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

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Spiky sounds sparkling: How voiceless consonants present in the brand name of a beverage are more appropriate in conveying its carbonation strength

Abhishek Pathak[1], Kosuke Motoki[2], Monin Techawachirakul[3], and Gemma Anne Calvert[3]

[1]School of Business, University of Dundee, UK

[2]Department of Food Science and Business, Miyagi University, Japan

[3]Nanyang Business School, Nanyang Technological University, Singapore

Keywords: Sound symbolism; brand names; consonants; voiceless; phonemes; cross modal correspondences

Highlights

- Link between voiceless phonemes and carbonated beverages was investigated
- Voiceless (vs. voiced) phonemes are more appropriate for carbonated beverages
- Voiceless (vs. voiced) phonemes are more associated with spiky (vs. rounded) shapes
- Angular letters (and phonemic sounds) are more appropriate for carbonated beverages

Abstract

Research suggests that speech sounds within a brand name can influence taste expectations of a product (e.g., voiceless consonants are often linked to sour tastes). Though carbonated beverages are sold across all markets in the world, to date, linkages between the brand names and their carbonation expectation yet remains unexplored. This research investigates how specific speech sounds contained within a brand name can enhance the carbonation perception of a beverage. Across three studies, we demonstrate that hypothetical brand names (or pseudo words) containing voiceless consonants (p, k, t, f) are more associated with carbonated beverages and spikiness compared to voiced consonants (b, d, g, v), which are more associated with still water and roundedness. In the fourth study, we examine the coexisting role/effect of the orthographic and phonemic angularity of individual consonants (and phonemic sounds) and confirm that voiceless (vs. voiced) consonants (and phonemic sounds) are more associated with spikiness (vs. roundedness). Our findings add to the growing body of literature linking sound symbolism, taste expectations and cross-modal correspondences.

Spiky sounds sparkling: How voiceless consonants present in the brand name of a beverage are more appropriate in conveying its carbonation strength

1. Introduction

Carbonated water and beverages are available in most parts of the world and are even served with regular meals in some countries (e.g., Argentina, Netherlands, Germany) (Rodwan, 2018). In the US itself, between 2013-18, sales of carbonated water experienced its fastest growth (compared to still water and other soft drinks) and is soon expected to reach US$24.5 billion, reflecting its very high consumer demand. Despite such popularity, little is known about how brands can convey the strength of carbonation to consumers using popular brand attributes (e.g., brand names). For example, San Pelligrino prides itself in soft, natural carbonation from the source at which it is bottled, whereas Schweppes Club Soda relies on synthesized carbonation resulting in greater fizziness. To date, linkages between a brand name and its carbonation expectation remain largely unexplored. In this paper, we investigate the link between voiceless (vs. voiced) consonants present within a brand name and expectations of carbonation strength, and provide evidence that voiceless (vs. voiced) consonants are more appropriate for carbonated (vs. still) water brands.

2. Theoretical background

A growing body of research has now established the cross-modal linkages between speech sounds and sensory attributes (e.g., shape, size, creaminess) (e.g., Crisinel, Jones, & Spence, 2012; Gallace, Boschin, & Spence, 2011; Spence & Gallace, 2011; Pathak & Calvert, 2020; Sidhu & Pexman, 2018). Specific to the sensory domain of taste, research has also reliably demonstrated the link between vowels and consonants with tastes (e.g., long vowels with

sweetness; Pathak, Calvert, & Motoki, 2020). Humans can perceive five distinct tastes- sweet, bitter, salty, sour and umami. Apart from these five basic tastes, the sensory perception of taste is also believed to be influenced by other related attributes (e.g., texture of the food, aroma). Relevant to the current paper, it also appears that the CO_2 present in a beverage has a distinct taste and most consumers relate the fizz or bubbly feeling of carbonation as sour and acidic (Chandrashekar et al., 2009). Scientists believe that our sour taste receptors also act as the 'carbonation taste sensors', although the sour taste of carbonation is now believed to be due to multiple sensory inputs (e.g., fizz, tingling, flavour, sour taste receptors) (Chandrashekar et al., 2009; Spence, 2015).

Just as the fizz/bubbles are perceived to be sour, in psycholinguistics, research has demonstrated cross-modal linkages between pseudo words (e.g.,kiki, takete) (i.e., those containing voiceless consonants /k/ and /t/) with sourness (Crisinel et al., 2012) and acidic tastes (e.g., vinegar) (Gallace et al., 2011). Similarly, consistent with the oral-somatosensory explanation of tingling of carbonation with sharp tastes, carbonated water is also strongly associated with sharp sounds (e.g., /t/, /k/) and angular shapes. In contrast, still water is more associated with softer sounds (e.g., /b/) and rounded shapes (Ngo, Piqueras-Fiszman, & Spence, 2012; Spence & Gallace, 2011). Relevant to the present research, voiceless consonants have been shown to increase expectations of sourness (Motoki et al., 2020).

Given these findings, it is likely that voiceless consonants in brand names can influence the expected carbonation strength of a branded beverage. Since voiceless (vs. voiced) consonants have been shown to be particularly spiky (McCormick et al., 2015), we hypothesize an association between voiceless (vs. voiced) consonants with carbonated (vs. still) water and argue

that consumers will expect brand names composed of voiceless (vs. voiced) consonants to be more appropriate for the brands of carbonated (vs. still) water.

In Studies 1 and 2, we demonstrate that people indeed expect names created from the voiceless (vs. voiced) consonants to be associated with carbonated (vs. still) water brands. In Studies 3 and 4, we investigate the cross-modal associations of voiced and voiceless sounds with shapes (roundness/angularity). Prior research has demonstrated that voiceless (vs. voiced) consonants are also considered spikier (vs. rounded) (D'Onofrio, 2013) and consumers match sour tastes with angular shapes (Velasco, Woods, Marks, Cheok, & Spence, 2016). Given this evidence, we demonstrate the cross-modal association of voiceless (vs. voiced) phonemes with spikiness (vs. roundedness) (Velasco et al., 2016). In Study 3, we demonstrate this association using pseudo words and in Study 4 with individual phonemic sounds and written letters. Study 4 also attempts to explore the orthographic and phonemic angularity (vs. roundedness) of individual phonemes (spoken) and letters (written).

3. Method and overview of studies

In the English language, the following six pairs of phonemes exist where the predominant difference is only voicing- /p, k, t, f, sh, s/ and /b, g, d, v, zh, z/ respectively (/zh/ as in measure). Out of these, /s/ vs. /z/ and /sh/ vs. /zh/ were excluded in the current research, as these sounds might evoke the association of fizzy drinks or a common association of /z/ sound with /fizz/, /sizzler/ etc. The rest of the four phoneme-pairs (e.g., /p/ and /b/) were used to create 24 word-pair stimuli in a CV-CV-C format (CV= Consonant Vowel) (e.g., /CVCVC/ = /pasak/) (see Appendix 1 for all stimuli). Vowel /a/ was used as the only vowel throughout, as vowels themselves can influence the results (e.g., Motoki et al., 2020). All studies were designed on the

Inquisit 6 platform from Millisecond.com and participants were native English speakers residing in the USA and recruited from Amazon Mechanical Turk (AMT). Participants were allowed to take part in only one of the studies related to the current research. The research was approved by the ethics committee of a large South-east Asian university and participants who consented to participate were paid for their time and effort. The sample size for all four studies was kept at N≈60; the power to detect a medium-sized effect (0.24) in a repeated measures ANOVA (all four studies) was found to be $1 - \beta \approx 0.952$ using G*Power 3.1.9 (Faul et. al, 2007). Participants were familiarized with the experimental procedure with a few practice trials in all four studies.

4. Study 1

In Study 1 participants were told that a company is looking for a brand name for two of its bottled water brands (a still water and a carbonated water) in a foreign country. Participants were told that they would see one brand name in the middle of the screen, which referred to either a still water brand or a carbonated water brand. They then had to rate the brand names on one attribute- how appropriate is the brand name for a still or carbonated water brand? The rating was done on a visual analogue scale (VAS) from 0 to 100 (0 = still water and 100 = carbonated water). A linear scale was used to represent the carbonation continuum because the perceived carbonation strength (or fizziness, as it is commonly called by the consumers) varies on a continuum. Similar scales have been used in the past in cross-modal research (e.g., Spence & Gallace, 2011; Zampini & Spence, 2011).Thirty brand names (i.e. fifteen each of the words created from voiced vs. voiceless consonants) were then presented randomly.

4.1 Participants

A total of 61 participants completed the study; data of two participants who had repeated the study was excluded (*Min to Max* $_{age}$ = 27 to 77 yrs.; M_{age} = 46.37 yrs., *SD* = 12.97; *Males* = 32, *Females* = 27). 57 out of 59 participants were native English speakers and five knew languages other than English (two knew French and one each know Spanish, Mandarin and Telugu).

4.2 Results

A repeated measures ANOVA revealed that participants rated the words created from voiceless (vs. voiced) consonants as more appropriate for a carbonated water brand (and less appropriate for a still water brand) (Grubbs test revealed one outlier at $p = 0.05$ who was excluded; *Critical Z* = 3.19), M_{Voiced} = 43.01, *SD* = 15.96, $M_{Voiceless}$ = 53.38, *SD* = 14.67, $F_{(1, 57)} = 9.19$, $p = 0.004$, $\eta_p^2 = 0.14$. Additionally, one-sample *t*-tests revealed that the brand names/words created from voiced consonants differed significantly from the mid-point of fifty ($t_{(57)} = 3.34$, $p = 0.001$, $d = 0.44$), but not the words composed from voiceless consonants ($t_{(57)} = 1.76$, $p = 0.08$),

5 Study 2

While Study 1 employed a rating task, in Study 2, a free-choice task was used where participants were asked to create new brand names for carbonated drinks. In addition to the carbonated water, an additional category of Cola drinks was introduced in Study 2 to increase the generalizability of our findings.

5.1 Participants

A total of 54 participants completed the study (*Min to Max* $_{age}$ = 21 to 69 yrs.; M_{age} = 40.22 yrs., *SD* = 12.21; *Males* = 27, *Females* = 27). 53 out of 54 participants were native English

speakers and seven knew languages other than English (two knew Italian, two knew Cantonese, one each know French, Chinese and Kiswahili).

5.2 Procedure

Participants were told that a company was launching a new brand of a strong carbonated water (or cola drink to half of the participants) in an international market and was looking for a new brand name. Participants were asked to create six brand names from the given letters, where the name of the brand itself conveyed the carbonation strength of the drink. All eight voiceless and voiced letters (/p/, /b/, /k/, /g/, /t/, /d/, /f/, /v/) were then randomly presented on the screen in a straight horizontal line, in Arial font (upper caps, covering 5% of the vertical screen space). Participants were asked to follow certain rules, 1) any of the vowels (/a/, /e/, /i/, /o/, /u/) could be used, 2) brand names should contain at least five letters each, should be pronounceable, should not be random letters (e.g., SXZL) and should not resemble any known English word or brand names. Participants had to type the brand names in six text boxes provided below these instructions.

5.3 Results

Results are reported in 2 ways, firstly, to see the overall picture, the entire data was analysed. Participants used a significantly higher number of voiceless (vs. voiced) consonants for creating brand names (BNs) for carbonated (vs. still) water or cola drinks (Grubbs test revealed no outliers at $p = 0.05$; *Critical Z* = 3.16; $M_{Voiceless}$ [1]= 10.28, $SD = 3.64$, $M_{Voiced} = 8.28$, $SD = 3.39$, $F_{(1, 52)} = 8.21$, $p = 0.006$, $\eta_p^2 = 0.14$)[2]; no difference in the drink categories was observed (i.e. carbonated water and cola drinks) ($F_{(1, 52)} = 0.02$, $p = 0.88$).

In the second analysis, we deleted the BNs where participants did not follow the rules of the BN creation (e.g., a few participants created BNs such as /aeiou/, /kdvtg/). The data was

reanalysed after deleting all such entries and results similar to first analysis were found ($M_{Voiceless}$ = 7.83, SD = 4.76, M_{Voiced} = 5.94, SD = 3.81, $F_{(1, 52)}$ = 9.95, p = 0.003, η_p^2 = 0.164); no difference in the drink categories was observed ($F_{(1, 52)}$ = 0.05, p = 0.83). We also report the frequency of individual letters used by participants to create the brand names (Figure 1). Voiceless consonants were used more than the voiced ones, except for the pair of /v/ and /f/, where the consonant /v/ (voiced) was used more frequently than /f/ (voiceless). This difference observed in the frequency of letters /v/ and /f/ was likely due to the higher orthographic angularity of the letter /v/ (when compared to /f/), a point that is discussed in detail in Studies 3 and 4.

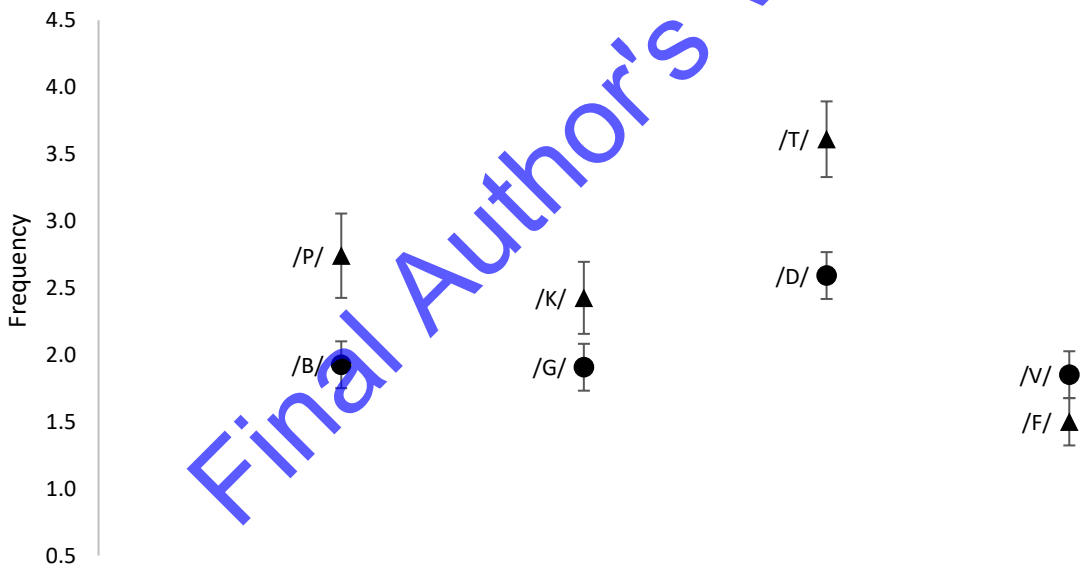

Figure 1. Frequency of voiceless (p, k, t, f) vs. voiced (b, g, d, v) consonants used by the participants to create the BNs
Error bars represent SE of means

6 Study 3

In Studies 1 and 2, a rating task and a free-choice paradigm were used to arrive at the results. Research suggests that consumers often link carbonated (vs. still) water with angularity (vs. roundedness) (e.g., Bremner et al., 2013; Ngo et al., 2012). Study 3 aimed to use this indirect shape-sound paradigm to test our findings. Participants were told that they would see one word in the middle of the screen; they then had to rate it on how rounded or spiky they thought the sounds of the word to be on a linear VAS from 0 to 100 (e.g., Ngo et al., 2012; Spence & Gallace, 2011; Zampini & Spence, 2011) (0 = very rounded and 100 = very spiky). Thirty brand names (i.e. fifteen each of the words created from voiced vs. voiceless consonants) were then randomly presented. We expected voiceless (vs. voiced) phonemes to be more associated with spikiness (vs. roundedness).

6.1 Participants

A total of 60 participants completed the study; data of two participants who repeated the study was excluded (*Min to Max* $_{age}$ = 27 to 74 yrs.; *M* $_{age}$ = 44.96 yrs., *SD* = 11.82; *Males* = 21, *Females* = 37). All 59 participants were native English speakers and two knew languages other than English (Russian and Chinese).

6.2 Results

A repeated measures ANOVA revealed that participants rated the names/words created from voiceless (vs. voiced) consonants as spikier (vs. rounded) (Grubbs test revealed no outliers at p = 0.05; *Critical Z* = 3.19), M_{Voiced} = 43.63, *SD* = 15.48, $M_{Voiceless}$ = 65.46, *SD* = 12.13, $F_{(1, 57)}$ = 68.60, $p < 0.001$, $\eta_p^2 = 0.55$. Additionally, one-sample t-tests revealed that the words created from

both voiced and voiceless consonants differed significantly from the mid-point of fifty (voiced: $t\ (57) = 3.13$, $p = 0.003$, $d = 0.41$; voiceless: $t\ (57) = 9.70$, $p < 0.001$, $d = 1.27$).

7 Study 4

In the previous studies, we used word stimuli created from voiceless and voiced consonants. Such stimuli may not be equally pronounceable (e.g., Bakhtiari, Körner & Topolinski, 2016) and the ease (or difficulty) of pronunciation might influence the expected results. Similarly, the orthographic angularity of the letters themselves could confound the results (e.g., Doyle & Bottomley, 2011). For example, letters /k/ and /v/ are spikier than letters /p/and /b/ (Cuskley, Simner, & Kirby,2017). As a result, the hypothetical word/brand name /Fasak/ (voiceless, but more angular) may be rated as spikier than the word /Bagad/ (voiced, but more rounded). However, since participants could read and see the word stimuli at the same time, it is difficult to segregate the influence of orthographic angularity (or roundedness) from that of phonemic angularity (or roundedness). To avoid these confounds, in Study 4, we used only individual letters and aural phonemic sounds (e.g., a single phonemic sound e.g., /pa/) and not a word stimulus as used in Study 3. We expect the voiceless (vs. voiced) consonants (both letters and phonemes) to be more associated with spikiness (vs. roundedness).

7.1. Procedure and design

Stimuli consisted of eight letters (/p, k, t, f/ and /b, g, d, v/) and corresponding phonemic sounds (e.g., /pa/). Phonemic stimuli were downloaded from the interactive IPA chart of the Department of Linguistics, University of Victoria, Canada freely available at https://web.uvic.ca/ling /resources/ ipa/charts /IPAlab/IPAlab.htm. Participants were asked to use headphones and a computer with keyboard and mouse. The script was programmed to abort in

case a respondent logged in using any other device (e.g., a mobile phone). Visual stimuli (i.e., the individual letters) were presented in capital letters in Arial font in the middle of the screen covering 5% of the screen height. Participants were told that they would hear a few sounds and see a few letters and they had to rate how 'round' or 'spiky' they thought those sounds/letters were (on a VAS from 0 to100 where 0 = round and 100 = spiky). The presentation of letters or phonemes was counterbalanced between participants i.e., half the participants rated letters first and the other half rated phonemic sounds first. Before the start of the experiment, an audio check was made, where participants had to listen to a word (USA) and type it in the text box presented on their screen. After the audio check, participants familiarized themselves with the experimental design in a few practice trials, where known shapes (e.g., circle) were presented.

7.2. Participants

A total of 60 participants completed the study; data of one participant who repeated the study was excluded (*Min to Max* $_{age}$ = 22 to 69 yrs.; M_{age} = 43.90 yrs., *SD* = 13.13; *Males* = 31, *Females* = 28). 56 out of 59 participants were native English speakers and eight knew languages other than English (5 knew Spanish, one Tamil, one Korean and one Vietnamese).

7.3. Results

7.3.1 Orthographic roundedness vs. spikiness

Participants rated voiceless (vs. voiced) consonants as more angular (vs. rounded) (Grubbs test revealed two outliers at $p = 0.05$ with $Z = 3.70$ and $Z = 3.28$, who were excluded) ($M_{Voiceless} = 66.00$, $SD = 8.82$, $M_{Voiced} = 35.22$, $SD = 12.20$, $F_{(1, 56)} = 202.22$, $p < 0.001$, $\eta_p^2 = 0.78$. Additionally, one-sample *t*-tests revealed that both voiced and voiceless consonants differed

significantly from the mid-point of fifty (voiced: $t\ (57) = 9.14$, $p < 0.001$, $d = 1.21$; voiceless: $t\ (57) = 13.70$, $p < 0.001$, $d = 1.81$). All voiceless consonants were found to be more angular than the voiced ones except for /f/ and /v/, where the voiced consonant /v/ was found to be more angular (difference between /p/ vs. /b/- $M_{/p/} = 24.53$, $SD = 20.83$, $M_{/b/} = 15.10$, $SD = 15.68$, $t\ (56) = 3.94$, $p < 0.001$, $d = 0.52$; difference between /t/ vs. /d/- $M_{/t/} = 78.39$, $SD = 17.04$, $M_{/d/} = 17.56$, $SD = 19.26$, $t\ (56) = 14.20$, $p < 0.001$, $d = 1.88$; difference between /k/ vs. /g/- $M_{/k/} = 85.72$, $SD = 13.71$, $M_{/g/} = 24.58$, $SD = 24.54$, $t\ (56) = 16.25$, $p < 0.001$, $d = 2.15$; differences between /f/ vs. /v/- $M_{/f/} = 75.40$, $SD = 21.12$, $M_{/v/} = 83.61$, $SD = 21.88$, $t\ (56) = 2.33$, $p = 0.023$, $d = 0.31$ (Figure 2).

7.3.2 Phonemic roundedness vs. spikiness

Participants rated voiceless (vs. voiced) phonemes as more angular (vs. rounded) though not significantly (Grubbs test revealed no outliers at $p = 0.05$, *Critical Z* = 3.19) ($M_{Voiceless} = 44.08$, $SD = 16.02$, $M_{Voiced} = 41.55$, $SD = 16.40$, $F_{(1, 58)} = 1.56$, $p = 0.22$. However, comparison of the individual phonemes revealed that phonemes /b/ vs. /p/ and /t/ vs. /d/ were in the expected line i.e., voiceless phonemes being more angular than voiced phonemes, whereas phonemes /k/ vs. /g/ and /f/ vs. /v/ were not in the expected line (i.e., voiced phonemes were found to be more angular than the voiceless ones) (Figure 2).

As in the orthographic angularity, phoneme /v/ was rated as significantly angular even phonemically (compared to phoneme /f/). We feel the maximum difference in the results is due to the ratings of phonemes /f/ and /v/. If the data is analysed without the ratings of phonemes /f/ and /v/, voiceless phonemes are found to be significantly more angular than the voiced ones, ($M_{Voiceless\ (without\ /f/)} = 43.37$, $SD = 20.61$, $M_{Voiced\ (without\ /v/)} = 35.26$, $SD = 18.86$, $F_{(1, 58)} = 12.86$, $p = 0.001$, $\eta_p^2 = 0.18$ (difference between /p/ vs. /b/- $M_{/p/} = 46.24$, $SD = 27.51$, $M_{/b/} = 22.2$, $SD =$

24.44, *t (58)* = 4.98, *p* < 0.001, *d* = 0.65; difference between /t/ vs. /d/- $M_{/t/}$ = 55.03, *SD* = 32.20, $M_{/d/}$ = 37.51, *SD* = 27.20, *t (58)* = 3.67, *p* = 0.001, *d* = 0.48; difference between /k/ vs. /g/- $M_{/k/}$ = 32.39, *SD* = 30.39, $M_{/g/}$ = 46.05, *SD* = 30.31, *t (58)* = 2.53, *p* = 0.014, *d* = 0.33; difference between /f/ vs. /v/- $M_{/f/}$ = 42.69, *SD* = 28.66, $M_{/v/}$ = 60.42, *SD* = 30.52, *t (58)* = 3.24, *p* = 0.002, *d* = 0.42) (Figure 2).

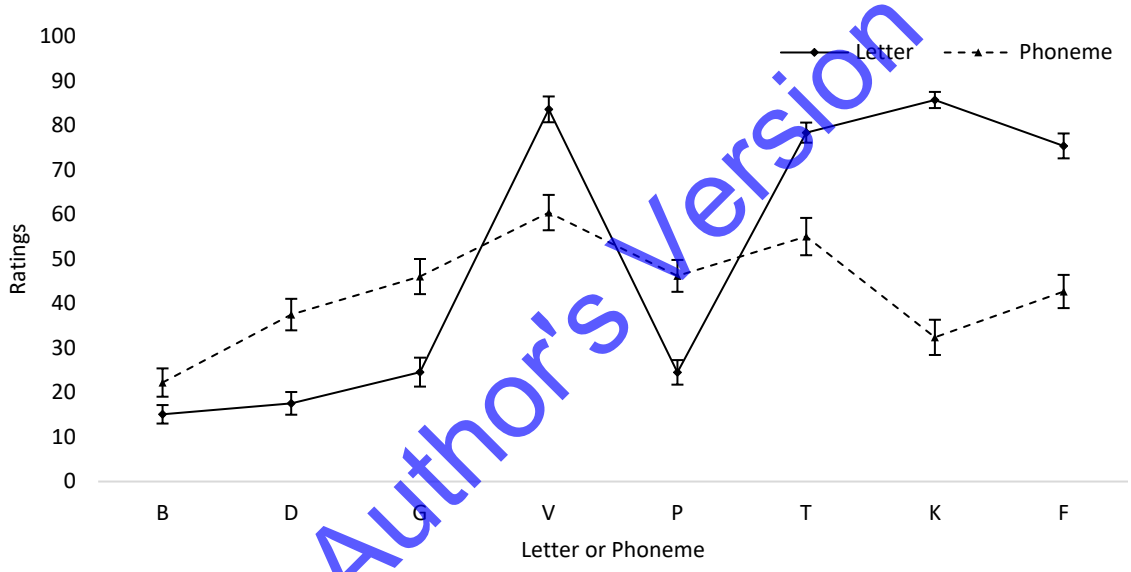

Figure 2. Ratings of voiceless (p, k, t, f) vs. voiced (b, g, d, v) letters and phonemes
0 = rounded, 100 = angular; Error bars represent SE of means

7.3.3 Comparing phonemic vs. orthographic angularity

Voiced phonemes were perceived as more angular compared to voiced letters (Figure 2) (except for the letter /v/ which was rated as spikier than its phonemic counterpart), whereas voiceless letters were perceived as more angular than voiced phonemes (except for the letter /p/ which was rated as more rounded than its phonemic counterpart). As mentioned earlier, it is difficult to tease apart the orthographic angularity (or roundedness) from the phonemic one. In view of this, we assume that when consumers see the brand names, they are influenced by both

(i.e. letters as as sounds/phonemes). Considering this, we averaged the respective ratings of letters and phonemes into one single score, which revealed that voiced consonants (letters plus phonemes) were considered significantly more rounded, whereas the voiceless consonants (letters plus phonemes) were considered as significantly more angular ($M_{Voiceless} = 55.19$, $SD = 8.74$, $M_{Voiced} = 38.73$, $SD = 12.89$, $F_{(1, 58)} = 112.13$, $p < 0.001$, $\eta_p^2 = 0.66$). Additionally, one-sample *t*-tests revealed that both voiced and voiceless consonants differed significantly from the mid-point of fifty (voiced: $t\ (58) = 6.71$, $p < 0.001$, $d = 0.87$; voiceless: $t\ (58) = 4.56$, $p < 0.001$, $d = 0.59$).

8 General Discussion

The current research investigated the effect of voiceless (vs. voiced) consonants present in brand names on the expected carbonation content of beverages. Across four studies, we demonstrated that hypothetical names containing voiceless (vs. voiced) consonants were more (vs. less) associated with carbonated (vs. still) water. The results of Study 1 (a rating task) and 2 (a free-choice task) demonstrated the association of voiceless (/p, k, t, f/) (vs. voiced, /b, d, g, v/) consonants and carbonated (vs. still) water brands (including cola drinks). Study 3 demonstrated the cross-modal correspondences of voiceless and voiced consonants contained within a brand name with spikiness and roundedness. Finally, Study 4 used individual letters and phonemic sounds to further explore the role of orthographic and phonemic angularity and demonstrated that voiceless consonants (letters plus phonemes) were considered as significantly more angular, whereas voiced consonants (letters plus phonemes) were considered as significantly more rounded. These findings reinforce the cross-modal linkages between voiceless consonants, angularity and the expected carbonation content of novel brand names.

Prior literature has demonstrated that sharp (vs. rounded) visual logos and sounds can provide reliable cues about the carbonation strength of a beverage (Ngo et al., 2012; Spence & Gallace, 2011). Even the pitch-size association and higher frequency sounds can influence the expectations of carbonation (e.g., smaller bubbles make higher frequency sounds, which leads to an expectation of a fresher beverage (Roque, Lafraire, & Auvray, 2020). Taking this research forward, the current paper adds further evidence of the effect of brand names and consonants on carbonation perception.

In the current study, voiceless consonants (/p/, /t/, /k/; both letters and phonemes) were perceived as significantly spikier, whereas voiced consonants (/b/, /d/, /g/; both letters and phonemes) were perceived as more rounded. However, the voiceless consonant /f/ was considered more rounded while its voiced counterpart /v/ was considered more angular. One possible explanation for this can be found in the sound-shape matching described by Knoeferle, Maggioni, & Spence (2017), where voiceless fricatives (e.g., /v/) are generally considered more angular than voiced fricatives (e.g., /f/). As per this account, the acoustic cues associated with the phonemes (e.g., frequencies) and the shape of lips while uttering the phonemes (e.g., /v/ is spoken with flattened lips) are important determinants of the perceived angularity or roundedness of any sound. This account also emphasises the importance of vowels in the process and argues that the perceived angularity or roundedness of any consonant may differ when it is presented with different vowels (e.g., /vi/ may be considered as more angular than /vo/), and it is often difficult to attribute 'proportional angularity' to either vowels or consonants present in a word. Another explanation is provided by Cuskley et al. (2017) who attributed this to the curvature of the letter f (vs. v). However, this account may not fully explain our findings as the latter authors, used a rounded font in small caps for the stimulus (/f/), whereas we used upper caps (/F/), which

makes the stimulus more angular. It is likely that if we had used a stimulus in small caps, we would have seen results similar to other voiceless consonants in our stimuli, however is yet to be tested. Chuskely et al. (2017) also discuss the dominance of orthographic angularity over the phonemic one, which suggests that the *written* brand names may affect the consumer perception *more* than the spoken brand name. Despite these explanations, more research is needed to further segregate and compare the orthographic and phonemic angularity of various consonants and the underlying mechanisms.

Our findings give an idea to firms to create brand names for beverages which can bring congruency in a product's name and its expected carbonation. For example, our findings show that the letters /k/, /t/ and /f/ are dominant in enhancing the angularity of a word or a brand name. These sounds seem to be a good fit for a beverage with strong carbonation (e.g., names of Cola vs. Cola Max can be chosen with a mix of these letters). Similarly, marketers can also use the orthographic angularity of the letters present in a brand name [e.g., /F/ and /T/ (more angular) vs. /f/ and /t/ (less angular)] of a beverage to enhance its perceived carbonation strength.

8.1 Limitation and future research

Firstly, our participants are predominately Americans, it remains to be seen whether these results can be generalised to other cultures. For example, there are studies which describe contradictory results in shape-taste associations in some cultures (e.g., Bremner et al., 2013); thus our results may not be extendable to those cultures. Secondly, we used the term carbonated (vs. still) water or a generic 'cola drinks' in our studies. The market nowadays has many popular variants of carbonated drinks (e.g., fruit juices, vitamin or energy drinks) and it is not clear whether these results will apply to all currently available carbonated beverages (especially since

many beverages differ in sourness, a main denominator of our findings). Thirdly, in Studies 3 and 4 we used a bipolar scale (round to spiky) as end labels, without presenting the associated images of round vs. spiky. Also, end labels were not counterbalanced (i.e. all participants saw 0 = rounded and 100 = spiky) and were not consistent across studies 3 and 4 (study 3 used the end labels of 'very rounded to very spiky', whereas study 4 used 'round vs. spiky' instead). It is unlikely that the results will vary if the end label presentation is different (i.e. shapes instead of text), nonetheless it is a limitation which can be addressed in future research. Fourthly, in Study 4, although we report the results of orthographic and phonemic angularity separately, it is very difficult to actually segregate these from each other (e.g., even in the orthographic presentation of letter /b/, a participant may pronounce the letter silently, which is difficult to control). Fifthly, although we presented only the consonants in Study 4, often letters are pronounced with vowels (e.g., /b/ can be read as /ba/ or /bee/), thus introducing a further potential confound which is, as yet, difficult to control. Sixthly, we used only the vowel /a/ in our stimuli. Previous research has shown that the vowels themselves can alter expectations of food attributes (Motoki et al., 2020). Given these findings, whether our results will differ when other vowels (e.g., front vs. back) are used in the stimuli, is a question that future research can address. Lastly, though our research demonstrates the linkages between voiceless consonants, carbonation, and spikiness, we do not examine the underlying mechanisms, and more research is needed to discuss the finer explanations of these findings. Similarly, the combination of letters (or phonemes) might influence the threshold of the expected carbonation. For example, brand names containing higher number of voiceless consonants (e.g., three) might be perceived as "strongly fizzy", whereas brand names containing fewer voiceless consonants (e.g., one) might be perceived as "less fizzy". Even the combination of phonemes/letters and other extrinsic factors (e.g., fonts, colors,

bubble sounds etc.) might modulate the expected carbonation, which the future rsearch can explore further. Despite these limitations, we feel that the findings of this paper can aid brand managers in selecting and creating brand names for beverages which are congruent with the sensory expectations of their product.

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Footnote 1

M refers to the average number of voiceless (or voiced) consonants participants used to create six fictitious BNs for the carbonated drinks.

Footnote 2

Note that the data was normally distributed.

Appendix 1

Stimuli used in Studies 1 and 3

Voiceless
Patak, Pataf, Pakat, Pakaf, Pafak, Pafat, Tapak, Tapaf, Takap, Takaf, Tafap, Tafak, Kapat, Kapaf, Katap, Kataf, Kafap. Kafat, Fapat, Fapak, Fatap, Fatak, Fakap, Fakat
Voiced
Badag, Badav, Bagad, Bagav, Bavag, Bavad, Dabag, Dabav, Dagab, Dagav, Davab, Davag, Gabad, Gabav, Gadab, Gadav, Gavab, Gavad, Vabad, Vabag, Vadab, Vadag, Vagab, Vagad