made to ensure that participants were indeed listening and responding. In both studies, participants were asked to guess the purpose of the experiment and none of the participants could make a correct guess.

In Study 1, participants were told that they would hear words in a foreign language and they had to guess whether those referred to sweet (vs. non-sweet) food products in that language. In Study 2, participants were shown images of naturally sweet and man-made sweet (vs. non-sweet) food products and were asked to create novel names for those (see Study 2 for details). The number of long vowels used by participants to create novel words was then analyzed (see Appendix 2 for an example). In natural language usage, long vowels are sometimes used to signify magnitude or size (e.g., big vs. biiiig for big vs. bigger). If participants relate long vowels with magnitude and not with euphony, then we should be able to replicate our findings in a different taste dimension too (e.g., words with short vs. long vowels will also be associated with

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bitter vs. very bitter categories). Study 3 aimed to rule out this alternative explanation. In Study 3, we tested the association of long (vs. short) vowels in sweet (vs. very sweet) category (Study 3a) and bitter (vs. very bitter) category (Study 3b). The results of Study 3 confirmed that the association of long vowels with taste holds true for sweet tastes but not for bitter ones; providing additional evidence that the euphonic nature of long vowels leads to expectations of taste sweetness.

4. Study 1

4.1. Participants

Sixty participants between the ages of 23 to 70 years completed the study, $M_{Age} = 42.70$ yrs., $SD = 13.03$, $Males = 33$, $Females = 27$). All participants were native English speakers and were fluent in English (one participant also knew Korean, three knew Spanish, one Japanese and two participants were multilingual).

4.2. Procedure and design

Participants were told that they would hear words in a foreign language and the words referred to either sweet or non-sweet foods in that language. They then had to decide whether the words belonged to a sweet (vs. non-sweet) food product category in that language. All twenty words were then presented, one at a time and looped continuously until a response was received. Before the start of the experiment, participants completed a few practice trials with real products which familiarized them with the experimental procedure.

4.3. Results and discussion

The results were analyzed in two ways. To check the interaction of vowels (long vs. short) and choice of products (sweet vs. non-sweet), a repeated measures ANOVA¹ was conducted on the proportions, which showed a significant interaction, $F(1, 59) = 11.42$, $p =$

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0.001, $n_p2 = 0.16$. A Wilcoxon signed rank test further showed that the participants chose more words with long (vs. short) vowels as appropriate for sweet (vs. non-sweet) products, $Z = 2.978$, $p = 0.003$, $r = 0.27$ (sweet products: $M_{Long\ vowels} = 0.53$, $SD = 0.15$; $M_{Short\ vowels} = 0.43$, $SD = 0.16$; non-sweet products: $M_{Long\ vowels} = 0.47$, $SD = 0.15$; $M_{Short\ vowels} = 0.57$, $SD = 0.16$)¹. The results of Study 1 provides support for our hypothesis of a link between words with long vowels and expected taste attributes; specifically, it demonstrates a stronger association of long vowels with expectations of sweetness compared to short vowels. We are not claiming that short vowels are harsh, are not sweet and cannot be expected in the name of a sweet product (there is no evidence to believe so), rather, we provide evidence that words containing long vowels evoke expectations of sweetness to a greater extent than words containing short vowels².

5. Study 2

While Study 1 used a forced choice paradigm, Study 2 relied on a free choice task in which images of sweet (vs. non-sweet) food products were presented to participants and they were required to create novel words for those and the number of vowels used to create novel words were analyzed.

5.1. Participants

Sixty three participants between the ages of 22 to 70 years completed the study, $M_{Age} = 42.46$ yrs., $SD = 13.38$, $Males = 37$, $Females = 26$. All participants were native English speakers and were fluent in English (one participant reported as 'average' in English; eleven participants knew a language other than English, three knew Spanish, two French, one each knew Turkish, Nepali, Telugu, Serbian, Arabic and German).

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5.2. Procedure and design

Participants were told to imagine a scenario in which they were writing a story for children. In the story, a friendly alien lands on earth and speaks in a language called ‘Drogish’ (e.g., as in Whissell, 2003). The alien meets a child on Earth (the main character of the story) and although the child does not know Drogish, he/she is still able to understand the meanings of many words spoken by the alien just by listening to the sounds of the words. In this task, participants were told that they would see a few food products on the screen and they had to create words which they thought the alien would use for those products in Drogish. Images of six sweet food items (three natural: mango, banana, honey and three man-made: cake, ice-cream, pie) and six non-sweet items (three natural: bitter-gourd, chilly, lemon and three man-made: cheeseburger, baked beans, burrito) were then presented and participants were told to type in the created words in a text box. A few restrictions were put in place. The created word should i) include a minimum of 5 letters; ii) be pronounceable, and iii) not resemble any known word or brand. The software further restricted the use of certain consonants (e.g. /m/, /n/, /g/ could not be used when the image of mango was shown).

Before the start of experiment, participants received a few practice trials with neutral food products (e.g., bread) which familiarized them with the experimental procedure. Instructions were shown on the screen along with the consonants which participants could use. Examples of both short and long vowels were shown and participants were told to put two vowels together in case they wanted to depict long vowels (e.g., for ‘mate’ = use ‘mayte’; for mite = use ‘maite’; letter /y/ could be used with another vowel to convey a long vowel and could be used singularly to depict a consonant). For analysis, the number of long vowels used by each participant to create

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words for sweet (vs. non-sweet) product was counted and divided by six (i.e. the number of images shown) and compared with the other category (see Appendix 2 for an example).

5.3. Results and discussion

A Wilcoxon signed rank test on the proportions of long vowels in each category (sweet vs. non-sweet) showed that participants used a significantly higher number of long vowels to create novel words for sweet (vs. non-sweet) food products, $Z = 3.15$, $p = 0.002$, $r = 0.28$ (proportions of long vowels in: *Words Sweet products* = 0.73, $SD = 0.40$, *Words Non-sweet products* = 0.58, $SD = 0.41$). The data of two participants who did not follow the instructions was excluded; these participants created known English words or unpronounceable words instead. Results of Study 2 provide additional support for our hypothesis and demonstrates that in a free choice task, respondents tend to use higher number of long vowels to convey sweet (vs. non-sweet) products.

6. Study 3

In Study 3, we wished to rule out a potential alternative explanation of the effect reported so far. In natural language usage, one may say ‘sweet vs. sweeter’ to convey a sweet vs. sweeter taste (i.e., less vs. more). However, in a similar fashion, one also finds that the vowels are sometimes prolonged to convey size or magnitude; for example, ‘big vs. biiig’ to convey the size difference between a big vs. bigger object. If this is a potential confound or an alternative explanation of the results, then we should be able to get similar results using another taste attribute [i.e. if words with long vowels are conveying magnitude rather than euphony, they would be expected to be sweeter (vs. less sweet) and more bitter (vs. less bitter) in different set of participants]. To rule this out, in Study 3, we examined the link between long (vs. short) vowels with sweet vs. very-sweet categories (study 3a) and with bitter vs. very-bitter categories (study 3b). All instructions and procedures remained the same as in Study 1. Participants listened

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to the words and classified them into sweet vs. very-sweet categories (study 3a) and bitter vs. very-bitter categories (study 3b). Nine word pairs were used as stimuli ².

6.1. Study 3a

6.1.1. Participants

Sixty-one participants between the ages of 21 to 70 years completed the study, $M_{Age} = 43.28$ yrs., $SD = 11.43$, $Males = 33$, $Females = 28$). All participants were native English speakers and were fluent in English (eight participants knew a second language, four knew Spanish two French and one each knew Japanese and Turkish)

6.1.2. Results

To check the interaction of vowels (long vs. short) and choice of products (sweet vs. non-sweet), a repeated measures ANOVA¹ was conducted on the proportions which showed a significant interaction, $F(1, 60) = 15.53$, $p < 0.001$, $\eta^2 = 0.21$. A Wilcoxon signed rank test on the proportions showed that participants chose a higher number of words with long (vs. short) vowels for very-sweet (vs. sweet) products, $Z = 3.56$, $p < 0.001$, $r = 0.32$ (very-sweet products: $M_{Long\ vowels} = 0.50$, $SD = 0.20$, $M_{Short\ vowels} = 0.35$, $SD = 0.18$); sweet products: $M_{Long\ vowels} = 0.50$, $SD = 0.20$, $M_{Short\ vowels} = 0.65$, $SD = 0.18$). Results of Study 3a are in line with our hypothesis.

6.2. Study 3b

6.2.1. Participants

Sixty-two participants between the ages of 23 to 73 years completed the study, $M_{Age} = 41.23$ yrs., $SD = 12.48$, $Males = 29$, $Females = 33$). All participants were native English speakers and were fluent in English (except one who reported to be average in fluency) (four participants knew a second language; two knew Spanish and one each knew Chinese and German).

6.2.2. Results

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The interaction of vowels (long vs. short) and choice of products (bitter vs. non-bitter), on repeated measures ANOVA¹ was not significant, $F(1, 61) < 1, p = 0.37$. A Wilcoxon signed rank test on the proportions showed no difference between the participants' choice for bitter (vs. very-bitter) products in words with long (vs. short) vowels, $Z = 1.32, p = 0.19$ (very-bitter products: $M_{Long\ vowels} = 0.43, SD = 0.20, M_{Short\ vowels} = 0.40, SD = 0.20$); bitter products: $M_{Long\ vowels} = 0.57, SD = 0.20, M_{Short\ vowels} = 0.60, SD = 0.20$). Results of Study 3b add further weight to our hypothesis, and suggest that long vowels are linked with euphony and thereby with sweetness, and that these results are not reflective of perceptions of size or magnitude.

7. General discussion

Languages across the world are built around vowels and consonants. Consonants carry a very distinctive sound (e.g., /b/ vs. /p/) and are believed to provide the lexical root information. For example, /demos/ is the root leading to words such as democracy and demographic (i.e., conveying concepts related to people). Similarly, in Semitic languages (e.g., Arabic), lexical root (i.e. consonants) conveys the concept of a word, whereas vowels are used to bring out further distinctions within that concept. For example, in Arabic /d/, /s/, t/, /n/ conveys the concept linked to study and words such as /madrasatun/ (school) and /dira:satun/ (study) convey extensions within this concept (Nespor, Peña, & Mehler, 2003).

While consonants provide the lexical information, vowels provide the more fine-grained information within a word (also called prosody). Across languages, speakers rely on prosodic cues to convey finer messages such as emotions, sarcasm, inquisitiveness etc. and vowel sounds are believed to be major tools for prosodic manipulations. For example, 'a great teacher' vs. 'a greeaat teacher', can be sarcastic or factual depending on the vowel length and stresses (both of which are prosodic tools) employed along the points of speech. Some researchers suggest that,

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“vowels sing but consonants speak” (Kolinsky et al., 2009), and within the vowels, long vowel sounds are considered especially melodic and euphonic. Poets, writers and even babies are adept at using long vowel sounds to convey melody and euphony. Motherese (also known as infant directed speech) and lullabies are considered to be especially rich in long vowels, which babies find sweet and soothing (Kuhl & Meltzoff, 1997). Similarly, in the adult communication, *baby-talk* has been shown to be universal across cultures, and is believed to strengthen relationships between adult couples, making them more intimate, affectionate and warm (Bombar & Littig Jr, 1996). In fact, the use of long vowels to enhance euphony is evident not only in English but across cultures (e.g., Arabic, Greek). Building on this evidence, we hypothesised that since long vowels are considered euphonic, their use in novel words will imbue them with a sweet quality (compared to similar words with short vowels). Across three studies, we demonstrate that respondents do find words with long vowels as more appropriate for sweet (vs. non-sweet) products. Though the findings of sound symbolism have been shown to be equally applicable across cultures, we cannot claim generalization of our findings, as the sample was mainly native English speakers recruited from the USA.

Prior research has established a link between speech sounds and taste attributes repeatedly. However, most of these studies have focused on the link between vowel positions (front vs. back and high vs. low) and product attributes such as brightness, size, shapes, taste etc. (Westbury, Hollis, Sidhu, & Pexman, 2018). Here, we provide evidence, that within the same vowel position (e.g., both /i/ and /i:/ are front vowel sounds), the length of a vowel can be a further discriminatory factor which can lead to different association(s) with taste attributes. All short vowels have corresponding long vowels too, but will those convey the same sound-symbolic attributes as short vowels? Apparently, the literature is not clear on this, and the current

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paper builds on this gap to show the linkages between vowel length and the expectation of sweetness.

We bring to notice three important points here, 1), peripheral vowels (e.g., /oo/ is high and back) within the oral cavity are generally longer in duration, as physiologically it takes longer to open the mouth wide to utter that sound, 2), similarly, high vowel sounds (e.g., /i/ as in **hit**) tend to be shorter in duration than the low vowels (e.g., /a/ as in /robot/) and 3), all front vowels in the English language are unrounded, whereas the back vowel sounds are rounded (note here that the rounding of lips increases the length of the oral cavity and lowers the resultant resonant frequency of the vowel sound uttered), which makes the back vowels longer in duration (Ottenheimer & Pine, 2018; Wade, 2017). When literature comments on the linkages between taste (or product) attributes with front or back (or high and low) vowels, it automatically brings in the confound of the vowel length. This raises questions whether so far we were comparing only front vs. back and high vs. low vowel distinctions or ‘front+short’ vs. ‘back+long’ and ‘high+short’ vs. ‘low+long’ vowel distinctions. Hitherto, these were not explored in depth, since vowel length was not considered as important (or different) as the vowel position. More research is needed to explore answers in depth. To conclude, we present a novel evidence of cross modal linkages between vowel length and taste attributes, and urge the research community to explore the impact of vowel length in the context of product attributes other than taste.

References

- Bombar, M. L., & Littig Jr, L. W. (1996). Babytalk as a communication of intimate attachment: An initial study in adult romances and friendships. *Personal Relationships*, 3(2), 137-158.
- Deroy, O., Crisinel, A.-S., & Spence, C. (2013). Crossmodal correspondences between odors and contingent features: Opaper sweedors, musical notes, and geometrical shapes. *Psychonomic Bulletin & Review*, 20(5), 878-896.
- Fónagy, I. (1963). Die Metaphern in der Phonetik [The metaphors in phonetics]. The Hague: Mouton.
- Fort, M., Martin, A., & Peperkamp, S. (2015). Consonants are more important than vowels in the bouba-kiki effect. *Language and Speech*, 58(2), 247-266.
- Fujisawa, N., Iwamiya, S.-i., & Takada, M. (2004). Auditory imagery associated with Japanese onomatopoeic representation. *Journal of Physiological Anthropology and Applied Human Science*, 23(6), 351-355.
- Knöferle, K., & Spence, C. (2012). Crossmodal correspondences between sounds and tastes. *Psychonomic Bulletin & Review*, 19, 992-1006
- Kolinsky, R., Lidji, P., Peretz, I., Besson, M., & Morais, J. (2009). Processing interactions between phonology and melody: Vowels sing but consonants speak. *Cognition*, 112(1), 1-20.
- Kuhl, P.K., Meltzoff, A.N. (1997). Evolution, nativism, and learning in the development of language and speech. In: Gopnik, M. (Ed.), *The Inheritance and Innateness of Grammars*. Oxford University Press, New York, USA, pp. 7-44.

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- Lockwood, G., & Dingemans, M. (2015). Iconicity in the lab: A review of behavioral, developmental, and neuroimaging research into sound-symbolism. *Frontiers in Psychology, 6*(1246).
- Motoki, K., Saito, T., Park, J., Velasco, C., Spence, C., & Sugiura, M. (2020). Tasting names: Systematic investigations of taste-speech sounds associations. *Food Quality and Preference, 80*, 103801.
- Nielsen, A., & Rendall, D. (2011). The sound of round: Evaluating the sound-symbolic role of consonants in the classic Takete-Maluma phenomenon. *Canadian Journal of Experimental Psychology/Revue canadienne de psychologie expérimentale, 65*(2), 115.
- Nespor, M., Peña, M., & Mehler, J. (2003). On the different roles of vowels and consonants in speech processing and language acquisition. *Lingue e Linguaggio, 2*(2), 203-230.
- Ottenheimer, H. J., & Pine, J. M. (2018). *The anthropology of language: An introduction to linguistic anthropology*. Belmont, California, USA: Wadsworth.
- Pathak, A., & Calvert, G. A. (2020). Sounds sweet, sounds bitter: How the presence of certain sounds in a brand name can alter expectations about the product's taste. *Food Quality and Preference, 83*, 103918.
- Spence, C., & Gallace, A. (2011). Tasting shapes and words. *Food Quality and Preference, 22*(3), 290-295.
- Tambovtsev, Y. (2010). Euphony in world languages. *Lingua Posnaniensis, 52*(1), 99-111.
- Velasco, C., Woods, A. T., Marks, L. E., Cheok, A. D., & Spence, C. (2016). The semantic basis of taste-shape associations. *PeerJ, 4*, e1644.
- Wade, L. (2017). The role of duration in the perception of vowel merger. *Laboratory Phonology: Journal of the Association for Laboratory Phonology, 8*(1).

LONG VOWELS AND TASTE EXPECTATION

Westbury, C., Hollis, G., Sidhu, D. M., & Pexman, P. M. (2018). Weighing up the evidence for sound symbolism: Distributional properties predict cue strength. *Journal of Memory and Language*, *99*, 122-150.

Wharton, T. (2009). *Pragmatics and non-verbal communication*. Cambridge, Cambridge University Press.

Whissell, C. (2003). The emotional symbolism of two English e-sounds: /I/as in “cheap” is pleasant and /I/as in “chip” active. *Perceptual and Motor Skills*, *96*(1), 149-165.

Yorkston, E., & Menon, G. (2004). A sound idea: Phonetic effects of brand names on consumer judgments. *Journal of Consumer Research*, *31*(1), 43-51.

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Footnotes

Footnote 1 – Though the data is non-normal, ANOVA was performed to test the interaction; non-parametric tests are also reported to test the differences in a statistically correct way; means are reported instead of medians as these are more appropriate here to understand the proportions.

Footnote 2 – During the analysis of Study 1, we found a potential confound; the hypothetical word ‘mapol’, though is pronounced as /maypyool/ in the long vowel format (see IPA notation in Appendix 1) may trigger association with the maple syrup. In view of this, the data was reanalyzed without this word pair and the results were similar to those reported earlier, $Z = 2.995$, $p = 0.003$, $r = 0.27$.

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Appendix 1

Hypothetical word	IPA notation (short vowels)	IPA notation (long vowels)
Kinez	kinez	kami:z
Gelin	gelɪn	gi:lɑm
Hizan	Hi:zæn	Ha:zɛm
Zomil	zɒmɪl	zəʊmaɪl
Varum	væɾʌm	veɪru:m
Nolip	nɒlɪp	nəʊlaɪp
Tomen	tɒmen	təʊmi:n
Latez	lætez	leɪti:z
Mapol	mæpɒl	Meɪpəʊl
Monef	Mɒnef	Məʊni:f

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Appendix 2

A sample of novel words created by participants in Study 2 for the sweet (vs. non-sweet) products.

Sweet 1	Sweet 2	Sweet 3	Sweet 4	Sweet 5	Sweet 6	Non-Sweet 1	Non-Sweet 2	Non-Sweet 3	Non-Sweet 4	Non-Sweet 5	Non-Sweet 6
portoo	staavita	reetora	mreema	reetura	atanat	caanapa	biitusa	saapa	tamoosa	teemor	lookiso
preool	difal	flappa	quinda	tralg	blaynt	pancolia	kipra	zimpen	flumpia	gropeel	jeagon
applo	pamey	okool	qohol	unkin	izaplan	alale	deepe	payen	tamep	leeze	iddowa
pulpil	swiitcomb	sweetum	lahvah	flakeyswiit	fudgiibop	coocoomah	saur	krunx	fattiisaws	mealee	flooffas
aloza	beely	adazly	eazta	ecanza	oazly	pickea	sourza	papsy	hunesa	reeza	weazl
varack	zaveet	coreese	teint	smout	plound	pelink	stista	preak	lapeek	hopit	misoul
viice	speerm	yolloy	holat	fyiee	iyeeew	nihiji	sour	hoytty	phiita	magity	eolle
parst	ceefl	kliwy	naawy	woomt	beelt	haxis	seets	wahmin	stuvy	rafir	eesin
eshpar	gluooov	tuootoe	googoo	lukluk	hebal	zinnee	ziteb	zingter	slups	pepuooz	cogen
sliteo	treel	plarata	honer	crigi	fooley	pepia	portuga	prang	splan	walor	effing
rapoo	ogreel	ayaya	oobie	vando	dublee	seely	greet	hotsy	hupoo	havlo	moodoo
supatay	glipdrue	plepup	doodum	smeeth	puntibungoo	opahmay	fifto	mudonast	lammomapad	humocrumee	opimina
ushypa	goomelimmy	yimfrity	goomgoom	yamelmamel	pialapoogy	yikofez	surqitat	shotzyfarzhoz	fantodamy	lagomely	moalymun
swejcy	stikswe	yelostik	meltmth	yumtim	tooqui	selon	tarsy	burmth	hothold	chimlo	woundup
pifutas	beeliqs	yelsums	sweetups	sweeocts	ibpette	jalfoxes	greeps	pepsums	hamsams	gapomz	pacfoodsum
yellowdak	smootstil	tuskler	broas	wacum	ivanih	hashly	gredot	hotsing	meatusk	wetrug	longhash
frui	swoud	yelzol	darlate	weazz	intan	acaze	trapiz	hotzie	hamzup	camay	eglong
aaot	loopp	aaree	moott	iello	taate	cooff	eekko	heete	uudde	faate	vaapp
padya	loomey	pamma	lannel	kiekle	doofeef	foofle	jijes	fefer	foohel	peemc	mullilo
juicooze	libbley	capapa	lavalay	mashoo	feezey	cukoo	kigot	spikey	jukel	mummo	eggloo
shabba	swooby	fafoofa	throop	froomee	dipplo	klenk	sitra	reens	nomkot	plorpz	slancha
flouwie	oumgie	mauveq	smothum	boumka	feani	kucisk	eibok	hiprey	meswif	mectu	faesi
vidzak	jivoy	yurga	lavou	trunda	izgit	mulon	giset	spikzy	humpats	clarpe	gudisa
yesal	sweelie	yelerd	rubbly	isloo	neenoo	spoonel	sorpo	hotpap	yumnel	rumpy	ensac
sweeetrz	pakjee	chaklak	paigao	treetzz	taiffee	chawnuf	geeta	hawtaa	hadtep	taflaf	flooha
illko	dioge	glarp	oomdur	tooma	oonon	ilife	spife	koots	ullum	croll	oncho

Each row represents one participant; Sweet 1 to 6 represent six images of sweet products (mango, honey, banana, cake, pie, ice-cream) and Non-Sweet 1 to 6 represent six images of non-sweet products (bitter-gourd, lime, chilly, cheeseburger, baked beans, burrito); The number of long vowels used by each participant to create words for sweet (vs. non-sweet) product was counted and divided by six (i.e. the number of images shown) and compared with the other category. For example, participant 1 used five (vs. six) long vowels (highlighted in bold) in words for sweet (vs. non-sweet) categories. It resulted in 0.83 (i.e. 5/6 for sweet category) vs. 1 (i.e. 6/6 for non-sweet category). Long vowels for the other participants were counted and analyzed in a similar way.