RUNNING HEAD: LOCALIZING TASTES IN 2D SPACE

"Sweet'n Low"[1]? On the localization of tastes and tasty products in 2D space

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[1] "Sweet'n Low" here is alluding to the well-known brand name "Sweet'n Low" (http://www.sweetnlow.com/)

Abstract

People map different sensory stimuli, and words that describe/refer to those stimuli, onto spatial dimensions in a manner that is non-arbitrary. Here, we evaluate whether people also associate basic taste words and products with characteristic tastes with a distinctive location (e.g., upper right corner) or a more general direction (e.g., more right than left). Based on prior research on taste and location valence, we predicted that sweetness would be associated with higher vertical spatial positions than the other basic tastes. The results of Experiments 1 and 2 support the view that participants do indeed locate the word "sweet" higher in space than the word "bitter". In Experiment 2, the participants also positioned products that are typically expected to be sweet (cupcake and honey) or bitter (beer and coffee) spatially. Overall, the sweet-tasting products were assigned to higher locations than were the bitter-tasting products. In order to test whether taste/location congruency would also affect product evaluations, a third experiment was conducted. The results of Experiment 3A (between participants) and 3B (within participants) failed to provide any evidence for the existence of consistent taste/location congruency effects. However, in Experiment 3B, the participants evaluated the sweet products as looking more appetizing when presented in upper relative to lower shelf locations. In none of the three studies was an association found between tastes and positions along the horizontal axis. Taken together, these results suggest that sweet and bitter tastes are differentially located in vertical, but not horizontal, space. The potential implications of these findings for both our understanding of the crossmodal correspondences, as well as for taste evaluation, and product placement are discussed.

Keywords: Taste, space, correspondence, product, shelf-position.

52 “Sweet’n Low”? On the localization of tastes in 2D space

53 **Introduction**

54

55 A growing body of empirical research highlights how people associate dimensions of
56 perceptual experience. Relevant to the present study, people have been shown to associate
57 information between perceptual features or dimensions and locations in space in ways that are
58 distinctly non-random (e.g., Marks, 1978; Spence, 2011). For example, a crossmodal
59 correspondence has been demonstrated between light (dark) colours with lighter (heavier)
60 weights (Walker, Francis, & Walker, 2010) and higher (lower) pitch with higher (lower)
61 elevations (e.g., Parise, Knorre, & Ernst, 2014). Importantly, such associations have also been
62 shown to influence information processing and decision-making. So, for example, in one
63 study, Sunaga, Park, and Spence (2016) reported a series of experiments demonstrating that
64 the crossmodal correspondence between lightness and location can facilitate product search
65 and choice.

66 A great deal of research has been conducted on the crossmodal associations between
67 visual and auditory features (e.g., pitch) and locations in 2D space (e.g., Jamal, Lacey,
68 Nygaard, & Sathian, 2017; Parkinson, Kholer, Sievers, & Wheatley, 2012; Romero-Rivas et
69 al., 2018; see Deroy, Fernandez-Prieto, Navarra, & Spence, 2018, for a review). To the best of
70 our knowledge, however, no research has yet been conducted on any associations that may
71 exist between gustatory tastes and locations in 2D or 3D space. However, there are good
72 reasons to believe that tastes might, in fact, be mapped spatially, in particular, along the
73 vertical axis.

74 On the one hand, a growing body of research suggests that different pitches of sound,
75 varying from low to high, are differentially associated with tastes (see Knöferle & Spence,
76 2012, for a review). For instance, Crisinel and Spence (2010) found evidence to suggest that

people associate sweet- and sour-tasting foods to high-pitched sounds (though see Simner, Cuskley, & Kirby, 2010). Based on the transitivity hypothesis of crossmodal correspondences, one may expect that if a dimension A in one modality (taste quality) corresponds with a dimension B in another modality (auditory pitch), and dimension B corresponds with dimension C in a third modality (elevation in space, which is not strictly speaking referring to another modality but rather another perhaps, amodal, dimension), people will link dimensions A and C in a predictable manner (see Deroy, Crisinel, & Spence, 2013, for a review).

On the other hand, the research also shows that people represent affective stimuli spatially, in particular, along the vertical plane, such that positively-valenced objects and words tend to be located higher relative to their negatively-valenced counterparts (e.g., Damjanovic & Santiago, 2016; Machiels & Orth, 2017; Marmolejo-Ramos et al., 2013, 2017; Meier & Robinson, 2004; Sasaki, Yamada, & Miura, 2016). Moreover, in a recent study, Marmolejo-Ramos et al. (2018) provided some evidence for the idea that in terms of 3D space, participants consistently place positive (negative) concepts in higher (lower) locations and nearer to (farther from) their body (see also Piqueras-Fiszman, Kraus, & Spence, 2014) with no preferential associations with locations in the horizontal plane (though note that previous research has, on occasion, documented a weaker pitch/left-right association, see Mudd, 1963).

Such an affective mapping of dimensions might not be restricted to the sense of taste, but may instead reflect a more general mechanism pertaining to perceptual associations. There is evidence to suggest that perceptual dimensions differentiate emotions (Collier, 1996; Machiels & Orth, 2017; Osgood, Suci, & Tannebaum, 1957). Cavanaugh, Maclnnis, and Weiss (2015) conducted a study in which the participants had to rate a number of perceptual dimensions from all sensory modalities (e.g., bright-dark, sweet-sour) in terms of eight

different categories of emotion. Their analysis revealed that perceptual dimensions differentiate between valence (positive and negative) and arousal (high vs. low).

That said, tastes (and taste words) are known to have specific hedonic properties, such that sweet is generally liked more than bitter and sour (e.g., Mennella, 2014). These hedonic properties of basic tastes appear to influence how people associate basic tastes and features in other perceptual dimensions, especially when such dimensions share a common valence (e.g., Velasco et al., 2015, 2016). For instance, people tend to associate sweet with round shapes (with both being categorized as pleasant) and bitter or sour with angular shapes (with both being categorized as less pleasant, Salgado Montejo et al., 2015; Spence & Deroy, 2013; Turoman et al., 2018; Velasco et al., 2015, 2016). The fact that people map affective stimuli vertically and that tastes have characteristic hedonic properties makes it possible to hypothesize that people might also locate tastes in the vertical plane in a manner that is non-random. Were such an observation to be documented, this would potentially be interesting in the context of food and drink marketing, where the location of products with characteristic tastes might be represented differently in the consumer's mind (based on the correspondence between taste and specific locations), as a function of the location where they are presented on the shelf.

Based on the transitivity hypothesis of crossmodal correspondences, as well as the research on affect/space mappings, in the present research, we studied how people associate tastes with different relative spatial locations. Our prediction was that, at the very least, sweet would tend to be located in higher positions relative to bitter, which would likely be located in a lower relative position. Experiments 1 and 2 evaluated the extent to which participants locate taste words and products with characteristic tastes in 2D space. Based on the literature reviewed above, one simple hypothesis was that sweet would be located in a position that was higher relative to bitter, given their respective affective connotations. In Experiment 3, we

tested whether changing the position of everyday products that are typically associated with different tastes would influence the participants' visual evaluation of the products in a 2D virtual shelf.

Experiment 1

Methods and materials

Participants. 62 participants (22 females, 38 males, and 2 who failed to specify), born between 1948 and 1998 (*Mean* birth year = 1975 in 2015, *SD* = 15.26, note that participants were asked to report the year they were born) were recruited from the adult education institute of Hasselt University, to take part in Experiment 1. All of the experiments reported here were conducted in accordance with the Declaration of Helsinki (http://www.who.int/bulletin/archives/79%284%29373.pdf).

Materials, design, and procedure. The stimuli consisted of four A4 pages. On each page, one of the basic taste words (the words "sweet", "sour", "bitter", and "salty") were printed in Verdana, size 15, with a centre alignment on the first line of the page. A circle with a 100 mm radius was presented in the middle of the page (see Figure 1). The centre of the circle was indicated by a cross. A circle was chosen in order to provide the same scale reference form the centre coordinates (0, 0), in any direction.

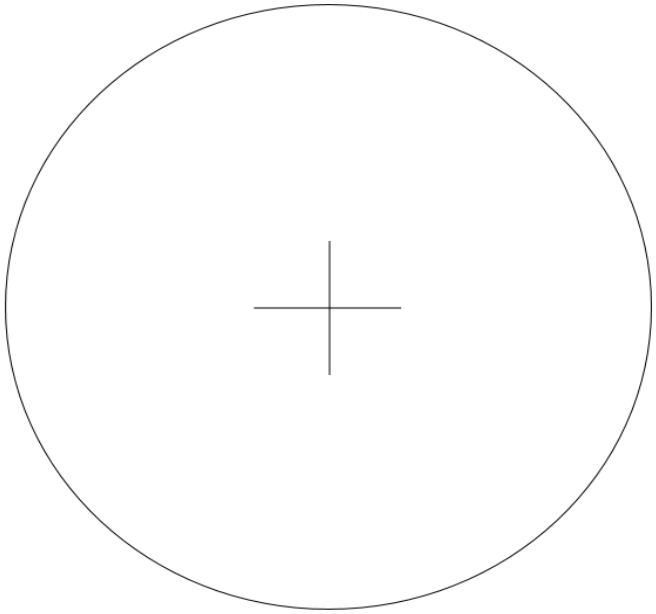


Figure 1. Circle used by participants to locate the tastes and tastants in Experiments 1 and 2. The participants placed a cross at the location that best matched the taste.

This experiment followed a 2 x 4 within-participants experimental design, with the factors of position (x and y in mm) and taste (sweet, sour, salty, and bitter). Before starting the experiment, the participants were presented with the general aims of the study ("We're interested in where you would intuitively locate a taste in space.") and gave their verbal consent to take part in the study. Next they were then asked some demographic questions (gender and year of birth). In the task "taste words in space", the participants had to allocate the taste words, one-by-one, in the circle (four circles, one per taste) via the question "Please indicate by placing a cross in the circle where the taste ____ belongs". Taste words were presented one by one, in a random order. The participants were given a new circle for every taste word they were asked to locate. The participants were not given the possibility of reviewing their location responses for the preceding taste words.

Analysis. The data (which can be accessed here: osf.io/xbmdv) were analysed by means of a 2 x 4 analysis of variance-type statistic (ATS, see Erceg-Hurn & Mirosevich,

2008). Significant main effects and interactions were further analysed with Bonferroni-corrected Wilcoxon Signed Rank tests. Cliff's Delta was used as a measure of effect size (see Cliff, 1996, for details).

Results and discussion

Analysis of the data revealed a significant main effect of taste, $F_{ATS}(2.87, \infty) = 3.54$, $p = .015$, and a significant interaction between taste and position, $F_{ATS}(2.86, \infty) = 4.11$, $p = .007$. There was no effect of position, $F_{ATS}(1.00, \infty) = 0.78$, $p = .378$ (see Figure 2, for a summary of the results). Overall, the participants located the word 'sweet' at a higher position than the word 'bitter' ($p = .024$, Cliff's Delta = .357, 95% CI [.153, .533]). No other differences were documented between tastes ($ps > .068$). As for the interaction term, participants located the word 'sweet' higher than 'bitter' on the y-axis ($p = .003$, Cliff's Delta = .395, 95% CI [.196, .563]). No other significant differences were observed ($ps > .142$).

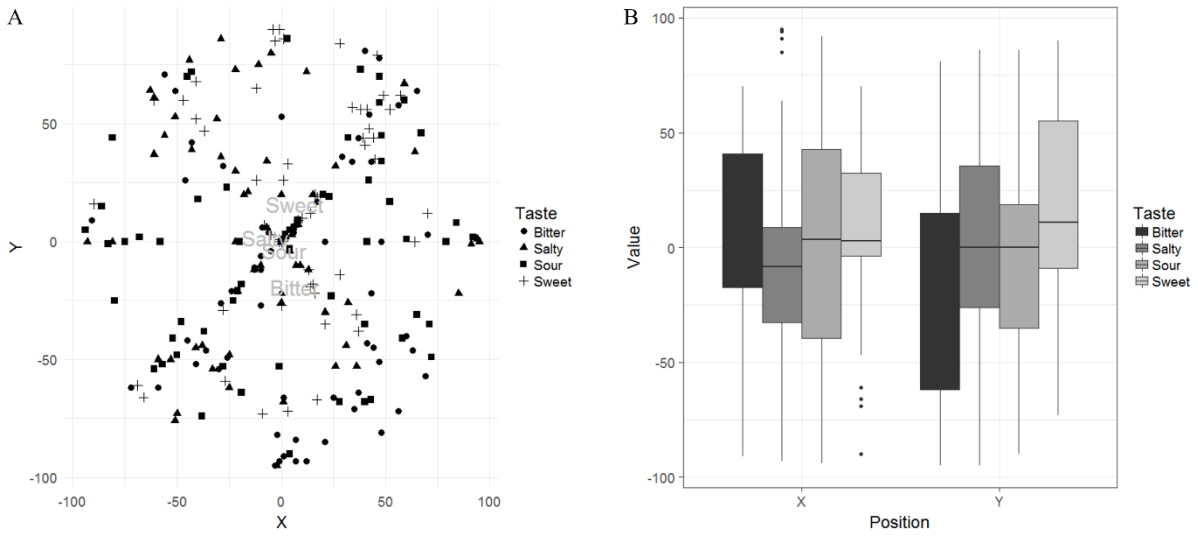


Figure 2. Panel A represents the different locations along the x- and y-axes chosen by the participants for each taste word. The different taste words were indicated on their average location. Panel B presents a boxplot including: The minimum value, first quartile, median, third

quartile, and maximum value. The points shown individually are those falling in the lower or upper percentiles (see Weissgerber, Milic, Winham, & Garovic, 2015).

The results of Experiment 1 provide evidence for the notion that sweet is located higher along the circle's y-axis than bitter. As suggested in the Introduction, such a result might be explained by the fact that sweet and bitter can perhaps be considered as the tastes that differ most in terms of their hedonic valence (positive and negative, respectively).

Given that we used taste words instead of actual tastants[2], we also ran a small control study in order to assess the extent to which such perceptual stimuli would yield similar results. 23 participants (11 females and 12 males) between the ages of 18 and 25 years (*M age* = 19.17 years, *SD* = 1.70) were recruited from Hasselt University. Solutions of four of the basic tastes, including sweet (sucrose, Tiense fijne kristalsuiker, 24.00 g/L), sour (citric acid, 1.20 g/L), bitter (caffeine, 0.54 g/L), salty (kitchen salt, 4.00 g/L), were used (following Hoehl, Schoenberger, & Busch-Stockfisch, 2010). The participants were given a glass of bottled water to rinse their mouth out between tasting the samples. The design, procedure, and analysis were the same as those used in Experiment 1. The analysis revealed a significant main effect of taste, $F_{ATS}(2.67, \infty) = 5.53$, $p = .001$. However, no effect of position, $F_{ATS}(1, \infty) = 0.82$, $p = .366$, nor interaction between taste and position, $F_{ATS}(2.59, \infty) = 0.453$, $p = .687$, was observed. Bonferroni-corrected Wilcoxon Signed Rank Tests revealed that the participants selected higher values for the sweet than for the salty taste ($p = .024$, Cliff's Delta

[2] Note, however, that research on correspondences has typically shown a similar pattern of correspondences when it comes to taste words and tastes (see Velasco et al., 2015, for an example on taste/shape correspondences and Saluja & Stevenson, in press; for a similar pattern of results on taste/colour correspondences). Importantly, when people are out shopping in the store, or virtually online, it is unlikely that they are actually tasting the product so using taste words in the present research might better represent the actual scenario of consumers estimating tastes in relation to a given location in space. In addition, there are many cases I which the taste words themselves are present on the product's packaging itself to communicate it to the consumer.

= .509, 95% CI [.162, .744]). Although this follow-up experiment has a small sample size, the difference between taste words and tastants might reflect the fact people rarely experience tastants in isolation and, when it comes to drinks, it is more common to have sweet, bitter, and sour flavoured drinks rather than salty ones. Moreover, when people are given taste words, they may be thinking about representatives of the categories, whereas actual tastants may not necessarily align with them.

In Experiment 2, we attempted to replicate and extend the results of our first study. The participants in this new study performed two tasks, one in which they were asked to locate different taste words in 2D space, and another in which they were asked to locate products with characteristic bitter or sweet tastes in the same 2D space. We expected that just as in Experiment 1, sweet and bitter would be the taste words that differed the most in terms of their location in vertical space, and that this would also be verified for taste products. Thus, the second task of Experiment 2 focused on products that people normally associate with sweet and bitter.

Experiment 2

Methods and materials

Participants. 80 new participants (38 females, and 42 males) between the ages 18 and 21 years (*M age* = 18.54 years, *SD* = 0.71) were recruited from Hasselt University. The data from one participant with incomplete responses was excluded from the analyses.

Apparatus and materials. The stimuli consisted of the words “sweet”, “sour”, “bitter”, and “salty” (Verdana, size 15, task 1), and pictures of four products, namely, beer, coffee (beans), cupcakes, and honey (dimensions: 5 cm x 5 cm, see Figure 3). Note that the first two are generally characterised as bitter products, whilst the two latter are regarded as sweet (something which is later confirmed with data).



Figure 3. Products used in Experiment 2 (mean value and standard deviations of luminosity are presented in parenthesis): A) bottle of beer (M value = 238.3, SD = 47.5), B) bag of coffee beans (M value = 219.2, SD = 59.3), C) box of cupcakes (M value = 226.1, SD = 41.1), and D) pot of honey (M value = 210.2, SD = 68.3).

Design and procedure. Two tasks were included in Experiment 2. In one task (the "taste words in space" task), the participants followed the same task as in Experiment 1. In the other task, which will be called "products in space", the participants had to place the four products presented in Figure 3, within a circle with the same dimensions as those used in the task involving taste words. Task order was counterbalanced across participants and the order of presentation of the taste words and products was randomized. Both tasks followed a 2 x 4 experimental design, with the factors of position (horizontal, vertical) and either taste (sweet, sour, bitter, or salty) or product (beer, coffee, cupcake, and honey). The products used in this experiment were selected based on the idea that they should be easy to categorize as either

bitter or sweet. Overall, the procedure and data analysis were the same as for Experiment 1. Note that for the task with products, we aggregated the data as a function of taste (i.e., sweet products: cupcake and honey, and bitter products: coffee, beer, together), in order to test our hypothesis, which was directed at taste properties of products overall.

Results and discussion

Tastes in space. A significant main effect of taste, $F_{ATS}(2.87, \infty) = 18.13$, $p < .001$, and a significant taste x position interaction, $F_{ATS}(2.97, \infty) = 7.75$, $p < .001$, were observed. There was no effect of position, $F_{ATS}(1.00, \infty) = 2.53$, $p = .111$ (see Figures 4A and 4B, for a summary of the results). Overall, the participants indicated higher values for sweet than for bitter ($p < .001$, Cliff's Delta = .598, 95% CI [.430, .726]), salty ($p = .015$, Cliff's Delta = .306, 95% CI [.125, .466]), and sour ($p < .001$, Cliff's Delta = .454, 95% CI [.281, .599]), and for salty than for bitter ($p = .002$, Cliff's Delta = .339, 95% CI [.160, .497]). As for the interaction term, the participants located sweet higher on the y-axis than bitter ($p < .001$, Cliff's Delta = .662, 95% CI [.509, .775]), salty ($p = .003$, Cliff's Delta = .367, 95% CI [.190, .520]), and sour ($p < .001$, Cliff's Delta = .484, 95% CI [.313, .625]), and salty in a higher position in the y-axis than bitter ($p < .001$, Cliff's Delta = .410, 95% CI [.235, .559]). No other differences were observed ($ps > .064$).

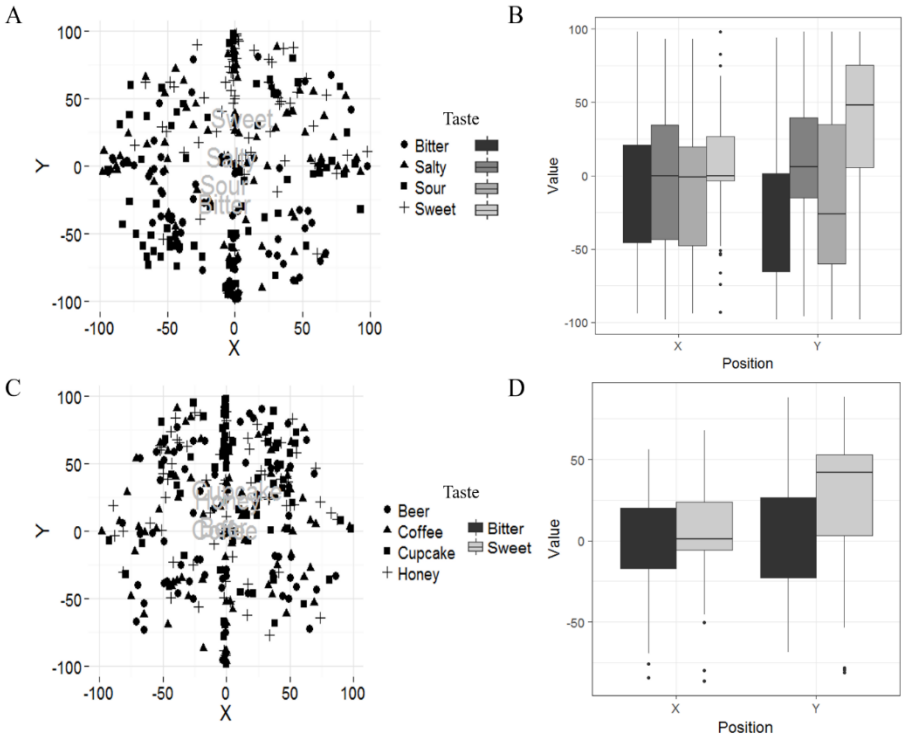


Figure 4. Similar to Figure 2, the different locations on the X- and Y-axes as chosen by the participants and boxplots for taste words (A and B) and products (C and D) are presented. The taste and product labels are indicated at their average location.

Products in space. The data were aggregated as a function of the taste of the product (sweet vs. bitter). The analysis revealed significant main effects of taste, $F_{ATS}(1, \infty) = 18.30$, $p < .001$, and position, $F_{ATS}(1, \infty) = 13.16$, $p < .001$. Additionally, a significant interaction between taste and position, $F_{ATS}(1, \infty) = 6.55$, $p = .011$ (see Figures 4C and 4D, for a summary of the results), was also observed. Sweet products were located in higher positions than the bitter products, Cliff's Delta = .369, 95% CI [.192, .522]. Overall, the participants indicated higher values on the Y axis than on the X axis (Cliff's Delta = .352, 95% CI [.173, .508]). As for the interaction term, significant differences were observed between bitter and sweet, $p < .001$, Cliff's Delta = .386, 95% CI [.207, .540], along the y-axis but not along the

x-axis, p = .160, Cliff's Delta = .127, 95% CI [-.055, .301]. On average, sweet products were located in higher positions than the bitter products.

Taken together, the results of the first two experiments revealed that individuals place sweet (top) and bitter (bottom) tastes onto 2D space in a manner that is non-random, for both words and for products. Following these experiments, we decided to conduct a third study to test whether changing the spatial positioning of products on a shelf would influence their evaluations.

Experiment 3

Experiment 3A

Methods and materials

Participants. 258 participants from UK (178 females, 80 males, *M age* = 36.38 years, *SD* = 12.48) were recruited using Prolific Academic (http://prolificacademic.co.uk/) to take part in this experiment.

Apparatus and materials. The four products (beer, coffee beans, cupcakes, and honey) used in Experiment 2 were used here as well and placed on a 2 x 2 shelf (see Figure 5). The two groups of products (sweet products versus bitter products) were either placed at the top or at the bottom of the shelf. Note, however, that in order to counterbalance the position of the different products and avoid position compatibility biases, each item within a product group (e.g., sweet or bitter) was placed either on the right or on the left of the top or bottom of the shelf, leading to eight different combinations.

INSERT FIGURE 5 ABOUT HERE

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297 ***Design and procedure.*** The experiment followed a 2 x 2 mixed design with product
298 position (top vs. bottom) as the between-participant factor and taste (sweet and bitter) as the
299 within-participant factor. Half of the participants had to evaluate the shelf versions with the
300 sweet products on top and the other half the shelf versions with the bitter products on top.
301 Participants rated the expected bitterness, the expected sweetness, how appetizing they found
302 the products, as well as their willingness to buy (WTB) for each product with 7-points Likert
303 scales (1 = strongly agree; 7 = strongly disagree). In addition to testing whether taste/position
304 congruency would influence the expected taste properties of the products, we also wanted to
305 evaluate whether such congruency would influence the evaluation of the products. Based on
306 the idea that congruency may enhance the fluency with which objects (e.g., Velasco et al.,
307 2016) are processed and therefore their evaluation, we included appetizing and WTB as non-
308 sensory product evaluation measures. Specifically, the following questions were included:
309 "When you look at this product on the shelf, to what extent do you agree with the following
310 statements? - this product looks bitter; - this product looks sweet; - this product looks
311 appetizing; - I would be willing to buy the package of coffee". The order of the questions and
312 the order of evaluation of the products were randomized across participants. Note that similar
313 to Experiment 2, the data were aggregated as a function of taste, in order to test our
314 hypothesis.
315
316 **Results and discussion**
317 Mixed design ATS with position (top versus bottom) as the between-participant factor
318 and taste as the within-participant factor were conducted for each of the variables included in
319 Experiment 3 (see Table 1, for a summary of the analysis and Figure 6, for a visualization of
320 the results).
321 ----------

INSERT TABLE 1 ABOUT HERE

As expected, in terms of the main effect of taste, participants rated the sweet products as less bitter, Cliff's Delta = .557, 95% CI [.473, .632], sweeter, Cliff's Delta = .734, 95% CI [.662, .793], and as more appetizing, Cliff's Delta = .320, 95% CI [.224, .410], than the bitter products. Similarly, the participants reported that they would be willing to buy more for the sweet products than for the bitter products, Cliff's Delta = .231, 95% CI [.132, .325]. Further analysis on the interaction effect of taste and position on the bitterness ratings revealed that the participants evaluated the bitter products as slightly more bitter when the bitter products where on the top and the sweet products on the bottom relative to the reversed positioning (p = .019, Cliff's Delta = .117, 95% CI [.027, .304]), whilst no difference between these conditions in the case of the sweet products (p = .395, Cliff's Delta = .061, 95% CI [-.080, .200]).

INSERT FIGURE 6 ABOUT HERE

The results of this experiment do not offer evidence in support of the idea that taste/space congruence influences people's taste and product evaluations. Indeed, the only interaction effect seems to suggest the reverse, namely, when bitter products are placed on top (vs bottom) of the shelf, the participants rate them as tasting more bitter. One alternative explanation for this result might be related to the fact that this study followed a mixed experimental design and as such, the between-participant manipulation does not emphasis elevation as relevant dimension. Previous research on crossmodal correspondences involving speeded classification tasks have indicated that crossmodal effects may arise from orthogonal variation of stimulus dimensions, on a trial-by-trial basis (Gallace & Spence, 2006; Melara,

1989; Melara & Marks, 1990a, b; Walker & Walker, 2016). In other words, when two dimensions (e.g., location and tastes) interact, participants may not be able to ignore the irrelevant dimension (e.g., location) when such dimension varies orthogonally, though not when it is kept constant (there was a between participant factor and as such, this did not vary), to the relevant dimension (products with specific tastes, which are the ones we ask participants to evaluate) in the same experimental task (see also Parise & Spence, 2013). In order to achieve this orthogonal variation, in Experiment 3B we conducted a within participant version of Experiment 3A.

Experiment 3B

Methods and materials.

201 participants from UK (115 females, 80 males, *M age* = 36.63 years, *SD* = 10.97) were recruited using Prolific Academic (http://prolificacademic.co.uk/) to take part in this experiment. The experimental design and procedure of Experiment 3B only differed from that of 3A in that the study followed a 2 x 2 within-participants design with product position (top vs. bottom) and taste (sweet vs. bitter) as factors.

Results and discussion

The results of the within participant ATS are presented in Table 1 (see also Figure 7). As in Experiment 3A, the participants rated the sweet products as tasting less bitter, Cliff's Delta = .426, 95% CI [.319, .522], sweeter, Cliff's Delta = .633, 95% CI [.538, .712], and as more appetizing, Cliff's Delta = .262, 95% CI [.151, .368], than the bitter products. In addition, the participants reported that they would be more willing to buy for the sweet products than for the bitter products, Cliff's Delta = .170, 95% CI [.057, .278]. The analysis on the interaction effect of taste and position on the appetizing ratings revealed that the participants evaluated the sweet products as slightly more appetizing when the sweet products

were on top and the bitter products on the bottom relative to the reversed arrangement (p = .004, Cliff's Delta = .028, 95% CI [-.085, .140]), whilst no difference between these conditions was observed in the case of the bitter-tasting products (p = .351, Cliff's Delta = .005, 95% CI [-.108, .118]).

INSERT FIGURE 7 ABOUT HERE

Overall, the results of Experiment 3B suggest that varying the irrelevant dimension orthogonally can affect the hedonic evaluation of the sweet products, however, no further effects were observed.

General Discussion

The present study is the first research designed to assess any relationships between taste words (sweet, sour, bitter, and salty) and products with characteristic tastes on the one hand, and locations in 2D space on the other. In Experiment 1, the participants were given different taste words and asked to locate them within a circle, which provided a frame for both vertical and horizontal planes, with equal distances from the circle's centre. Participants located sweet in a higher position than bitter. Experiment 2 was designed to replicate and extend these results. For that reason, the same task used in Experiment 1 was included, as well as a new task involving products that are typically associated with either a sweet or a bitter taste. The results of Experiment 2 provided further evidence to suggest that people locate the word sweet in higher positions than the word bitter. Similarly, participants also located sweet products higher in space than bitter products.

Experiment 3 assessed whether manipulating taste-space congruency on a 2D shelf display would result in different product evaluations. The results of Experiment 3A failed to

reveal the expected congruency effects, instead, participants seemed to consider the bitter products as more bitter when presented in the upper, relative to the lower, shelf location. Considering that some crossmodal congruency effects arise from relative compatibility effects in tasks where the irrelevant dimension is varied orthogonally, Experiment 3B involved a within-participants' version of Experiment 3A. Here, the results revealed that the participants evaluated the sweet products as looking more appetizing when presented in upper relative to lower locations on the shelf. Next, we discuss these results.

Why would people locate sweet and bitter differentially in vertical space?[3] First, it is worth noting that people are not generally required to locate tastes in space in their everyday lives. Nevertheless, the compatibility between these seemingly unrelated features (tastes and spatial locations) reflects some level of organization taking place within our conceptual system. In this case, and based on the ideas that people represent valenced concepts in 2D and 3D space (Marmolejo-Ramos et al., 2018), and that sweet and bitter are characteristically valenced stimuli, or concepts (Mennella, 2014), it is possible that, all other things being equal, participants might guide their judgements based on the feature's valence[4]. As mentioned in the introduction section, it is known that perceptual dimensions differentiate valence, something that might as well guide the extent to which people relate them to one another

[3] In our experiments, we primed participants explicitly (experiments with taste words) and implicitly (experiments with products), to think about taste properties (locate tastes or locate products with specific tastes). Nevertheless, at least in the experiments involving products, we cannot necessarily rule out that other concepts may be activated, as a function of location (e.g., healthiness, power, e.g., Sundar & Noseworthy, 2014). Future research may aim to understand what sort of concepts are activated by vertical and horizontal space, as well as the way in which consumers prioritize them when estimating taste properties or evaluating products with characteristic tastes.

[4] Something interesting to consider here is the idea that people learn to like (or acquire a liking for) bitter foods and, as such, one may expect more variability in terms of their ratings of such foods (Mennella, 2014), than foods having a different dominant taste. In addition, there are individual differences when it comes to sweetness liking (e.g., Looy et al., 1992; Yeomans et al., 2017). In that sense, there may be differences evoked by such tastes that are not necessarily a result of liking, but liking might be a consequence instead. This may be thought of as a possible counterargument for the suggested valence mechanism. There are a number of points that may be considered here though: 1) Other taste words were included in the study which provide a reference point to bitter and sweet. In particular, in Experiment 2 in the task involving taste words, differences were found between sweet and all the other tastes in vertical space. 2) Research on crossmodal correspondences has controlled for taste "likers" and "dislikers" and still showed that people match tastes and pitch regardless of taster status (Crisinel & Spence, 2012). 3) Nevertheless, future research should aim to rule out other potential mechanisms for the taste/shape matching.

(Cavanaugh, MacInnis, & Weiss, 2015, Collier, 1996; Velasco et al., 2016). Whilst this view might provide a framework in which to interpret the results of the present study, other possible mechanisms for such matching might not be ruled out. It might be that this relationship reflects the transitivity hypothesis of crossmodal correspondences and therefore it is just a by-product of other correspondences (Deroy, Crisinel, & Spence, 2013).

Another alternative explanation is that there are certain statistical regularities in the environment that are encoded in our brains and therefore give rise to such an intuitive matching between sweet and bitter and higher and lower locations in 2D space, respectively (cf. Velasco et al., 2016). In the present case, one might wonder whether, for example, vegetables are generally found at, or below, ground level (e.g., chicory, potatoes, tomatoes), while fruits at higher positions (and above the ground, e.g., grapes, see Parise, Knorre, & Ernst, 2014, for an example of naturalistic correlations between pitch and elevation and way of evaluating them). On the other hand, given that the different experiments used either taste words, one may wonder whether the sound symbolic meaning of the words “sweet” and “bitter” may have driven the results (e.g., Velasco et al., 2016). However, the location of products in the taste words and product tasks of Experiment 2 was similar. This may indicate that the association process may not solely based on sound symbolism.

The way in which perceptual dimensions are organized is certainly relevant for consumer contexts as it provides, in this particular case, a rationale for the evaluation and design of food and drink product experiences. It is also important here to reflect on why it is that taste-space congruency may or may not influence people’s product evaluations. Study 3 did not find consistent evidence in support of a congruency effect on taste evaluation. Whilst the absence of evidence obviously does not mean evidence of absence, we neveretheless did not find evidence to suggest that the taste/vertical space congruency influence product evaluation consistently across tasks.

A possible explanation of the aforementioned results might be found in the absence of a shelf at eye level. In other words, although in Experiment 3A and 3B one shelf is indeed higher than the other, there is no central position reference. In contrast, in Experiments 1 and 2, the midpoint of the circle (i.e., neither high nor low) was indicated. Consequently, it could be that some participants considered the highest shelf to be on eye level and thus a higher spatial location was absent. Furthermore, following the results of Marmolejo-Ramos et al. (2018) concerning the placement of positive concept higher and nearer, the results could also have been influenced by which shelf (i.e., the lower or the higher) was considered to be the eye level since this would be considered to be nearer to the body.

The relationship that was observed concerning the location of basic tastes (i.e., sweet higher to bitter) does, however, provide a possible avenue to communicate the expected taste of a product. Much alike the use of certain colours and shapes on product packaging to signal the expected taste, one might thus also consider ordering the product from high to low based on their expected taste (i.e., sweet products above and more bitter product lower) to provide an additional cue concerning the expected taste. This could especially be worthwhile for those products that are similar in appearance but different in taste (e.g., candy which can have a sweet taste but also a bitter taste). Although no immediate effect on product evaluation or willingness to buy was found in experiment 3A and 3B, it could be that – after tasting the product located in the congruent location – a higher level of satisfaction may be found when taste expectations are confirmed.

Here, it is also important to mention that, by including a shelf and products in a more realistic shopping context, multiple additional variables may also play a role (e.g., heaviness, Deng & Kahn, 2009; rationality/emotion Cian et al., 2015; power Sundar & Noseworthy, 2014; Wongkitrungrueng, Valenzuela, & Sen, in press). For example, Deng and Kahn showed that, in the context of product packaging, the bottom is considered as a heavier location than

the top. Their results also suggest that the heaviness of a package might be positively correlated with richness in taste. Thus, a product placed on the bottom of a shelf might be rated richer in taste than a product placed on the top. This association could come into conflict with the association between taste and location put forward in the first two experiments.

It should also be noted that, on average, bitter products were not disliked but rather, consumers just found them just a little less appetizing than sweet products. Indeed, whilst there may be differences in terms of how appetizing consumers find specific products, there may not be many widespread products in a supermarket that are necessarily unappetizing or disliked by the majority of people. In this sense, the difference in terms of how appetizing the product was between sweet and bitter products was not a difference between appetizing and non-appetizing but between different levels on the neutral/appetizing end of the scale. Note that, pleasantness can play an important role in crossmodal associations (Crisinel & Spence, 2012). Therefore, further studies might integrate people who like/dislike bitter products (beer, coffee), to see whether for the latter, expectations of bitterness are more influenced by the positioning on the shelf than for people that like bitter products.

The results of the present study may be relevant for those researchers and practitioners interested in the evaluation of food and drink tastes. That is, certain locations might be feel more appropriate for those products that have certain distinct tastes, at least when consumers are thinking about taste. Indeed, one might even consider that the association between tastes and the vertical plane might, perhaps, be tacit in the market place or alternatively internalized by the consumer. The results presented here might also be relevant for those thinking about the communication of the taste of a product by means of the product packaging (e.g., communication of sweet taste located in the upper section of the packaging while a bitter taste could better be communicated in the lower section of the packaging) or by means of placement on the shelves. All-in-all, our results provide the first evidence to suggest

a relationship between taste qualities and the vertical plane. Future research might build on our results in order to understand all the implications that such relationships might have in consumer contexts.

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