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Tasting names:

Systematic investigations of taste-speech sounds associations

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ABSTRACT (236/250 words)

Product names can be developed to effectively convey specific sensory attributes to the consumer. Most of previous research on crossmodal correspondences has shown that people selectively associate words (e.g., 'Maluma', 'Takete') with taste attributes. To provide practical insights for naming new products in the food industry, it is important to obtain a more nuanced understanding concerning those properties of speech sounds (i.e., vowels, consonants) influencing people's taste expectations. In this study, we investigated taste-speech sound correspondences by systematically manipulating the vowels and consonants comprising fictitious brand names. Based on the literature on crossmodal correspondences and sound symbolism, we investigated which vowels/consonants contribute more to the association between speech sounds and tastes (sweet/sour/salty/bitter). Across three experiments, we systematically varied vowels (front: [i][e], back: [a][u][o]), and affricate consonants (e.g., fricative: [f][s], stop: [p][t]) as well as voiced/voiceless consonants (e.g., voiced: [b][d], voiceless: [f][k]). Japanese participants were presented with brand names and had to evaluate the taste that they expected the product to have. The results revealed that: (1) front (back) vowels increased expected sweetness (bitterness); (2) fricative (stop) consonants increased expected sweetness (saltiness/bitterness), (3) voiceless (voiced) consonants increased expected sweetness/sourness (saltiness/bitterness). Moreover, consonants, which were pronounced first in the brand names, exerted a greater influence on expected taste than did the vowels. Taken together, these findings help advance theoretical foundations in sound-taste correspondences as well as provide practical contributions to the food practitioners to develop predictive product names.

Keywords: Crossmodal correspondences; Sound symbolism; Tastes; Brand names; Vowels; Consonants.

INTRODUCTION

Imagine entering a store and seeing two competing new food products, one named "Fesi", and the other "Gebi". What would you expect each product to taste like? For example, which product do you think would taste sweeter, and which more bitter? Based on the results of the research reported here, the likelihood is that you will regard "Fesi" as the sweeter product while "Gebi" probably sounds a little more bitter to you. Choosing the name for a product is a key element in brand identity (Klink, 2000, 2001, 2003; Kohli & LaBahn, 1997; Marx, 2018). No wonder, then, that such naming decisions are expected to be amongst the most important marketing decisions (Trout & Ries, 1981). Indeed, it has been noted that top brand names have different sound patterns than do general brand names (Bergh, Collins, Schultz, & Adler, 1984; Schloss, 1981; Van Doorn, Paton, & Spence, 2016). Brand naming strategies have also been shown to influence recall and preference (e.g., Lowrey, Shrum, & Dubitsky, 2003; Meyers-Levy, Louie, & Curren, 1994).

New brands (and hence brand names) are being created all the time, with marketing managers faced with the task of selecting the most appropriate brand names whenever they launch a new product. Creating successful new brand names is undoubtedly big business. For instance, one brand naming firm, Lexicon Branding, Inc., has created brand names that are currently associated with several billion dollar brands (e.g., Dasani, BlackBerry, Febreze) and has global food and beverage industry clients such as Coca-Cola, Nestlé, and Bacardi. Thus, it is important to understand how and why it is that brand names influence consumers' perceptions and behaviours, even when they carry no obvious semantic meaning. Based on the available research on the crossmodal correspondence between speech sounds and tastes, as well as the literature on sound symbolism, here we systematically study how and why it is that consumers perceive tastes as a function of the speech sounds that are associated with brand names.

Sound symbolism and brand names

Sound symbolism refers to the non-arbitrary mappings that have been demonstrated between the sound of an utterance and perceptual and/or semantic elements (Lockwood & Dingemanse, 2015). In other words, people reliably infer meanings from speech sounds in a manner that is surprisingly consistent (e.g., Guevremont & Grohmann, 2015; Klink, 2000, Knoeferle, Li, Maggioni, & Spence, 2017; Pathak, Calvert, & Velasco, 2017; Pogacar, Plant, Rosulek, & Kouril, 2015; Sidhu & Pexman, 2019; Sidhu, Pexman, & Saint-Aubin, 2016;

Spence, 2012; Walker, 2016; Yorkston & Menon, 2004). One of the most oft-cited examples is the so-called maluma-takete effect (Köhler, 1929, 1947), often referred to as the bouba-kiki effect since Ramachandran and Hubbard (2001). This is the name given to the finding that people show striking agreement in their preferred names for objects in a forced-choice task. For example, "maluma" and "bouba" are more likely to be matched to a round shape, whereas "kiki" and "takete" are more likely to be matched with a sharp shape instead.

It has been suggested by a number of researchers that sound symbolism represents a useful basis for creating persuasive brand names (e.g., Klink, 2000, 2001, 2003; Yorkston & Menon, 2004). Indeed, naming based on sound symbolism has been studied extensively in recent years. Previous studies have shown that the speech sounds that are incorporated into brand names can influence how consumers perceive a brand (Klink, 2000; Yorkston & Menon, 2004). For instance, it has been demonstrated that brand names are capable of communicating physical information about a product's characteristic features (e.g., its size, strength, weight, personality, etc., Klink, 2000; Klink & Athaide, 2012), food attributes (such as creaminess and richness, Yorkston & Menon, 2004), as well as attributes of chemotherapy medications that are deemed more tolerable (such as smallness, fastness, lightness, Abel & Glinert, 2008). Moreover, sound symbolically appropriate brand names are likely to increase 'processing fluency' and this, in turn, may lead to increased chance of brand success (e.g., higher stock prices for companies; Alter & Oppenheimer, 2006). Taken together, the extant sound symbolism research on demonstrates how the individual speech sounds can contain meaning that may be useful in developing a new brand name (e.g., Guevremont, & Grohmann, 2015; Klink 2000, Knoeferle et al., 2017; Pathak et al., 2017; Pogacar et al., 2015; Spence, 2012; Yorkston & Menon 2004). It is, though, important to note that multiple meanings can be associated with a given brand name, depending on, amongst other things, the context/goals of the consumer (e.g., when the consumer is thinking about taste, or perhaps a brand attribute, such as whether the brand is luxury or not, Pathak et al., 2017). As we will see below, one such important sound symbolic meaning in the world of food and beverage is a product's taste.

Crossmodal correspondences between sounds and tastes

People map features in one sensory modality onto features in other modalities in a manner that turns out to be surprisingly consistent. These interactions between various different senses are referred to as crossmodal correspondences (see Spence, 2011, 2012, for reviews). A growing body of experimental evidence has recently shown a variety of crossmodal correspondences, such as between tastes and sounds (e.g., see Knöferle & Spence, 2012;

Motoki, Saito, Nouchi, Kawashima, & Sugiura, 2019a; Reinoso-Carvalho, Wang, van Ee, Persoone, & Spence, 2017;Spence, Reinoso-Carvalho, Velasco, & Wang, 2019; for reviews), tastes and shapes (Velasco, Woods, Petit, Cheok, & Spence, 2016), sounds and shapes (Spears, Ketron, & Cowan, 2016; Spence, 2012), odor and sounds (see Deroy, Crisinel, & Spence, 2013, for a review), and warmth and color (Motoki, Saito, Nouchi, Kawashima, & Sugiura, 2019b; see Spence, submitted, for a review), to mention just a few.

Relevant to the present study, previous research has documented correspondences between speech sounds and tastes (Crisinel, Jones, & Spence, 2012; Fónagy, 1963, 2001; Gallace & Spence, 2011; Ngo, Misra, & Spence, 2011; Ngo & Spence, 2011; Spence & Gallace, 2011). Words such as 'Ruki', 'Takete', 'Kiki', and 'Dectar' are typically associated with sourness, while 'Lula', 'Maluma', 'Bouba', and 'Bobolo' are often related to sweetness (Crisinel et al., 2012). Dark and mint chocolates appear to correspond with sharp speech sounds (e.g., "Tuki" and "Takete"), while milk chocolate appears to be related to rounded speech sounds instead (e.g., "Lula" and "Maluma", Ngo & Spence, 2011). "Tuki" and "Takete" are associated with 90% cocoa chocolates, whereas "Maluma" and "Lula" are linked with creamy milk chocolate instead (Ngo et al., 2011). "Kiki" and "Takete" are associated with salt and vinegar flavoured crisps/potato chips rather than with cheddar cheese, yoghurt, or blueberry jam (Gallace & Spence, 2011). Sparkling water, cranberry juice, and Maltesers (chocolate-covered malt honeycomb) are reliably associated with 'Kiki' and 'Takete', whereas still water, Brie, and Caramel Nibbles (chocolate-covered caramel) are matched with 'Bouba' and 'Maluma' instead (Spence & Gallace, 2011).

The majority of studies point to the idea that specific properties of speech sounds are associated with gustatory taste qualities in a manner that is non-random. At the same time, however, most previous studies have used the same limited set of words (e.g., 'Maluma', 'Kiki', 'Takete', 'Lula'), following the tradition established by the pioneering early studies. These studies, however, have not manipulated different speech sounds, such as those typically used in brand names and other words which may influence the extent to which a given taste is associated with the name. Typically-used words (e.g., 'Takete') include vowels (e.g., [a], [e]), and consonants (e.g., [t], [k]). Respective influences of vowels and consonants on the association between speech sounds and abstract shapes have been investigated previously (Nielsen & Rendall, 2013). To the best of our knowledge, no such research has yet investigated taste-sound correspondences by systematically varying the vowels and consonants, and therefore, their corresponding sound symbolism, in particular, as in relation to taste. That being said, see Fónagy (1963, 2001) for putative associations between vowel sounds and gustatory tastes, and Topolinski and Boecker (2016), for associations between the direction of consonantal articulation of artificial names and associated estimated food palatability). But which of these contributes more or less to the strength of the association between speech sounds and each basic taste (sweet/sour/salty/bitter)? And what are the respective contributions of vowels and consonants?

Vowels and consonants

The sounds of an utterance can be categorized broadly into vowels and consonants. Vowels consist of front/back vowel. Front vowels include [i], [e] (e.g., as in the word 'Kiki'), while back vowels have [a], [u], [o] (e.g., as in the word 'Maruma'). When we produce [i], [e], the tongue is positioned relatively to the front of the mouth. When we produce [a], [u], [o] sounds, the tongue is positioned relatively to the back of the mouth instead. Consonants can be classified into affricate consonants: fricative and stop. Fricative consonants include [f], [s], [v], [z] (e.g., as in 'Surf'), while stop consonants include [p], [t], [k], [b], [d], [g] (e.g., as in 'Put'). Put simply, a fricative consonant is a speech sound that is created by friction. A stop consonant is a sound that is created by stopping the air, then suddenly letting it out. Additionally, the fricative/stop consonants can be divided into subcategories of consonant: namely voiceless and voiced. Voiceless consonants include [p], [t], [k] sounds (e.g., 'Pick'), while voiced consonants include [b], [d], [g] sounds (e.g., 'Bird'). Voiceless means the vocal cords do not vibrate while producing the sound, whereas in voiced consonants they do.

Hypothesis development

We established our hypothesis based on the transitivity hypothesis of crossmodal correspondences. Namely, if dimension A in one sensory modality (e.g., taste) corresponds with dimension B in another modality/or dimension (e.g., auditory pitch), and dimension B corresponds with dimension C (e.g., vowels, consonants) in third modalities/or dimensions, then people may associate dimensions A and C in a predictable manner (Deroy et al., 2013; Fields, Verhave, & Fath, 1984). It has been shown that both tastes and sound symbolic words correspond with frequency/pitch variations. Front (vs. back) vowels, fricative (vs. stop) consonants (Ohala, 1994), and voiceless (vs. voiced) consonants (House & Fairbanks, 1953; Ohde, 1984) have higher frequency/pitch. Sweet and sour tastes are often associated with high-frequency/pitch sounds, while salty and bitter taste are preferentially associated with low-frequency/pitch sound (Crisinel & Spence, 2009, 2010; Knoeferle, Woods, Käppler, & Spence, 2015; Reinoso-Carvalho, Wang, De Causmaecker, Steenhaut, van Ee, & Spence, 2016, though see also Simner, Cuskley, & Kirby, 2010).

It has also been shown that tastes and speech sounds are associated with connotative and affective meanings. Front (vs. back) vowels, fricative (vs. stop) consonants and voiceless (vs. voiced) consonants are associated with small, fast, soft, light, femininity, and pleasant (vs. large, slow, hard, heavy, masculinity, and unpleasant) (Guevremont & Grohmann, 2015; Klink, 2000; Miron, 1961). Sweet and sour tastes are associated with connotative meanings similar to front vowels, fricative consonants, and voiceless consonants (e.g., soft, femininity, and pleasantness for sweetness, and light for sour; Crisinel et al., 2012), while salty and bitter tastes are associated with connotative meanings similar to back vowels, stop consonants, and voiced consonants (unpleasant and rough for bitterness, and unpleasant for saltiness; Crisinel et al., 2012). Moreover, here it is perhaps worth highlighting the fact that we are all born making stereotypical orofacial gestures with different tongue positions in response to different basic tastes (see Spence, 2012, for a review). Babies protrude their tongue out and up in response to sweetness, whereas the tongue goes out and down in response to bitterness (Steiner, Glaser, Hawilo, & Berridge, 2001). In fact, according to an early study, people report [i] (front vowel: the tongue in the front of the mouth) to be sweeter and less bitter than [u] (back vowel: the tongue in the back of the mouth) (Fónagy, 1963). Based on the transitivity hypothesis of crossmodal correspondences, the prediction can be made that front (vs. back) vowels, fricative (vs. stop) consonants, and voiceless (vs. voiced) consonants will correspond with sweet and sour (vs. salty and bitter) tastes.

With the aforementioned ideas in mind, in this study, we aimed to systematically study taste-speech sound correspondences. Based on the theory of crossmodal correspondences, we investigated the association between both vowels and consonants and tastes (sweet/sour/salty/bitter). Across a series of three experiments, we systematically varied vowels (front/back) and two types of consonants (fricative/stop and voiced/voiceless). The participants read brand names silently and then rated the expected taste. Note that mere silent reading is sufficient for the elicitation of sound symbolism because overt pronunciation by silent reading has been shown to elicit automatic subvocal pronunciation (e.g., Topolinski & Strack, 2009). In fact, previous research had participants read brand names silently, and they documented a significant sound symbolism effect (e.g., Coulter & Coulter, 2010; Klink, 2000). Additionally, in real settings, consumers usually perceive product names by just reading silently, and it seems that the silent reading of brand names has more ecological validity than reading them out aloud. Thus, in the present experiments, the brand names were read silently. Indeed, the significant results obtained suggest that the participants were doing as told.

METHODS

Design

The study had a 2 (vowels: front, back) × 2 (affricate consonants: fricative, stop) × 2 (voiceless/voiced consonants: voiceless, voiced) in which all factors were manipulated within-participants. The dependent variable was ratings of the expected taste (sweet, sour, salty, and bitter).

Participants

Data were collected from 317 participants (108 for Experiment 1, 108 for Experiment 2, 101 for Experiments 3). The final data of experiment 1 included 108 participants (50 female, mean age of 40.2 years, SD = 9.8). The sample sizes were determined based on recent crossmodal research using expected tastes and online experiments (Velasco, Beh, Le, & Marmolejo-Ramos, 2018). The final data from Experiment 2 included 105 participants (51 female, mean age of 40.3 years, SD = 9.4, we excluded the data from two participants given that more than 90% responses were the same number, one additional participant whose demographic data was missing). The final data for Experiment 3 included 99 participants (32 female, mean age of 39.7 years, SD = 9.9, we excluded the data from two participants whose responses were the same on 90% of trials). The participants were recruited on Lancers (https://www.lancers.jp/) and completed the survey on Qualtrics (https://www.qualtrics.com/jp/). Each platform allowed the participants to receive monetary compensation in return for completing the studies (200 JPY: or about 2 USD). This study was approved by the ethics committee of the School of Medicine at Tohoku University and was conducted in accordance with the Declaration of Helsinki (Ref: 2018-1-556).

Stimuli

We systematically varied vowels (front/back) and two types of consonants (fricative/stop and voiced/voiceless) in order to create the experimental stimuli. To increase the generalizability of our results, different patterns of stimuli were used for the three experiments (Experiments 1, 2, 3a, and 3b). The experimental stimuli are shown in Table 1.

Table 1. The stimuli used in this study.

			Vowel	
			Front	Back
			i *e*	*a* *o* *u*
Fricative	Voiceless	*f* *s*	Sefi	Sufo
	Voiced	*z* *v*	Zevi	Zuvo
Stop	Voiceless	*p* *t* *k*	Tepi	Tupo
	Voiced	*b* *d*	Gebi	Gubo

Stimuli for Experiment 1

			Vowel	
			Front	Back
			i *e*	*a* *o* *u*
Fricative	Voiceless	*f* *s*	Fise	Fosu
	Voiced	*z* *v*	Vize	Vozu
Stop	Voiceless	*p* *t* *k*	Pite	Potu
	Voiced	*b* *d*	Bige	Bogu

Stimuli for Experiment 2

			Vowel	
			Front	Back
			i *e*	*a* *o* *u*
Fricative	Voiceless	*f* *s*	Sife	Sufa
	Voiced	*z* *v*	Zive	Zuva
Stop	Voiceless	*p* *t* *k*	Tike	Tuka
	Voiced	*b* *d*	Bide	Buda

Stimuli for Experiment 3a

			Vowel	
			Front	Back
			i *e*	*a* *o* *u*
Fricative	Voiceless	*f* *s*	Fesi	Faso
	Voiced	*z* *v*	Vezi	Vazo
Stop	Voiceless	*p* *t* *k*	Kepi	Kapo
	Voiced	*b* *d*	Debi	Dabo

Stimuli for Experiment 3b

Note: Across experiments, we systematically varied vowels (front: [i][e], back: [a][o][u]), and affricate consonants (fricative: [f][s][z][v], stop: [p][t][k][b][d]) as well as voiced/voiceless consonants (voiced: [z][v][b][d], voiceless: [f][s][p][t][k]).

Taste association task

The participants saw brand names, and had to rate the expected intensity of each taste for each of the stimuli. They responded with the taste that they expected such a product to have (sweet, sour, salty, or bitter) on a visual analog scale (VAS) ranging from 0 (not at all) to 100 (very much). The participants rated sweet (How sweet would you expect a product with this name?), sour (How sour would you expect a product with this name?), salty (How salty would you expect a product with this name?), and bitter (How bitter would you expect a product with this name?). The original rating questions (in Japanese) are shown in Appendix Figure A. In total, there were eight trials (all combinations of vowels and consonants) in which the participants matched each brand name with the expected tastes. After that, the participants also saw the same brand names and answered the valence (preference) question for each name (How do you feel about this product with this name?), using VAS from (very negative) to 100 (very positive). The order in which the brand names were presented was randomized across participants. The order of tastes was also randomized. Although some research on crossmodal correspondences has used actual tastants (Saluja & Stevenson, 2018; Velasco, Woods, Deroy, & Spence, 2015), we used taste words instead. Although there are more basic tastes including umami (Rosenstein, & Oster, 1988), we used the four most familiar basic tastes based on the previous studies using basic taste words (e.g., Spence, Wan, Woods, Velasco, Deng, Youssef, & Deroy, 2015; Velasco, Woods, Hyndman, & Spence, 2015; Velasco, Woods, Marks, Cheok, & Spence, 2016).

Statistical Analysis

An analysis of variance (ANOVA) was conducted in order to assess the effects of vowels and two types of consonants on the expected taste of the product. The within-participant design included a 2 (vowels: front, back) × 2 (affricate consonants: fricative, stop) × 2 (voiceless/voiced consonants: voiceless, voiced) design. The dependent variable was ratings of expected tastes (sweetness, sourness, saltiness, or bitterness) and preference. First, we ran the analysis for each experiment (Experiment 1, 2, 3a, 3b), separately (see Table 2 for statistical summaries and Appendix figures for illustrations of the results). Thereafter, we ran the analysis on the combined data from all three experiments (see also Table 2 for statistical summaries and Figure 1 for the illustrations of each result). The mean and SD of expected tastes and preference ratings were shown in Appendix Table A-E (Experiment 1, 2, 3a, 3b, and the combined data from all three experiments). We mainly focused on main effects of each factor. Whenever a significant interaction term was observed, a post-hoc analysis was conducted in order to understand the interaction in more detail. The post-hoc analysis was conducted using Shaffer's modified sequentially rejective Bonferroni procedure. Note that only significant results ($p < .05$) are reported. The measures of effect sizes used for the ANOVA were the partial eta square ($\eta 2p$). Additionally, we ran correlation analysis to test how taste ratings are related to preferences, using all trials of the combined data. All statistical analyses were conducted using R software (R core Team, 2017). All ANOVA and subsequent multiple testings were conducted using anovakun, a package of R software (Iseki, 2013).

Table 2. Statistical summaries of ANOVA with vowel, fricative/stop consonant, and voiceless/voiced consonants as independent factors.

		Experiment 1			Experiment 2			Experiment 3a			Experiment 3b			Combined all experiments		
	Effect	***F***	***p*-value**	**ηp2**	***F***	***p*-value**	**ηp2**	***F***	***p*-value**	**ηp2**	***F***	***p*-value**	**ηp2**	***F***	***p*-value**	**ηp2**
Sweetness	Vowel	21.42	<.001	0.167	12.42	<.001	0.107	0.44	.507	0.005	5.64	.020	0.054	27.24	<.001	0.062
	Fricative/stop	13.75	<.001	0.114	97.55	<.001	0.484	84.30	<.001	0.462	2.13	.148	0.021	102.27	<.001	0.200
	Voiceless/voiced	26.43	<.001	0.198	78.40	<.001	0.430	53.34	<.001	0.353	17.17	<.001	0.149	160.30	<.001	0.281
	Vowel × Fricative/stop	7.00	.009	0.061	16.72	<.001	0.139	1.69	.197	0.017	11.92	<.001	0.108	32.67	<.001	0.074
	Vowel × Voiceless/voiced	5.25	.024	0.047	2.93	.090	0.027	0.23	.632	0.002	0.15	.701	0.002	3.70	.055	0.009
	Fricative/stop ×Voiceless/voiced	7.12	.009	0.062	0.17	.685	0.002	92.17	<.001	0.485	0.71	.403	0.007	9.45	.002	0.023
	Vowel× Fricative/stop × Voiceless/voiced	28.88	.000	0.213	12.60	<.001	0.108	0.13	.718	0.001	45.71	<.001	0.318	1.03	.311	0.003
Sourness	Vowel	0.12	.725	0.001	1.48	.227	0.014	0.50	.479	0.005	13.01	.001	0.117	1.96	.163	0.005
	Fricative/stop	6.11	.015	0.054	5.44	.022	0.050	1.01	.316	0.010	0.71	.400	0.007	0.36	.548	0.001
	Voiceless/voiced	9.60	.003	0.082	2.99	.087	0.028	0.03	.855	0.000	0.02	.878	0.000	5.44	.020	0.013
	Vowel × Fricative/stop	2.17	.143	0.020	3.32	.071	0.031	14.35	<.001	0.128	0.35	.556	0.004	14.92	<.001	0.035
	Vowel × Voiceless/voiced	0.09	.763	0.001	12.62	<.001	0.108	0.42	.520	0.004	1.06	.305	0.011	1.51	.219	0.004
	Fricative/stop ×Voiceless/voiced	0.11	.738	0.001	0.11	.738	0.001	3.31	.072	0.033	0.99	.322	0.010	2.60	.108	0.006
	Vowel× Fricative/stop × Voiceless/voiced	0.46	.499	0.004	0.71	.401	0.007	0.39	.535	0.004	4.22	.043	0.041	2.01	.157	0.005
Saltiness	Vowel	6.41	.013	0.057	2.58	.111	0.024	0.04	.837	0.000	0.01	.934	0.000	3.32	.069	0.008
	Fricative/stop	0.79	.376	0.007	13.55	<.001	0.115	4.66	.033	0.045	0.00	.987	0.000	12.52	<.001	0.030
	Voiceless/voiced	8.16	.005	0.071	2.04	.157	0.019	8.33	.005	0.078	5.39	.022	0.052	21.45	<.001	0.050
	Vowel × Fricative/stop	6.41	.013	0.057	2.20	.141	0.021	0.06	.805	0.001	1.39	.242	0.014	5.41	.021	0.013
	Vowel × Voiceless/voiced	0.02	.881	0.000	0.01	.917	0.000	6.38	.013	0.061	4.63	.034	0.045	6.33	.012	0.015
	Fricative/stop ×Voiceless/voiced	0.00	.984	0.000	2.30	.133	0.002	37.27	<.001	0.276	0.29	.592	0.003	15.73	<.001	0.037
	Vowel× Fricative/stop × Voiceless/voiced	0.00	.952	0.000	0.63	.431	0.022	1.34	.251	0.014	0.00	.944	0.000	0.07	.795	0.000
Bitterness	Vowel	2.23	.139	0.020	3.44	.067	0.032	3.44	.067	0.032	2.08	.153	0.021	4.94	.027	0.012
	Fricative/stop	20.50	<.001	0.161	59.20	<.001	0.363	59.20	<.001	0.363	3.45	.066	0.034	25.70	<.001	0.059
	Voiceless/voiced	95.51	<.001	0.472	183.12	<.001	0.638	183.12	<.001	0.638	34.72	<.001	0.262	302.37	<.001	0.425
	Vowel × Fricative/stop	12.09	<.001	0.102	8.14	.005	0.073	8.14	.005	0.073	0.11	.738	0.001	8.13	.005	0.019
	Vowel × Voiceless/voiced	6.51	.012	0.057	0.01	.928	0.000	0.01	.928	0.000	5.26	.024	0.051	6.59	.011	0.016
	Fricative/stop ×Voiceless/voiced	17.13	<.001	0.138	21.87	<.001	0.174	21.87	<.001	0.174	0.59	.443	0.006	1.01	.317	0.002
	Vowel× Fricative/stop × Voiceless/voiced	11.56	<.001	0.098	11.56	<.001	0.098	11.56	<.001	0.098	5.65	.019	0.055	5.51	.019	0.013
Preference	Vowel	65.12	<.001	0.378	66.95	<.001	0.392	9.64	.003	0.090	29.80	<.001	0.233	151.55	<.001	0.270
	Fricative/stop	171.48	<.001	0.616	164.46	<.001	0.613	118.71	<.001	0.548	1.20	.277	0.012	294.71	<.001	0.418
	Voiceless/voiced	56.99	<.001	0.348	195.86	<.001	0.653	104.07	<.001	0.515	8.43	.005	0.079	268.28	<.001	0.396
	Vowel × Fricative/stop	7.45	.007	0.065	44.72	.007	0.301	4.97	.028	0.048	23.81	<.001	0.196	65.46	<.001	0.138
	Vowel × Voiceless/voiced	7.33	.008	0.064	0.05	.819	0.001	0.63	.429	0.006	0.11	.738	0.001	0.33	.568	0.001
	Fricative/stop ×Voiceless/voiced	3.16	.078	0.029	0.16	.690	0.002	21.33	<.001	0.179	31.12	<.001	0.241	2.29	.131	0.006
	Vowel× Fricative/stop × Voiceless/voiced	41.66	<.001	0.280	33.02	<.001	0.241	3.05	.084	0.030	19.08	<.001	0.163	18.48	<.001	0.043

RESULTS

Experiment 1

Expected sweetness. The analysis of the results of Experiment 1 revealed significant main effects of the vowels, the fricative/stop consonants, and the voiceless/voiced consonants. Front (vs. back) vowels, fricative (vs. stop) consonants, and voiceless (vs. voiced) consonants increased expected sweetness, respectively. There was a significant interaction between the vowels and the fricative/stop consonants. Fricative and stop consonants increased expected sweetness when the names included front (vs. back) vowels (fricative: $F_{1, 107} = 25.486$, $p < .001$, $\eta^2 p = 0.192$; stop: $F_{1, 107} = 4.798$, $p = .031$, $\eta^2 p = 0.043$). An interaction was also documented between the vowels and the voiceless/voiced consonants ($F_{1, 107} = 5.246$, $p = .024$, $\eta^2 p = 0.047$). Voiceless consonants increased expected sweetness when the names included front (vs. back) vowels ($F_{1, 107} = 23.439$, $p < .001$, $\eta^2 p = 0.180$). The expected sweetness of those products associated with brand names that included voiced consonants did not differ between front and back vowels ($F_{1, 107} = 3.480$, $p = .065$, $\eta^2 p = 0.032$). The interaction between the fricative/stop consonants and the voiceless/voiced consonants was also significant. Voiced consonants increased expected sweetness when the names included fricative (vs. stop) consonants ($F_{1, 107} = 28.829$, $p < .001$, $\eta^2 p = 0.212$), while the expected sweetness of voiceless consonants did not differ between fricative and stop consonants ($F_{1, 107} = 0.717$, $p = .399$, $\eta^2 p = 0.007$). The interaction terms were modulated by a significant three-way interaction between the vowels, the fricative/stop consonants, and the voiceless/voiced consonants. Specifically, when the names included back vowels, there was no significant interaction between the fricative/stop consonants and the voiceless/voiced consonants ($F_{1, 104} = 3.819$, $\eta^2 p = .053$, $\eta^2 = 0.035$), whereas when the names included front vowels, there was a significant interaction between the fricative/stop consonants and the voiceless/voiced consonants ($F_{1, 104} = 25.282$, $p < .001$, $\eta^2 p = 0.191$). For the data including front vowels, voiced consonants increased expected sweetness when the names included fricative (vs. stop) consonants ($F_{1, 104} = 49.326$, $p < .001$, $\eta^2 p = 0.316$), while the expected sweetness of voiceless consonants did not differ between fricative and stop consonants ($F_{1, 104} = 0.305$, $p = .582$, $\eta^2 p = 0.003$).

Expected sourness. There were significant main effects of the fricative/stop consonants and the voiceless/voiced consonants: Fricative (vs. stop) consonants and voiceless (vs. voiced) consonants increased expected sourness, respectively.

Expected saltiness. There were main effects of the vowels and the voiceless/voiced consonants. The main effects indicated that back (vs. front) vowels and voiced (vs. voiceless) consonants increased expected saltiness, respectively. There was a significant interaction between the vowels and the fricative/stop consonants. Fricative consonants increased expected saltiness when the names include front (vs. back) vowels ($F_{1, 107}$ = 10.788, p = .001, η^2p = 0.092), whereas the expected saltiness of stop consonants did not differ between front and back consonants ($F_{1, 107}$ = 0.091, p = .763, η^2p = 0.001).

Expected bitterness. There were main effects of the fricative/stop consonants and the voiceless/voiced consonants, indicating that stop (vs. fricative) consonants and voiced (vs. voiceless) consonants increased expected bitterness, respectively. There was a significant interaction between the vowels and the fricative/stop consonants. That is, fricative consonants increased expected bitterness when the names included back (vs. front) vowels ($F_{1, 107}$ = 9.112, p = .003, η^2p = 0.103), while the expected bitterness of the stop consonants did not differ between the front and back vowels ($F_{1, 107}$ = 1.662, p = .200, η^2p = 0.015).

There was an interaction between the vowels and the voiceless/voiced consonants, with those products associated with brand names with voiceless consonants increasing expected bitterness when the names include back (vs. front) vowels ($F_{1, 107}$ = 9.112, p = .003, η^2p = 0.0785), while the expected bitterness of voiced consonants did not differ between the front and back vowels ($F_{1, 107}$ = 0.148, p = .701, η^2p = 0.001). There was also a significant interaction of the fricative/stop consonants and the voiceless/voiced consonants. Voiced consonants increased expected bitterness when the names include stop (vs. fricative) consonants ($F_{1, 107}$ = 31.738, p < .001, η^2p = 0.229), while the expected bitterness of voiceless consonants did not differ between fricative and stop consonants ($F_{1, 107}$ = 1.245, p = .267, η^2p = 0.012). A significant three-way interaction indicated that the two-way interaction was modified by the front/back vowels. When the brand names included front vowels, a significant interaction between the fricative/stop consonants and the voiceless/voiced consonants was observed ($F_{1, 107}$ = 26.058, p < .001, η^2p = 0.023). Voiced consonants increased the expected bitterness of fricative (vs. stop) consonants ($F_{1, 107}$ = 41.737, p < .001, η^2p = 0.108), whereas the expected bitterness of voiceless consonants did not differ between fricative and stop consonants ($F_{1, 107}$ = 1.116, p = .293, η^2p = 0.010). In contrast, when the names included back vowels, no significant interaction of the fricative/stop consonants and the voiceless/voiced consonants was observed ($F_{1, 107}$ = 0.099, p = .754, η^2p = 0.001).

Preference ratings The analysis revealed significant main effects of the vowels, the fricative/stop consonants, and the voiceless/voiced consonants. The main effects indicated that front (vs. back) vowels, fricative (vs. stop) consonants and voiceless (vs. voiced) consonants increased preference for the brand names, respectively. There was a significant interaction between the vowels and the fricative/stop consonants. Fricative and stop consonants increased preference for the brand names when the names included front (vs. back) vowels (fricative: $F_{1, 107} = 48.944$, $p < .001$, $\eta^2p = 0.314$; stop: $F_{1, 107} = 19.895$, $p < .001$, $\eta^2p = 0.157$). These interactions were qualified by a significant three-way interaction. When the names included voiceless consonants, significant interactions between the vowels and the fricative/stop consonants were observed ($F_{1, 107} = 5.727$, $p = .019$, $\eta^2p = 0.051$). Fricative and stop consonants increased preference for the brand names when the names included front (vs. back) vowels (fricative: $F_{1, 107} = 19.116$, $p < .001$, $\eta^2p = 0.152$; stop: $F_{1, 107} = 42.354$, $p < .001$, $\eta^2p = 0.284$). However, the data set including voiced consonants show differential effects ($F_{1, 107} = 40.449$, $p < .001$, $\eta^2p = 0.274$). Specifically, fricative consonants increased preference for the brand names when the names included front (vs. back) vowels ($F_{1, 107} = 52.691$, $p < .001$, $\eta^2p = 0.330$), while the preference ratings of stop consonants did not differ as a function of whether the vowel was front or back ($F_{1, 107} = 2.262$, $p = .136$, $\eta^2p = 0.021$). There was also a significant interaction between the vowels and voiceless/voiced consonants. Voiceless and voiced consonants increased preference for the brand names when the names included front (vs. back) vowels (voiceless: $F_{1, 107} = 58.829$, $p < .001$, $\eta^2p = 0.355$; voiced: $F_{1, 107} = 21.291$, $p < .001$, $\eta^2p = 0.166$).

Experiment 2

Expected sweetness. The analysis of the data from Experiment 2 revealed significant main effects of the vowels, the fricative/stop consonants, and the voiceless/voiced consonants. The main effects indicated that front (vs. back) vowels, fricative (vs. stop) consonants, and voiceless (vs. voiced) consonants increased expected sweetness, respectively. There was also a significant interaction between the vowels and fricative/stop consonants. Front and back vowels increased expected sweetness when the names included fricative (vs. stop) consonants ($F_{1, 104} = 21.596$, $p < .001$, $\eta^2p = 0.172$), while the expected sweetness of stop consonants did not differ between front and back vowels ($F_{1, 104} = 0.079$, $p = .780$, $\eta^2p = 0.001$). The interactions were modulated by a significant three-way interaction between the vowels, the fricative/stop consonants, and voiceless/voiced consonants ($F_{1, 104} = 12.604$, $p < .001$, $\eta^2p = 0.108$). When the data were divided into voiceless and voiced consonants, differential interactions were observed. When the names included voiceless consonants, there was no significant interaction between vowels and fricative/stop consonants ($F_{1, 104} = 0.004$, $p = .950$, $\eta^2p = 0.000$), whereas when the names included voiced consonants, there was a significant interaction between the vowels and fricative/stop consonants ($F_{1, 104} = 30.638$, $p < .001$, $\eta^2p = 0.228$). Fricative consonants increased expected sweetness when the names included front (vs. back) vowels ($F_{1, 104} = 19.050$, $p < .001$, $\eta^2p = 0.155$), while stop consonants increased expected sweetness when the brand names included back (vs. front) vowels ($F_{1, 104}$ = 8.910, p = .004, η^2p = 0.079).

Expected sourness. There was a main effect of fricative/stop consonants ($F_{1, 104}$ = 5.437, p = .022, η^2p = 0.050) with products with brand names that included stop consonants increasing expected sourness than those with fricative consonants. There was a significant interaction of the vowels and voiced/voiceless consonants ($F_{1, 104}$ = 12.624, p < .001, η^2p = 0.108). Voiceless consonants increased expected sourness when the names included back (vs. front) vowels ($F_{1, 104}$ = 11.491, p = .001, η^2p = 0.010), whereas the expected sourness of voiced consonants did not differ between the front and back vowels ($F_{1, 104}$ = 2.325, p = .130, η^2p = 0.022).

Expected saltiness. The main effect of fricative/stop consonants was significant ($F_{1, 104}$ = 13.550, p < .001, η^2p = 0.115), such that stop consonant increased expected saltiness than fricative consonants.

Expected bitterness. There were main effects of the fricative/stop consonants as well as of the voiceless/voiced consonants. The main effects indicated that stop (vs. fricative) vowels and voiced (vs. voiceless) consonants increased expected bitterness, respectively. There was a significant interaction between the vowels and fricative/stop consonants. Fricative consonants increased expected bitterness when the names included back (vs. front) vowels ($F_{1, 104}$ = 11.288, p = .001, η^2p = 0.098), while the expected bitterness of those products associated with brand names that incorporated stop consonants did not differ between front and back vowels ($F_{1, 104}$ = 0.613, p = .436, η^2p = 0.006). In contrast, no significant interaction between the vowels and voiced/voiceless consonants was observed.

There was also a significant interaction between the fricative consonants and voiced/voiceless consonants. Those products associated with voiceless and voiced consonants increased expected bitterness when the names included stop (vs. fricative) consonants (voiceless: $F_{1, 104}$ = 11.018, p = .001, η^2 = 0.096; voiced: $F_{1, 104}$ = 54.311, p < .001, η^2p = 0.343). Additionally, the interactions were modulated by a significant three-way interaction. Specifically, when the names included front vowels, there was a significant interaction of the fricative consonants and the voiced/voiceless consonants ($F_{1, 104}$ = 26.285, p < .001, η^2p = 0.202). Voiceless and voiced consonants increased the expected bitterness of stop (vs. fricative) consonants (voiceless: $F_{1, 104}$ = 5.442, p = .022, η^2p = 0.050; voiced: $F_{1, 98}$ = 50.013, p < .001, η^2p = 0.325). In contrast, when the names included back vowels, a significant interaction of the fricative/stop consonants and the voiceless/voiced consonants was not observed ($F_{1, 104}$ = 2.098, p = .151, η^2p = 0.020).

Preference ratings. Significant main effects of the vowels, the fricative/stop consonants, and the voiceless/voiced consonants were documented. The main effects indicated that front (vs. back) vowels, fricative (vs. stop) consonants, and voiceless (vs. voiced) consonants increased preference for the brand names, respectively.

There was a significant interaction of the vowels and fricative/stop consonants. Fricative and stop consonants increased preference for the brand names when the names included front (vs. back) vowels (fricative: $F_{1,\,104} = 97.141$, $p < .001$, $\eta^2p = 0.483$; stop: $F_{1,\,107} = 4.822$, $p < .001$, $\eta^2p = 0.044$). These interactions were qualified by a significant three-way interaction. When the dataset was split by voiceless/voiced consonants, differential effects emerged. When the names included voiceless consonants, there was no interaction between the vowels and the fricative/stop consonants ($F_{1,\,104} = 0.098$, $p = .755$, $\eta^2p = 0.001$). In contrast, when the names included voiced consonants, there was a significant interaction ($F_{1,\,104} = 87.733$, $p < .001$, $\eta^2p = 0.458$). Fricative consonants increased preference for the brand names when the names included front (vs. back) vowels ($F_{1,\,104} = 92.816$, $p < .001$, $\eta^2p = 0.472$), while preference ratings for the stop consonants did not differ as a function of whether the vowels were front or back ($F_{1,\,104} = 2.770$, $p = .099$, $\eta^2p = 0.026$).

Experiment 3a

Expected sweetness. The analysis revealed significant main effects of the fricative/stop consonants and the voiceless/voiced consonants. The main effects indicated that fricative (vs. stop) consonants and voiceless (vs. voiced) consonants increased expected sweetness, respectively. A significant interaction between the fricative consonants and the voiced/voiceless consonants was also documented. The voiceless consonants increased expected sweetness when the names include fricative (vs. stop) consonants ($F_{1,\,104} = 123.365$, $p <.001$, $\eta^2p = 0.557$), while the expected sweetness of voiced consonants did not differ between the fricative and stop consonants ($F_{1,\,104} = 0.012$, $p = .913$, $\eta^2p = 0.000$).

Expected sourness. The analysis revealed a significant interaction of the vowels and the fricative/stop consonants. Fricative consonants increased expected sourness when the names included back (vs. front) vowels ($F_{1,\,98} = 4.470$, $p = .037$, $\eta^2p = 0.044$), while stop consonants increased expected sourness when the names included front (vs. back) vowels ($F_{1,\,98} = 12.706$, $p = .001$, $\eta^2p = 0.115$).

Expected saltiness. Significant main effects were observed in the fricative/stop consonants and the voiceless/voiced consonants. The main effects indicated that stop consonants and voiced consonants increased expected saltiness than fricative or voiceless consonants, respectively. There was a significant interaction between the vowels and the voiceless/voiced consonants. Voiced consonants increased expected saltiness when the brand names included back (vs. front) vowels ($F_{1, 98} = 2.528$, $p = .115$, $\eta^2p = 0.043$), while expected saltiness of voiceless consonants did not differ between front and back vowels ($F_{1, 98} = 4.384$, $p = .039$, $\eta^2p = 0.025$). There was also a significant interaction between the fricative/stop consonants and the voiceless/voiced consonants. Voiceless consonants increased expected saltiness when the brand names include stop (vs. fricative) consonants ($F_{1, 98} = 30.302$, $p < .001$, $\eta^2p = 0.236$), whereas voiced consonants increased expected saltiness when the names included fricative (vs. stop) consonants ($F_{1, 98} = 4.327$, $p = .040$, $\eta^2p = 0.042$).

Expected bitterness. A significant main effect was observed in the voiceless/voiced consonants, indicating that those products described by brand names that incorporated voiced (vs. voiceless) consonants increased expected bitterness. There was a significant interaction of the fricative/stop consonants and the voiceless/voiced consonants. Voiceless and voiced consonants increased expected bitterness when the names included stop (vs. fricative) consonants (voiceless: $F_{1, 98} = 19.312$, $p < .001$, $\eta^2p = 0.165$; voiced: $F_{1, 98} = 12.928$, $p = .001$, $\eta^2p =0.117$).

Preference ratings. The analysis revealed main effects of the vowels, the fricative/stop consonants as well as the voiceless/voiced consonants. The main effects indicated that front (vs. back) vowels, fricative (vs. stop) consonants, and voiceless (vs. voiced) consonants increased preference for the brand names, respectively. There was a significant interaction between the vowels and the fricative/stop consonants. Fricative consonants increased preference for the brand names when the names included front (vs. back) vowels ($F_{1, 98} = 14.239$, $p < .001$, $\eta^2p = 0.127$), while preference ratings for the stop consonants did not differ between the front and back vowels ($F_{1, 98} = 0.419$, $p = .519$, $\eta^2p = 0.004$). A significant interaction was also revealed between the fricative/stop consonants and the voiceless/voiced consonants. Voiceless and voiced consonants increased preference for the brand names when the names include fricative (vs. stop) vowels (voiceless: $F_{1, 98} = 111.090$, $p < .001$, $\eta^2p = 0.531$; voiced: $F_{1, 98} = 36.193$, $p < .001$, $\eta^2p = 0.270$).

Experiment 3b

Expected sweetness. There were main effects of the vowels as well as the voiceless/voiced consonants such that front (vs. back) vowels and voiceless (vs. voiced) consonants increased expected sweetness, respectively. There was a significant interaction between the vowels and the fricative/stop consonants. Those products that were associated with brand names containing fricative consonants increased expected sweetness when the names include front (vs. back) vowels ($F_{1, 98}$ = 18.471, p < .001, η^2p = 0.159), while the expected sweetness of stop consonants did not differ between front and back vowels ($F_{1, 98}$ = 0.367, p = .546, η^2p = 0.004).

A significant three-way interaction indicated that the two-way interaction was modified by the front/back vowels. By separating the data into front and back vowels, different interactions were observed. When the data set included front vowels, a significant interaction between the fricative/stop consonants and the voiceless/voiced consonants was observed ($F_{1, 98}$ = 13.956, p < .001, η^2p = 0.125) as well as in the data for the back vowels ($F_{1, 98}$ = 22.151, p < .001, η^2p = 0.184). When the names included front vowels, voiceless consonants increased the expected sweetness of fricative (vs. stop) consonants ($F_{1, 98}$ = 13.296, p < .001, η^2p = 0.120), while the expected sweetness of voiced consonants did not differ between the fricative and stop consonants ($F_{1, 98}$ = 3.030, p = .085, η^2p = 0.030). In contrast, when the faux brand names included back vowels, voiceless consonants increased the expected product sweetness of fricative (vs. stop) consonants ($F_{1, 98}$ = 31.585, p < .001, η^2p = 0.244). The expected sweetness of products associated with brand names containing voiced consonants did not differ between fricative and stop consonants ($F_{1, 98}$ = 1.342, p = .250, η^2p = 0.014).

Expected sourness. A significant main effect of the vowels was observed. The products whose brand names included front vowels increased expected sourness than the products with brand names that incorporated back vowels. The analysis revealed a significant three-way interaction between the vowels, the fricative/stop consonants, and the voiceless/voiced consonants. When the data was separated by fricative and stop consonants, different interactive effects were observed. When the dataset included fricative consonants, there was no significant interaction of the fricative/stop consonants and the voiceless/voiced consonants ($F_{1, 98}$ = 0.374, p = .543, η^2p = 0.004). By contrast, when the data set included stop consonants, a significant interaction of the fricative/stop consonants and the voiceless/voiced consonants was observed ($F_{1, 98}$ = 4.299, p = .041, η^2p = 0.042). Voiceless consonants increased expected sourness when the names included front (vs. back) vowels ($F_{1, 98}$ = 13.067, p < .001, η^2p = 0.118), while the expected sourness of voiced consonants did not differ between the front and back vowels ($F_{1, 98}$ = 0.173, p = .678, η^2p = 0.002).

Expected saltiness. There was a main effect of the voiceless/voiced consonants such that voiced consonants increased expected saltiness than voiceless consonants. A significant interaction was documented between the vowels and the voiceless/voiced consonants. Back vowels increased expected saltiness when the names include voiced (vs. voiceless) consonants ($F_{1, 98}$ = 8.257, p = .005, η^2p = 0.078), while the expected saltiness of front vowels did not differ between voiceless and voiced consonants ($F_{1, 98}$ = 0.001, p = .982, η^2p = 0.000).

Expected bitterness. There was a significant main effect for the voiceless/voiced consonants. The main effect indicated that voiced (vs. voiceless) consonants increased expected bitterness. A significant interaction was observed between the vowels and the voiceless/voiced consonants. Those products with brand names that incorporated voiceless consonants increased expected bitterness when including back (vs. front) vowels in the brand name ($F_{1, 98} = 6.843$, $p = .010$, $\eta^2 p = 0.065$), while the expected bitterness of voiced consonants did not differ between the front and back consonants ($F_{1, 98} = 0.272$, $p = .603$, $\eta^2 p = 0.003$). A significant three-way interaction indicated that the two-way interaction was modified by the front/back vowels. When the names include front vowels, there was a significant effect for the interaction of the fricative/stop consonants and the voiceless/voiced consonants ($F_{1, 98} = 4.590$, $p = .035$, $\eta^2 p = 0.045$). The impact on taste expectations of voiceless consonants did not differ between stop consonants and fricatives ($F_{1, 98} = 0.581$, $p = .448$, $\eta^2 p = 0.006$), while the voiced consonants increased the expected bitterness of fricative (vs. stop) consonants ($F_{1, 98} = 4.933$, $p = .029$, $\eta^2 p = 0.048$). When the names included back vowels, there was no interaction between the fricative/stop consonants and the voiceless/voiced consonants ($F_{1, 98} = 1.130$, $p = .291$, $\eta^2 p = 0.011$).

Preference ratings. Main effects of the vowels and the voiceless/voiced consonants were observed. The main effects indicated that front (vs. back) vowels and voiceless (vs. voiced) consonants increased preference for the brand names, respectively. A significant interaction was documented between the vowels and the fricative/stop consonants. Fricative consonants increased preference for the brand names when the names included front vowels rather than back ($F_{1, 98} = 45.381$, $p < .001$, $\eta^2 p = 0.317$), whereas preference ratings for stop consonants did not differ between front and back vowels ($F_{1, 98} = 0.385$, $p = .536$, $\eta^2 p = 0.004$). These interaction terms were qualified by a significant three-way interaction. Splitting the dataset by voiceless/voiced consonants, gave rise to differential effects. Specifically, for those datasets that included voiced consonants, there was not a significant interaction between the vowels and the fricative/stop consonants ($F_{1, 98} = 0.152$, $p = 0.698$, $\eta^2 p = 0.002$). By contrast, when the names included voiceless consonants, there was a significant interaction ($F_{1, 98} = 40.180$, $p < .001$, $\eta^2 p = 0.291$). Fricative consonants increased preference for the brand names when the names included front (vs. back) vowels ($F_{1, 98} = 45.904$, $p < .001$, $\eta^2 p = 0.319$), while preference ratings for the stop consonants did not differ between the front and back vowels ($F_{1, 98} = 3.438$, $p = .067$, $\eta^2 p = 0.034$). There was also a significant interaction of the fricative/stop consonants and the voiceless/voiced consonants. Voiceless and voiced consonants increased preference for the brand names when the names included fricative (vs. stop) vowels (voiceless: $F_{1, 98} = 9.446$, $p = .003$, $\eta^2 p = 0.088$; voiced: $F_{1, 98} = 20.455$, $p < .001$, $\eta^2 p = 0.173$).

Combining the data from all three experiments

To increase the generalizability of the findings, we ran the analysis on the combined data from all three experiments. The results and the summary of significant findings are shown in Figure 1, and Table 3, respectively.

Expected sweetness The analysis revealed significant main effects of the vowels, the fricative/stop consonants, and the voiceless/voiced consonants. The main effects indicated that front (vs. back) vowels, fricative (vs. stop) consonants, and voiceless (vs. voiced) consonants increased expected sweetness, respectively. There was a significant interaction between the vowels and the fricative/stop consonants. Those products that were given brand names associated with fricative consonants increased expected sweetness when the names include front (vs. back) vowels ($F_{1, 410} = 52.416$, $p < .001$, $\eta^2 p = 0.113$), while the expected sweetness of stop consonants did not differ between front and back consonants ($F_{1, 410} = 0.066$, $p = .798$, $\eta^2 p = 0.000$). There was also a significant interaction of the fricative/stop consonants and the voiceless/voiced consonants. Voiceless and voiced consonants increased expected sweetness when the names included fricative (vs. stop) consonants, respectively (voiceless consonants: $F_{1, 410} = 67.562$, $p < .001$, $\eta^2 p = 0.142$; voiced consonants: $F_{1, 410} = 39.675$, $p < .001$, $\eta^2 p = 0.088$).

Expected sourness. A significant main effect was observed in the voiceless/voiced consonants. The main effect indicated that voiceless consonants increased expected sourness than voiced consonants. There was a significant interaction between the vowels and fricative/stop consonants. Stop consonants increased expected sourness when the names included front, rather than back, vowels ($F_{1, 410} = 14.127$, $p < .001$, $\eta^2 p = 0.033$), while the expected sourness of fricative consonants did not differ between front and back vowels ($F_{1, 410} = 3.214$, $p = .074$, $\eta^2 p = 0.008$).

Expected saltiness. Significant main effects of the fricative/stop consonants and of the voiceless/voiced consonants were observed. The main effects indicated that stop and voiced consonants increased expected saltiness than fricative or voiceless consonants, respectively. There was a significant interaction between the vowels and fricative/stop consonants. In particular, fricative consonants increased expected saltiness when the product brand names include back (vs. front) vowels ($F_{1, 410} = 9.030$, $p = .003$, $\eta^2 p = 0.022$), while the expected saltiness of stop consonants did not differ between front and back vowels ($F_{1, 410} = 0.131$, $p = .718$, $\eta^2 p = 0.000$). A significant interaction between the vowels and the voiceless/voiced consonants was observed. Voiced consonants increased expected saltiness when the names included back rather than front vowels ($F_{1, 410}$ = 9.776, p = .002, $\eta^2 p$ = 0.023), while the expected saltiness of voiceless consonants did not differ between the front and back vowels ($F_{1, 410}$ = 0.140, p = .708, $\eta^2 p$ = 0.000). There was also a significant interaction between the fricative/stop consonants and the voiceless/voiced consonants. Voiceless consonants increased expected saltiness when the names included stop (vs. fricative) consonants ($F_{1, 410}$ = 27.463, p < .001, $\eta^2 p$ = 0.063), while the expected saltiness of faux brand names incorporating voiced consonants did not differ between the fricative and stop consonants ($F_{1, 410}$ = 0.018, p = .893, $\eta^2 p$ = 0.000).

Expected bitterness. The analysis revealed main effects of the vowels, the fricative/stop consonants, and the voiceless/voiced consonants. The main effects indicated that back (vs. front) vowels, stop (vs. fricative) consonants, and voiced (vs. voiceless) consonants increased expected bitterness, respectively. The analysis revealed a significant interaction of the vowels and the fricative/stop consonants. Fricative consonants increased expected bitterness when the brand names included back (vs. front) vowels ($F_{1, 410}$ = 13.081, p < .001, $\eta^2 p$ = 0.031), whereas the expected bitterness of the stop consonants did not differ between the front and back vowels ($F_{1, 410}$ = 0.131, p = .717, $\eta^2 p$ = 0.000). There was also a significant interaction between the vowels and the voiceless/voiced consonants. The products described by brand names that incorporated voiceless consonants increased expected bitterness when the names include back (vs. front) vowels ($F_{1, 410}$ = 14.997, p < .001, $\eta^2 p$ = 0.035), while the expected bitterness of voiced consonants did not differ between the front and back vowels ($F_{1, 410}$ = 0.020, p = .887, $\eta^2 p$ = 0.000). A significant three-way interaction indicated that the two-way interaction was modified by the front/back vowels. When the names included front vowels, a significant interaction between the fricative/stop consonants and the voiceless/voiced consonants was observed ($F_{1, 410}$ = 4.970, p = .026, $\eta^2 p$ = 0.012). Those products having brand names that incorporated voiceless and voiced consonants increased expected bitterness when the names included stop (vs. fricative) consonants (voiceless: $F_{1, 410}$ = 9.311, p = .002, $\eta^2 p$ = 0.022; voiced: $F_{1, 410}$ = 21.059, p < .001, $\eta^2 p$ = 0.049). For the data set including back vowels, no significant interaction between the fricative/stop consonants and the voiceless/voiced consonants was observed ($F_{1, 410}$ = 0.848, p = .358, $\eta^2 p$ = 0.002).

Preference ratings. The analysis revealed significant main effects of the vowels, the fricative/stop consonants, and the voiceless/voiced consonants. The main effects indicated that front (vs. back) vowels, fricative (vs. stop) consonants and voiceless (vs. voiced) consonants increased preference for the brand names, respectively. A significant interaction of the vowels and the fricative/stop consonants was also documented, with the fricative and stop consonants being preferred when the names included front rather than back vowels (fricative: $F_{1, 410}$ = 183.480, $p < .001$, $\eta^2 p = 0.309$; stop: $F_{1, 410}$ = 14.882, $p < .001$, $\eta^2 p = 0.035$). This interaction term was qualified by a significant three-way interaction. When the dataset was split by voiceless/voiced consonants, differential effects emerged. For the data sets including voiceless consonants, there was a significant interaction of the vowels and the fricative/stop consonants ($F_{1, 410}$ =5.495, p =.020, $\eta^2 p = 0.013$). Fricative and stop consonants increased preference for the brand names when the names included front rather than back vowels (fricative: $F_{1, 410}$ = 76.697, $p < .001$, $\eta^2 p = 0.158$; stop: $F_{1, 410}$ = 21.219, $p < .001$, $\eta^2 p = 0.049$). For the data set including voiced consonants, there was also a significant interaction ($F_{1, 410}$ = 80.520, $p < .001$, $\eta^2 p = 0.164$). Fricative consonants increased preference for the brand names when the names included front rather than back vowels ($F_{1, 410}$ = 142.464, $p < .001$, $\eta^2 p = 0.258$), while preference ratings for those products described by brand names that incorporated stop consonants did not differ between the front and back vowels ($F_{1, 410}$ = 0.006, p = .936, $\eta^2 p$ = 0.000).

Correlations. As in previous research (Carvalho, Wang, van Ee, Persoone, & Spence, 2017), we ran correlation analyses to test how taste ratings are related to preferences, using all trials of the combined data (Appendix Table F). Although the expected sweetness, sourness, and saltiness were all positively correlated with preferences, the magnitude of the correlation coefficient was highest in the relations between the expected sweetness and preferences than in the relations between other tastes and preferences. Expected bitterness ratings were negatively correlated with preferences.

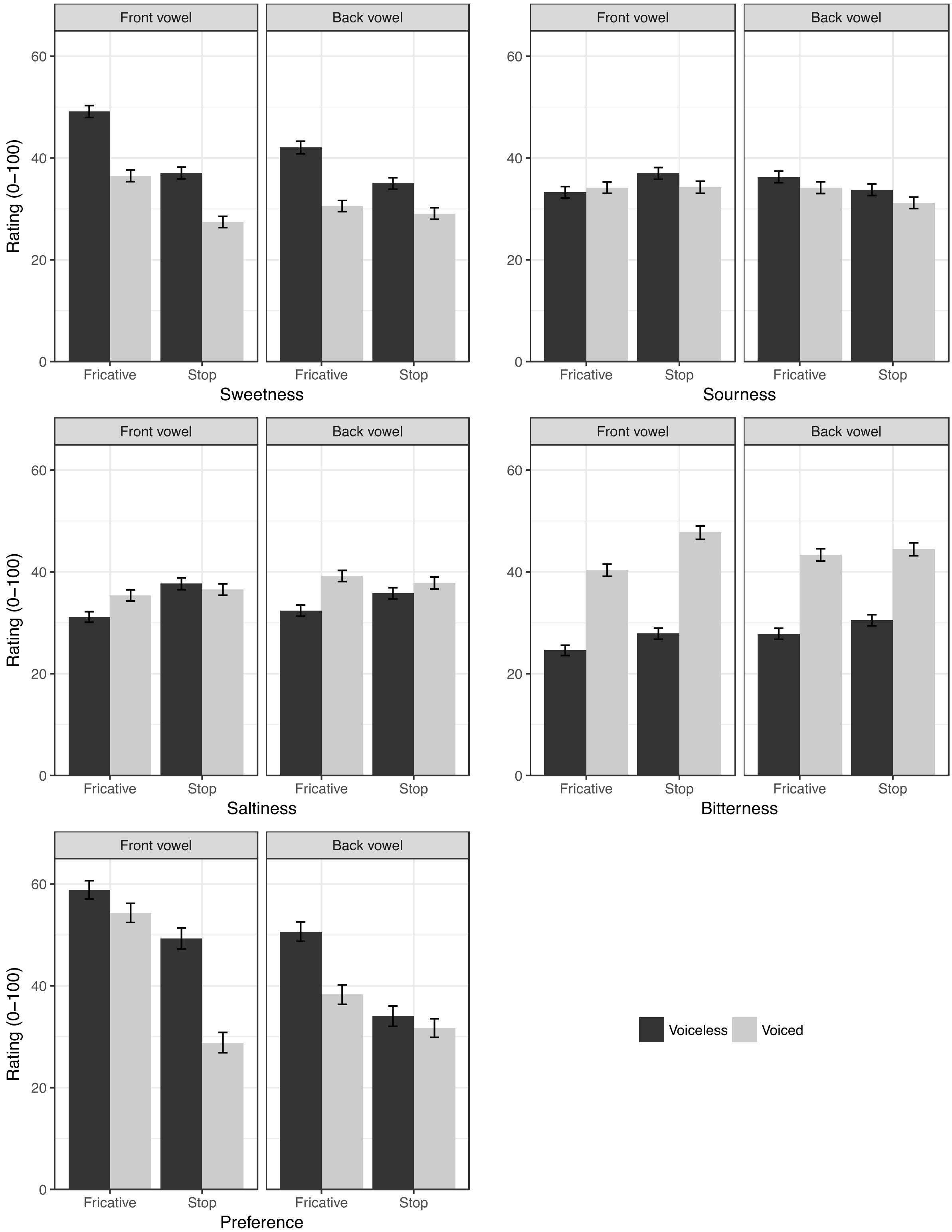

Figure 1. Results of the combined experimental analysis highlighting the influence of vowels and consonants on expected tastes. Ratings of expected tastes (sweet/sour/salty/bitter) on a 0-100 scale ('not at all' to 'very much'). Ratings of preference on a 0-100 scale ('very negative' to 'very positive'). Error bar represents standard error.

Table 3. Summary of significant results of the combined experimental analysis.

	Effect	Taste/preference enhancing sound	Comparison sound	*F*	*p*-value	ηp2
Sweetness	Vowel	Front	Back	27.24	<.001	0.062
	Fricative/stop	Fricative	Stop	102.27	<.001	0.200
	Voiceless/voiced	Voiceless	Voiced	160.30	<.001	0.281
	Vowel × Fricative/stop	Front & Fricative	Back & Fricative	52.42	<.001	0.113
	Fricative/stop ×Voiceless/voiced	Voiceless & Fricative	Voiceless & Stop	67.56	<.001	0.142
		Voiced & Fricative	Voiced & Stop	39.68	<.001	0.088
Sourness	Voiceless/voiced	Voiceless	Voiced	5.44	.020	0.013
	Vowel × Fricative/stop	Front & Stop	Back & Stop	14.13	<.001	0.033
Saltiness	Fricative/stop	Stop	Fricative	12.52	<.001	0.030
	Voiceless/voiced	Voiced	Voiceless	21.45	<.001	0.050
	Vowel × Fricative/stop	Back & Fricative	Front & Fricative	9.03	.003	0.022
	Vowel × Voiceless/voiced	Back & Voiced	Front & Voiced	9.78	.002	0.023
	Fricative/stop ×Voiceless/voiced	Stop & Voiceless	Fricative & Voiceless	27.46	<.001	0.063
Bitterness	Vowel	Back	Front	4.94	.027	0.012
	Fricative/stop	Stop	Fricative	25.70	<.001	0.059
	Voiceless/voiced	Voiced	Voiceless	302.37	<.001	0.425
	Vowel × Fricative/stop	Back & Fricative	Front & Fricative	13.08	<.001	0.031
	Vowel × Voiceless/voiced	Back & Voiceless	Front &Voiceless	15.00	<.001	0.035
	Vowel× Fricative/stop × Voiceless/voiced	Front, Stop, & Voiceless	Front, Fricative, & Voiceless	9.31	.002	0.022
		Front, Stop, & Voiced	Front, Fricative, & Voiced	21.06	<.001	0.049
Preference	Vowel	Front	Back	151.55	<.001	0.270
	Fricative/stop	Fricative	Stop	294.71	<.001	0.418
	Voiceless/voiced	Voiceless	Voiced	268.28	<.001	0.396
	Vowel × Fricative/stop	Front & fricative	Back & fricative	183.48	<.001	0.309
		Front & stop	Back & Stop	14.88	<.001	0.035
	Vowel× Fricative/stop × Voiceless/voiced	Front, Fricative, & Voiceless	Back, Fricative, & Voiceless	76.70	<.001	0.158
		Front, Stop, & Voiceless	Back, Stop, & Voiceless	21.22	<.001	0.049
		Front, Fricative, & Voiced	Back, Fricative, & Voiced	142.46	<.001	0.258

Note: Effect sizes for partial eta squared (ηp2) can be interpreted as follows: 0.01 ≅ small, 0.06 ≅ medium, and 0.14 ≅ large (Kittler, Menard, & Phillips, 2007; Velasco, Salgado-Montejo, Marmolejo-Ramos, & Spence, 2014).

DISCUSSION

Summary of results

The present study investigated how people associate speech sounds with tastes. Although previous research has documented sound-taste correspondences, to the best of our knowledge, no study has systematically investigated the role of vowels/consonants on expected tastes. Across three experiments using different brand names, this study demonstrated how consumers associate sound with tastes (or rather, how the sounds of brand names can set expectations regarding the likely taste of a product). The results of the present study demonstrate that faux brand names that incorporate: (1) front (back) vowels increase expected sweetness (bitterness); (2) fricative (stop) consonants increase expected sweetness (saltiness/bitterness); and (3) voiceless (voiced) consonants increase expected sweetness/sourness (saltiness/bitterness). Moreover, the consonants (which always appeared first, given the constraints of the Japanese language) were shown to exert a greater influence over the expected taste of the products than the vowels. Taken together, these findings indicate that consumers can associate the sounds of fictitious brand names with taste information reliably via subtle differences in name pronunciations. These results can be of help to industries in order to develop predictive brand names.

Consonants influence expected tastes more than vowels

The various findings reported here demonstrate that the consonants incorporated into brand names influence the expected taste of products more that do the vowels. However, given the constraints of the Japanese language (the vowels followed by the consonants, and the consonants always appearing first), it is not possible to say whether this reflects a genuine difference between consonants and vowels, or rather just a precedence effect, such that the first speech sound in a brand name tends to dominate taste expectations. Recently, a growing body of sound-symbolism research has demonstrated that consonants do indeed influence perception and judgments (e.g., Lockwood & Dingemanse, 2015, for a review; Sidhu, Deschamps, Bourdage, & Pexman, 2019). So, for example, voiceless consonants tend to be associated with light visual stimuli (e.g., a white square), while voiced consonants are matched to dark visual stimuli (e.g., a black square) (Hirata, Ukita, & Kita, 2011). Moreover, the role of consonants in sound-shape associations has also been reported (Nielsen & Rendall, 2013). In the case of taste-sound speech associations, most studies have compared pairs of typical words by changing their vowels and consonants at the same time (e.g., ‘Maluma’, ‘Takete’, ‘Kiki’, ‘Lula’). Even if the properties of speech sounds were manipulated, this has often been restricted solely to changing vowels (e.g., Yorkston & Menon, 2004, but see Klink & Lu, 2014, for an investigation of the roles of vowels and consonants on size/speed perceptions). Not only do our results indicate that consonants influence the expected taste more than do vowels, but also, amongst the two types of consonants, voiced/voiceless consonants were found to exert a larger influence on expected taste than fricative/stop consonants. Taken together, these findings highlight the differential effects of vowels, and the two types of consonants, on expected product taste and further suggest that consonants (especially voiced/voiceless consonants) have a larger effect on sound-taste mappings than do vowels.

Interaction effects

The results highlighted a number of interaction effects of vowels and consonants on expected tastes (though we did not predict any particular interaction effects). Although a variety of interaction effects were observed, the interaction between the vowels and fricative/stop consonants modulated all four of the expected tastes that were assessed in the present study. Fricative consonants increased expected sweetness when the names include front (vs. back) vowels, while fricative consonants increased expected saltiness and bitterness when the brand names include back (vs. front) vowels. Stop consonants increased expected sourness when the names included front rather than back vowels. Moreover, the interactive effects of the fricative/stop consonants and the voiceless/voiced consonants were observed in terms of people's sweet and sour taste expectations. Voiceless and voiced consonants increased expected sweetness when the names include fricative (vs. stop) consonants, respectively. Voiceless consonants increased expected saltiness when the names include stop (vs. fricative) consonants. In terms of the bitter taste, the interaction effects were qualified by a three-way interaction. When the names included front vowels, significant interactions of the fricative/stop consonants and the voiceless/voiced consonants were documented in terms of the expected bitter tastes of products. Voiceless and voiced consonants increased expected bitterness when the names included stop (vs. fricative) consonants. This result highlights the fact that the relationship between speech sounds and tastes is somewhat complex.

Possible mechanisms underpinning crossmodal correspondences

Valence matching

Why do people associate certain product names with taste information? One possible explanation underlying the associations is in terms of shared connotations (e.g., valence) among phonetic features and stimuli (Sidhu & Pexman, 2018). Crossmodal correspondences may be derived from similar emotional states which people often associate with different sensory dimensions (e.g., Crisinel, & Spence, 2012; Velasco, Woods, Deroy, & Spence, 2015; Velasco, Woods, Hyndman et al., 2015; Wang, Wang, & Spence, 2016). For example, it has been suggested that shape-tastes correspondences might well arise from the similar valence associated with both shapes and tastes (e.g., Velasco, Woods, Deroy et al., 2015; Velasco, Woods, Hyndman et al., 2015). So, for example, sweet tastes and round shapes are more likable than bitter and angular shapes (e.g., Velasco, Woods, Deroy et al., 2015). In the present study, the participants may have matched speech sounds with expected tastes based of their similar valence. Actually, our results demonstrated that brand names that including front (vs. back) vowels, fricative (vs. stop) and voiceless (vs. voiced) consonants are more often preferred. Given that people generally prefer sweet-tasting foods to those that taste bitter (e.g., Wang et al., 2016), the participants may explicitly (or implicitly) have associated the speech sounds present in brand names with taste information based on shared valence.

The explanation of valence matching underlying taste-speech sound correspondences can be can be thought of in terms of the valence transference theory. Previous research has shown that soundscape-/music-elicited emotions transfer to the subsequent taste perceptions (e.g., Kantono, Hamid, Shepherd, Lin, Skiredj, & Carr, 2019; Kantono, Hamid, Shepherd, Yoo, Grazioli, & Carr, 2016; Xu, Hamid, Shepherd, Kantono, Reay, Martinez, & Spence, 2019; Reinoso-Carvalho et al., 2017; Reinoso-Carvalho, Dakduk, Wagemans, & Spence, 2019). For example, listening to background music that elicits positive emotions increase the perception of sweet and milky, while music associated with negative emotions increase bitterness and creaminess instead (Kantono et al., 2019). It has also been reported that chocolates taste sweeter while listening to a "creamy" soundtrack which is more liked, while they taste more bitter while listening to a "rough" soundtrack which is less liked (Carvalho et al., 2017). Additionally, it has been shown that people like the beer more and rated it sweeter when listening to positively valenced music, while they rated it as more bitter when they listened to negatively valenced music (Carvalho et al., 2019). In line with previous research (e.g., Carvalho et al., 2017), our results showed that expected sweetness ratings were most positively correlated with preference ratings, while expected bitterness ratings were negatively correlated with preference ratings. Hence, the results of taste-speech sound correspondences can be partially explained by the valence matching, and evoked emotions from fictitious brand names may transfer to expected tastes.

Statistical correspondences

An alternative explanation of taste-speech sound correspondences is in terms of statistical regularities (Sidhu & Pexman, 2018). People may regularly be exposed to a certain mapping of sound symbolism and taste-related information. The matching of sound symbolism and basic taste properties might come from the internalization of the statistical regularities of the environment. This has been suggested to be one of the underlying mechanisms of crossmodal correspondences (e.g., Deroy et al., 2013; Motoki et al., 2019b, 2019c; Parise, Knorre, & Ernst, 2014; Spence, 2011; Velasco, Adams, Petit, & Spence, 2019). For example, in the present case, it would appear that those working in the food industry intuitively develop product names including front vowels, fricative and voiceless consonants for sweet products, while they may tend to give their salty products a name that contains stop and voiced consonants (see Spence, 2014, for examples of real-world brand names). Consumers might often see such associations between product names and tastes in store shelf, restaurant menu, food advertising etc. Such statistical regularities in the environment might then be internalized and encoded in the brain, and therefore people may be able to predict tasty information from subtle differences in product name pronunciations in some consistent manner.

Embodiment

An alternative explanation (note also here that the explanations need not be considered as mutually exclusive) that may be relevant here is the idea that people make distinctive bodily expressions (faces, mouth) when they ingest foods having different taste qualities (Rosenstein & Oster, 1988). In this sense, people's articulatory movements of the face and mouth when ingesting different tastes may be emulated by the production of specific speech sounds, which, in turn, may facilitate specific speech sound - taste associations. For example, articulating [i] accompanies the zygomaticus major muscle which is involved in smiling, while articulating [o] involves the orbicularis oris muscle which blocks smiling (Rummer, Schweppe, Schlegelmilch, & Grice, 2014). In our case, some brand names (e.g., 'Fise') may be more involved in bodily expressions similar with smiling or preferable digestion (i.e., sweet tastes) than others (e.g., 'Bogu').

Practical implications

The present findings have practical implications for marketing communications using sound symbolism of the brand name. It would appear that brand names which create appropriate consumer's expectations improve consumer's shopping experiences. First, the matching of brand names with product tastes may be expected to facilitate visual product search. That is, consumers usually do not take long to identify products on the shelf (Dickson, & Sawyer, 1990), and thus important to rapidly capture consumers' attention using product-intrinsic and -extrinsic factors (Motoki, Saito, Nouchi, Kawashima, & Sugiura, 2018, 2019d). Sensory congruency has been shown to facilitate visual product search (e.g., Knoeferle, Knoeferle, Velasco, & Spence, 2016; Sunaga, Park, & Spence, 2016; Velasco, Wan, Knoeferle, Zhou, Salgado-Montejo, & Spence, 2015), though it should be noted that congruency does not always help (Velasco, Michel, Youssef, Gamez, Cheok, & Spence, 2016). Thus, consumers' visual search may be facilitated by the use of brand names that match the taste of the product. Second, if a consumer's expectations are violated as a result of tasting experiences, they might have negative feelings (e.g., Yeomans, Chambers, Blumenthal, & Blake, 2008). Thus, by designing brand names in packaging that are congruent with inner food attributes, food industries can help consumers to effectively pay their attention and form more appropriate expectations which potentially results in satisfying experiences.

Limitations

One relevant limitation of the present study is that the words were presented visually. It may be the case that consumers see and read silently the product names in the written text (they were not presented with the speech sounds themselves). However, elsewhere it has been demonstrated that sound symbolism effects are consistent regardless of whether the stimuli are presented visually or aurally (Nielsen & Rendall, 2011). In both cases, the participants saw or heard the names reliably showed the sound-shape mappings. Thus, sound-tastes correspondences may show consistent patterns from visually or auditorily presented stimuli, though future research should investigate this issue more thoroughly. Second, it might be expected that the visual form might influence the results. The roundness and/or angularity of the stimuli (written text) may differ among vowels and consonants. However, a previous research found that word sounds are consistently matched with specific visual features (e.g., colours), even when the words were presented in the different visual forms (Asano & Yokosawa, 2011). Another study also showed that letter case (upper vs. lower) of brand names in English did not show differential effects of sound symbolism when they were presented in standard font (e.g., Arial, Times; Doyle, & Bottomley, 2011). Third, the order of vowel and consonants in brand names might influence the results. In this study, brand names always started with consonants (i.e., 'Fise', 'Gebi'), which is consistent with previous studies (e.g., BENOKA: Topolinski, Maschmann, Pecher, & Winkielman, 2014; PASOKI: Topolinski & Boecker, 2016; Bouba-kiki: Ramachandran & Hubbard, 2001). Brand names whose speech sounds start with consonants might be more natural. Additionally, those words which start with vowels and end with consonants (e.g., Ifes, Egib) are unusual and difficult to pronounce for the participants (Japanese). Future research should replicate the present findings using brand names which start with vowels and end with consonants. Fourth, it is important to note that familiarity may have influenced the pattern of results obtained. Although the authors (K.M. and T.S.) selected the fictitious brand names that seemed not to exist in the Japanese market, the degree of familiarity might differ among stimuli. For example, the participants might associate some fictitious brand names with real brands more than with others. Familiarity should be considered for development of experimental design in further study.

Future study

In the future, it will be worth investigating whether the taste-sound correspondences can be replicated in different cultures, given the greater sensitivity of the Japanese language/people to sound symbolic effects (Saji, Akita, Kantartzis, Kita, & Imai, 2019). That said, it is worth noting that crossmodal sound-meaning mapping has been found worldwide (Blasi, Wichmann, Hammarström, Stadler, & Christiansen, 2016; though see Styles & Gawne, 2017). Although sound-shape correspondences (e.g., *Kiki-bouba* paradigm) have been documented in Western (Chen, Huang, Woods, & Spence, 2019), Eastern (Asano, Imai, Kita, Kitajo, Okada, & Thierry, 2015), as well as African cultures (Bremner et al., 2013; Davis, 1961), though see Rogers and Ross (1975), for evidence of negative results from Papua New Guinea. However, sound-taste correspondences show different findings depending on the culture (Bremner et al., 2013). The Himba people from rural Namibia did not associate sparkling water to an angular shape, and they also tended to map less bitter (i.e., milk) chocolate onto angular shapes. The opposite mapping was true for Westerners. Further study should be needed to clarify the potential cultural differences that such results throw up.

Conclusions

In summary, the present findings showed how people associate sound symbolisms in product names with information concerning their likely gustatory properties. By systematically manipulating sound component in product names, the results identified that (1) front (back) vowels increase expected sweetness (bitterness), (2) fricative (stop) consonants increase expected sweetness (saltiness/bitterness), (3) voiceless (voiced) consonants increase expected sweetness/sourness (saltiness/bitterness). Moreover, in the present study, consonants (which always came first, given the constraints of the Japanese language) have a greater influence on expected taste perceptions than vowels. These correspondences may be attributed to valence matching, the internalization of statistical regularities, and/or bodily expressions. Together, these findings help advance theoretical foundations in sound-taste correspondences, can be used in order to construct new brand names that are best for each taste, and offer practical insights to practitioners who have interests in designing predictive brand names.

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APPENDIX

甘味：この商品はどのくらい甘いと思いますか？（全く甘くない〜非常に甘い）

酸味：この商品はどのくらい酸っぱいと思いますか？（全く酸っぱくない〜非常に酸っぱい）

塩味：この商品はどのくらい塩っぱいと思いますか？（全く塩っぱくない〜非常に塩っぱい）

苦味：この商品はどのくらい苦いと思いますか？（全く苦くない〜非常に苦い）

好ましさ：この商品についてどう感じますか？（非常にネガティブ〜非常にポジティブ）

Figure A. Rating questions on expected tastes and preference used in this research (in Japanese)

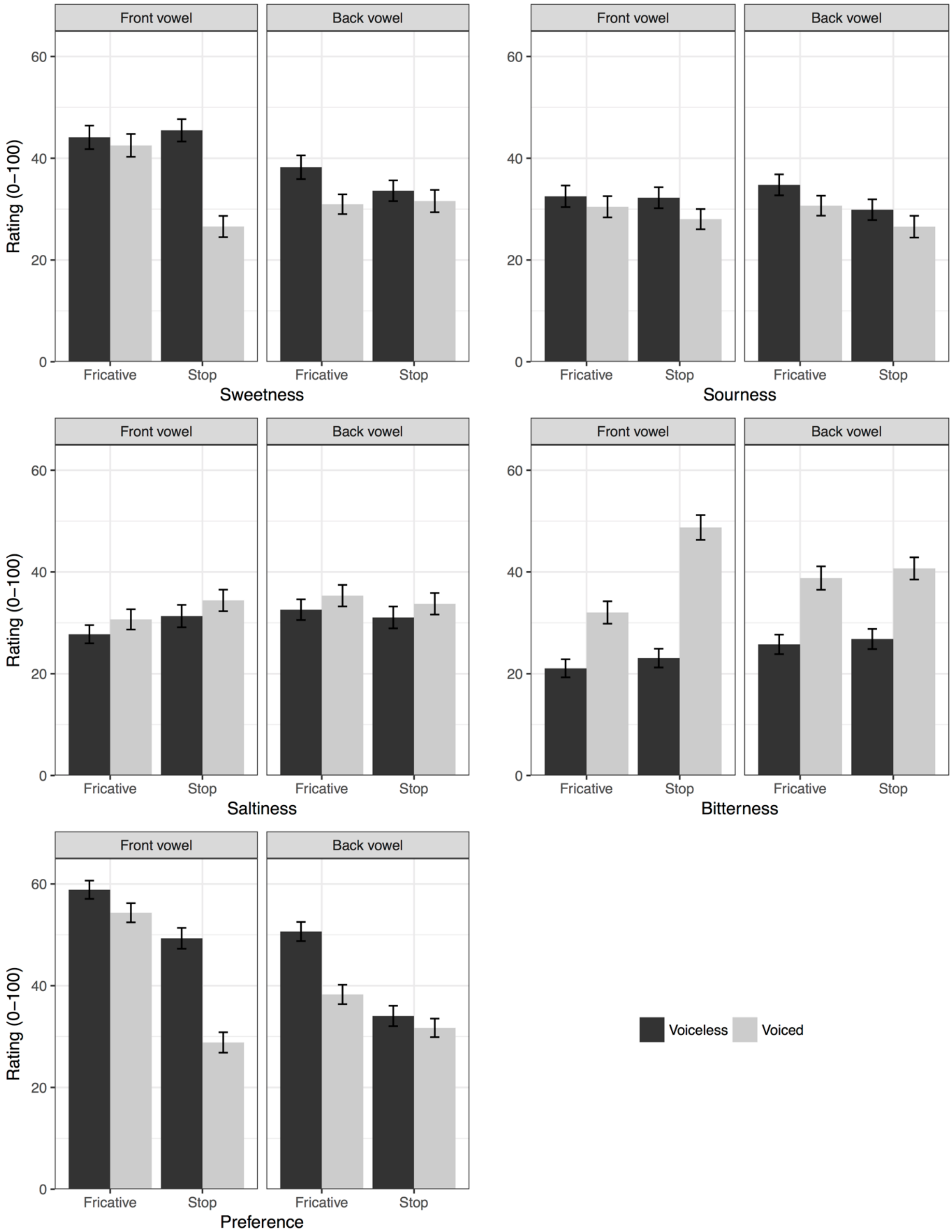

Figure B. Results of Experiment 1. The graphs highlight the influence of vowels and consonants on expected taste/preference. Ratings of expected tastes (sweet/sour/salty/bitter) on a 0-100 scale (‘not at all’ to ‘very much’). Ratings of preference on a 0-100 scale (‘very negative’ to ‘very positive’). Error bar represents standard error.

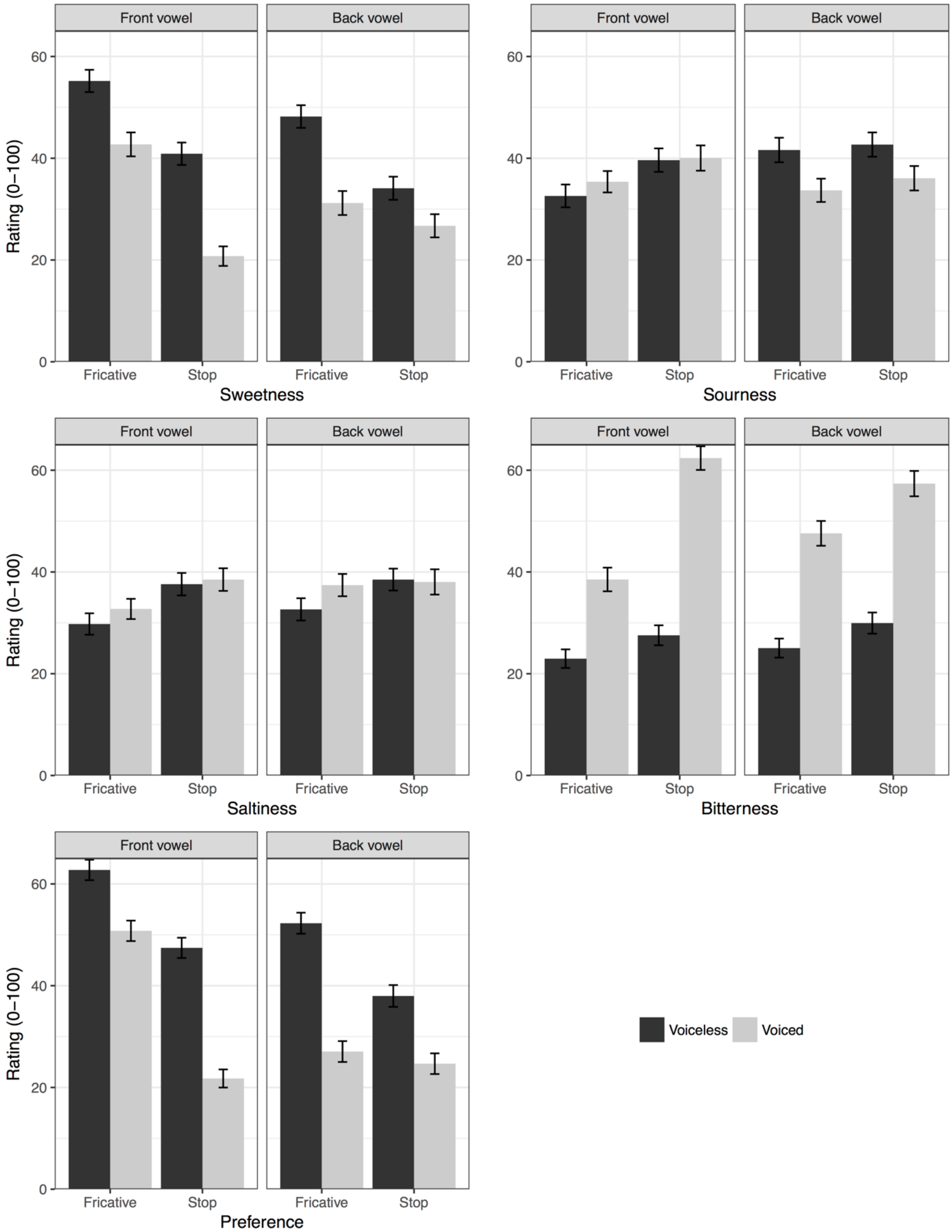

Figure C. Results of Experiment 2. The graphs highlight the influence of vowels and consonants on expected taste/preference. Ratings of expected tastes (sweet/sour/salty/bitter) on a 0-100 scale ('not at all' to 'very much'). Ratings of preference on a 0-100 scale ('very negative' to 'very positive'). Error bar represents standard error.

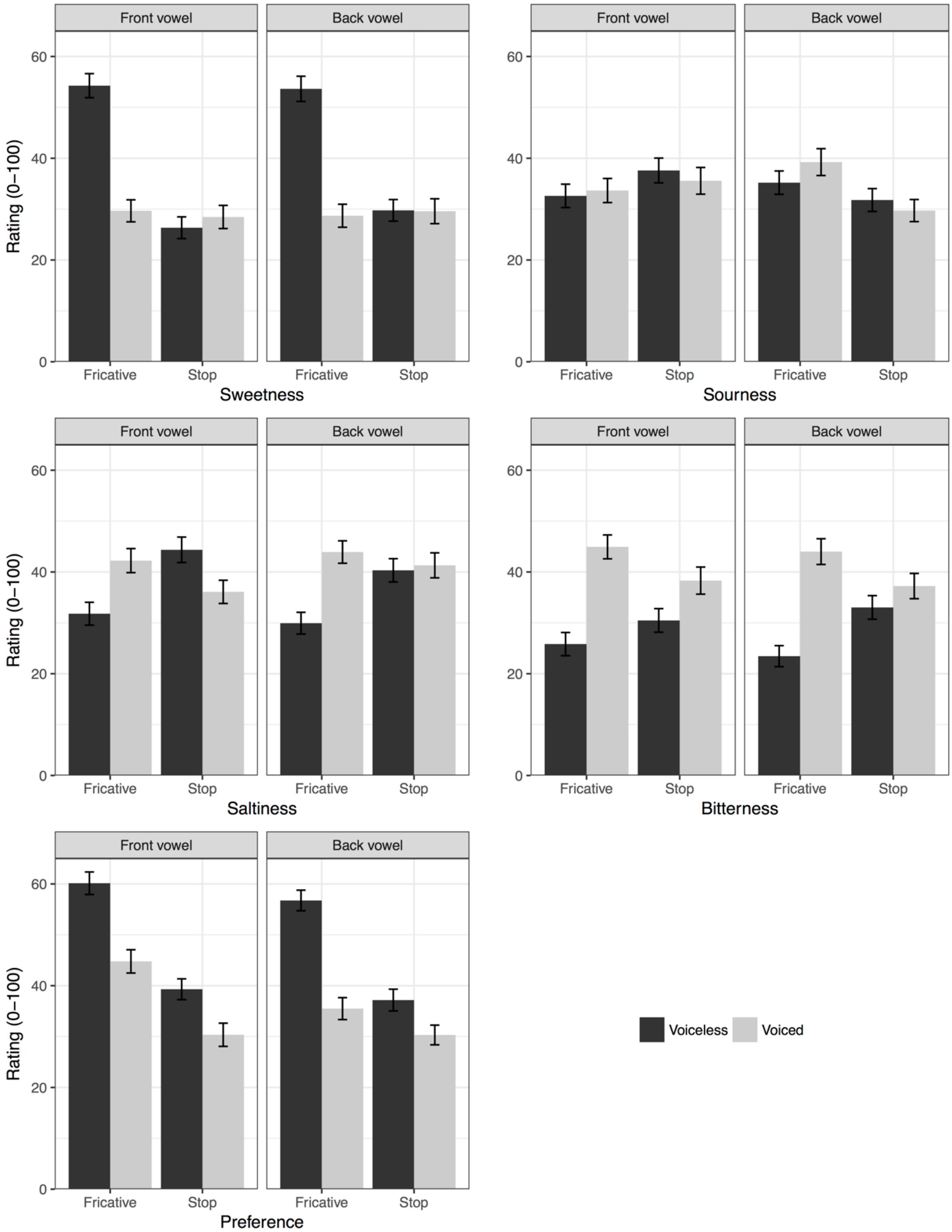

Figure D Results of Experiment 3a. The graphs highlight the influence of vowels and consonants on expected taste/preference. Ratings of expected tastes (sweet/sour/salty/bitter) on a 0-100 scale ('not at all' to 'very much'). Ratings of preference on a 0-100 scale ('very negative' to 'very positive'). Error bar represents standard error.

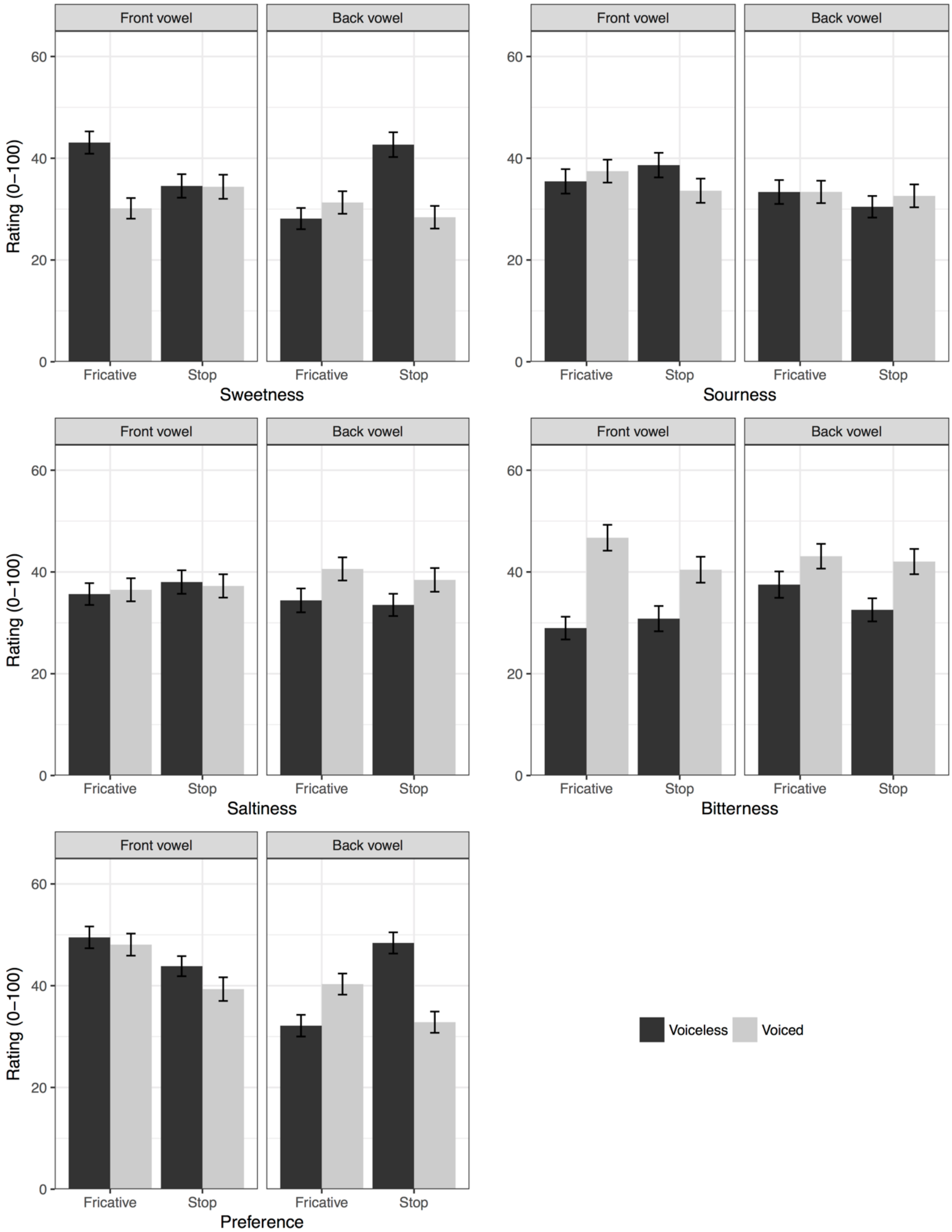

Figure E. Results of Experiment 3b. The graphs highlight the influence of vowels and consonants on expected product taste. Ratings of expected tastes (sweet/sour/salty/bitter) on a 0-100 scale ('not at all' to 'very much'). Ratings of preference on a 0-100 scale ('very negative' to 'very positive'). Error bar represents standard error.

Table A. Mean ratings (±SD) of expected tastes and preference in Experiment 1. Ratings of expected tastes (sweet/sour/salty/bitter) on a 0-100 scale ('not at all' to 'very much'). Ratings of preference on a 0-100 scale ('very negative' to 'very positive')

		Vowel	
		Front	**Back**
Fricative	**Voiceless**	44.11 (23.99)	38.23 (24.23)
	Voiced	42.52 (23.29)	30.96 (20.20)
Stop	**Voiceless**	45.49 (22.82)	33.61 (21.21)
	Voiced	26.57 (21.77)	31.58 (22.78)

Sweetness

		Vowel	
		Front	**Back**
Fricative	**Voiceless**	32.52 (22.09)	34.77 (21.43)
	Voiced	30.46 (21.69)	30.68 (20.37)
Stop	**Voiceless**	32.24 (21.48)	29.89 (21.20)
	Voiced	28.03 (20.65)	26.55 (22.24)

Sourness

		Vowel	
		Front	**Back**
Fricative	**Voiceless**	27.76 (18.64)	32.58 (21.09)
	Voiced	30.68 (20.72)	35.34 (22.00)
Stop	**Voiceless**	31.32 (22.97)	31.07 (22.29)
	Voiced	34.41 (21.98)	33.75 (21.98)

Saltiness

		Vowel	
		Front	**Back**
Fricative	**Voiceless**	21.06 (18.50)	25.77 (19.91)
	Voiced	32.04 (22.83)	38.81 (23.90)
Stop	**Voiceless**	23.07 (19.15)	26.82 (20.56)
	Voiced	48.74 (25.37)	40.69 (22.66)

Bitterness

		Vowel	
		Front	**Back**
Fricative	**Voiceless**	58.86 (18.64)	50.65 (19.57)
	Voiced	54.33 (19.61)	38.28 (19.80)
Stop	**Voiceless**	49.32 (21.26)	34.05 (20.84)
	Voiced	28.84 (20.79)	31.70 (18.97)

Preference

Table B. Mean ratings (±SD) of expected tastes and preference in Experiment 2. Ratings of expected tastes (sweet/sour/salty/bitter) on a 0-100 scale ('not at all' to 'very much'). Ratings of preference on a 0-100 scale ('very negative' to 'very positive').

Sweetness

		Vowel	
		Front	**Back**
Fricative	**Voiceless**	55.19 (22.42)	48.20 (22.78)
	Voiced	42.72 (24.13)	31.20 (24.13)
Stop	**Voiceless**	40.89 (22.55)	34.11 (23.26)
	Voiced	20.76 (19.63)	26.72 (23.35)

Sourness

		Vowel	
		Front	**Back**
Fricative	**Voiceless**	32.59 (23.02)	41.62 (24.72)
	Voiced	35.38 (21.56)	33.70 (23.44)
Stop	**Voiceless**	39.63 (23.63)	42.69 (24.49)
	Voiced	40.04 (25.48)	36.07 (24.62)

Saltiness

		Vowel	
		Front	**Back**
Fricative	**Voiceless**	29.77 (21.57)	32.65 (22.44)
	Voiced	32.73 (20.34)	37.42 (22.49)
Stop	**Voiceless**	37.60 (22.65)	38.50 (22.01)
	Voiced	38.51 (22.79)	38.04 (25.45)

Bitterness

		Vowel	
		Front	**Back**
Fricative	**Voiceless**	22.96 (18.71)	25.04 (19.14)
	Voiced	38.52 (23.81)	47.59 (24.94)
Stop	**Voiceless**	27.55 (20.16)	29.95 (21.29)
	Voiced	62.38 (23.83)	57.36 (25.52)

Preference

		Vowel	
		Front	**Back**
Fricative	**Voiceless**	62.74 (20.62)	52.28 (21.23)
	Voiced	50.78 (20.60)	27.06 (21.02)
Stop	**Voiceless**	47.44 (20.41)	37.98 (21.98)
	Voiced	21.76 (18.23)	24.67 (20.85)

Table C. Mean ratings (±SD) of expected taste and preference in Experiment 3a. Ratings of expected tastes (sweet/sour/salty/bitter) on a 0-100 scale ('not at all' to 'very much'). Ratings of preference on a 0-100 scale ('very negative' to 'very positive').

		Vowel	
		Front	**Back**
Fricative	**Voiceless**	54.26 (23.52)	53.64 (24.70)
	Voiced	29.67 (21.56)	28.70 (22.52)
Stop	**Voiceless**	26.34 (21.23)	29.76 (21.15)
	Voiced	28.46 (22.66)	29.59 (24.33)

Sweetness

		Vowel	
		Front	**Back**
Fricative	**Voiceless**	32.61 (22.85)	35.20 (22.83)
	Voiced	33.66 (23.56)	39.24 (26.23)
Stop	**Voiceless**	37.60 (24.23)	31.79 (22.33)
	Voiced	35.57 (26.12)	29.72 (21.63)

Sourness

		Vowel	
		Front	**Back**
Fricative	**Voiceless**	31.80 (22.34)	29.93 (21.25)
	Voiced	42.23 (23.53)	43.92 (21.89)
Stop	**Voiceless**	44.35 (24.93)	40.32 (22.74)
	Voiced	36.09 (22.69)	41.30 (24.43)

Saltiness

		Vowel	
		Front	**Back**
Fricative	**Voiceless**	25.83 (22.63)	23.46 (20.55)
	Voiced	44.93 (23.34)	44.00 (25.15)
Stop	**Voiceless**	30.48 (23.09)	33.03 (23.08)
	Voiced	38.30 (26.49)	37.23 (24.71)

Bitterness

		Vowel	
		Front	**Back**
Fricative	**Voiceless**	60.14 (21.97)	56.75 (20.14)
	Voiced	44.78 (22.79)	35.50 (21.45)
Stop	**Voiceless**	39.30 (20.35)	37.17 (21.29)
	Voiced	30.35 (22.70)	30.31 (19.26)

Preference

Table D. Mean ratings (±SD) of expected taste and preference in Experiment 3b. Ratings of expected tastes (sweet/sour/salty/bitter) on a 0-100 scale ('not at all' to 'very much'). Ratings of preference on a 0-100 scale ('very negative' to 'very positive').

		Vowel	
		Front	**Back**
Fricative	**Voiceless**	43.08 (21.80)	28.14 (20.79)
	Voiced	30.15 (20.16)	31.30 (22.00)
Stop	**Voiceless**	34.56 (23.01)	42.68 (24.20)
	Voiced	34.39 (23.59)	28.40 (22.17)

Sweetness

		Vowel	
		Front	**Back**
Fricative	**Voiceless**	35.46 (23.93)	33.36 (23.37)
	Voiced	37.47 (22.40)	33.38 (21.90)
Stop	**Voiceless**	38.65 (24.10)	30.47 (21.08)
	Voiced	33.62 (23.66)	32.61 (22.38)

Sourness

		Vowel	
		Front	**Back**
Fricative	**Voiceless**	35.66 (21.33)	34.41 (23.32)
	Voiced	36.50 (22.56)	40.60 (22.64)
Stop	**Voiceless**	38.02 (23.03)	33.53 (21.76)
	Voiced	37.25 (22.83)	38.44 (23.16)

Saltiness

		Vowel	
		Front	**Back**
Fricative	**Voiceless**	28.97 (22.22)	37.52 (25.76)
	Voiced	46.73 (25.28)	43.09 (24.22)
Stop	**Voiceless**	30.83 (24.74)	32.56 (22.57)
	Voiced	40.44 (25.35)	42.04 (24.71)

Bitterness

		Vowel	
		Front	**Back**
Fricative	**Voiceless**	49.50 (21.31)	32.14 (21.19)
	Voiced	48.07 (21.60)	40.31 (20.66)
Stop	**Voiceless**	43.84 (19.64)	48.40 (20.72)
	Voiced	39.32 (23.11)	32.83 (20.78)

Preference

Table E. Mean ratings (±SD) of expected taste and preference in the combined experimental analysis. Ratings of expected tastes (sweet/sour/salty/bitter) ranged from 0 (not at all) to 100 (very much). Ratings of preference ranged from 0 (very negative) to 100 (very positive).

		Vowel	
		Front	Back
Fricative	Voiceless	49.14 (23.55)	42.06 (25.03)
	Voiced	36.50 (23.19)	30.56 (22.19)
Stop	Voiceless	37.07 (23.47)	34.99 (22.87)
	Voiced	27.43 (22.37)	29.10 (23.15)

Sweetness

		Vowel	
		Front	Back
Fricative	Voiceless	33.27 (22.91)	36.29 (23.24)
	Voiced	34.18 (22.36)	34.16 (23.16)
Stop	Voiceless	36.96 (23.45)	33.75 (22.86)
	Voiced	34.26 (24.33)	31.20 (22.96)

Sourness

		Vowel	
		Front	Back
Fricative	Voiceless	31.15 (21.10)	32.40 (22.01)
	Voiced	35.39 (22.14)	39.20 (22.41)
Stop	Voiceless	37.68 (23.76)	35.79 (22.44)
	Voiced	36.55 (22.53)	37.80 (23.84)

Saltiness

		Vowel	
		Front	Back
Fricative	Voiceless	24.60 (20.68)	27.85 (22.05)
	Voiced	40.34 (24.43)	43.33 (24.67)
Stop	Voiceless	27.87 (21.96)	30.50 (21.92)
	Voiced	47.71 (26.89)	44.44 (25.52)

Bitterness

		Vowel	
		Front	Back
Fricative	Voiceless	57.91 (21.14)	48.08 (22.46)
	Voiced	49.62 (21.36)	35.23 (21.26)
Stop	Voiceless	45.11 (20.72)	39.26 (21.81)
	Voiced	29.92 (22.06)	29.84 (20.15)

Preference

Table F. Pearson correlation coefficients between participants' ratings for all trials of the combined data.

	Preference	**Sweetness**	**Sourness**	**Saltiness**	**Bitterness**
Preference	–	**0.54**	**0.20**	**0.13**	**-0.09**
Sweetness		–	**0.22**	**0.09**	-0.04
Sourness			–	**0.45**	**0.37**
Saltiness				–	**0.39**
Bitterness					–

Note: Df = 3286. Bold indicates significant correlations with Bonferroni correction ($p < .05/10$).