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Sounds spicy: Enhancing the evaluation of piquancy by means of a customised crossmodally congruent soundtrack

Qian (Janice) Wang [a,*], Steve Keller [b], Charles Spence [a]

[a] Crossmodal Research Laboratory, Oxford University, Oxford, UK
[b] iV Audio Branding, Nashville, TN, USA

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ABSTRACT

The aim of the present research was to uncover the auditory parameters that correspond to the experience of spiciness/piquancy in food, and to assess whether such crossmodal correspondences have perceptual consequences when it comes to evaluating the spiciness of actual foods tested in a naturalistic environment. An online study (Experiment 1) was conducted first in order to determine the acoustical/-musical parameters that best match spiciness. The results were used to compose a spicy soundscape that was incorporated into the subsequent experiments. Next, a between-participants study (Experiment 2) was conducted to test the effect of different background sound conditions on participants' expected and actual ratings of a novel restaurant dish. Four sound conditions were used in testing: the aforementioned spicy soundtrack, a sweet soundtrack, white noise, and silence. The expected spiciness of the dish was significantly higher in the spicy soundscape group as compared to the other groups. However, no significant differences were observed in the actual taste ratings. A contributing factor to this later result may have been the large disparity between the participants' expectations of spiciness and the actual (mild) spiciness of the test dish itself. To follow-up, a study (Experiment 3) was conducted with a spicier food sample and the same sound conditions. Here, the results revealed that the rated spiciness of the food sample was significantly higher in the spicy soundtrack condition than in the other sound conditions. Finally, a study using both mild and hot salsa (Experiment 4) demonstrated an interaction effect between the sound condition and stimuli spiciness level, consistent with the assimilation-contrast model of consumer expectation disconfirmation. These results therefore demonstrate that a soundscape with auditory attributes corresponding to spiciness can enhance the perception of spiciness in foods, likely via the setting of sensory expectations.

1. Introduction

Crossmodal correspondences consist of associations that the majority of people tend to share between seemingly-unrelated attributes (or dimensions) of experience in different sensory modalities (see Spence, 2011, for a review). The majority of the research that has been conducted over the last century has involved audio-visual correspondences, but there is an emerging interest in those crossmodal correspondences that are related to food/flavour (see Spence, Levitan, Shankar, & Zampini, 2010, for flavour and colour correspondences; Deroy, Crisinel, & Spence, 2013, for odour-sound correspondences, and Slocombe, Carmichael, & Simner, 2015, for touch-taste correspondences). Specifically, a growing list of correspondences have now been demonstrated between sonic properties and different flavour attributes; for example, high pitch is associated with sweet and sour basic tastes as well as with vanilla flavouring, and low pitch is associated with bitter taste and with coffee aromas and flavours (e.g., Crisinel & Spence, 2009, 2010, Mesz, Trevisan, & Sigman, 2011; see Knöferle & Spence, 2012, for a review).

Beyond the basic tastes, however, there are more complex flavours and tactile sensations involved in eating and drinking (Auvray & Spence, 2008; Reinoso Carvalho, Wang, Van Ee, Persoone, & Spence, 2017; Stevenson, 2009). The focus of the present work concerns the trigeminal sensation of spiciness/piquancy,[1] a burning or warming sensation triggered by the

* Corresponding author at: Crossmodal Research Laboratory, Department of Experimental Psychology, University of Oxford, South Parks Road, Oxford OX1 3UD, UK.
E-mail address: qian.wang@psy.ox.ac.uk (Q. (J.) Wang).

[1] Within the scope of the present paper, the term spiciness is used interchangeably with the term piquancy to refer to the hot/burning sensation from chili peppers.

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activation of capsaicin receptors in the mouth (Caterina et al., 1997). To date, no crossmodal correspondences have been documented between sounds and spiciness, though there is evidence of correspondences involving spiciness and attributes from the other senses (e.g., sight or smell).[2] Visually, spiciness is associated with the colour red. For instance, Shermer and Levitan (2014) demonstrated that the intensity (saturation) of red colouring of a salsa affected its perceived spiciness. Going one step further, Tu, Yang, and Ma (2016) recently demonstrated that even the colour of the plate on which a food is served can change both expected and actual spiciness ratings. People have also been shown to choose spicier sauces in rooms that are more brightly-lit, as compared to in rooms that are dimly-lit (Xu & Labroo, 2014). The first aim of the present research, then, was to uncover correspondences between basic auditory attributes and spiciness/piquancy.

According to Shermer and Levitan (2014), the red colouring used in their study to modify the salsa samples generated sensory expectations of spiciness, which in turn enhanced the perceived spiciness of the salsas. Our hypothesis is that auditory stimuli corresponding to spiciness might also enhance spiciness by way of generating expectations. In other words, if a specific soundscape can act to enhance expectations for a specific taste, then hearing the soundscape could lead people to adjust their sensory perceptions to try and conform to their initial taste expectations (see Lelièvre, Chollet, Abdi, & Valentin, 2009). When it comes to sounds and basic tastes, the research that has been published to date has revealed that soundtracks that are crossmodally congruent with basic tastes could enhance those tastes in food and drinks (Crisinel et al., 2012; Reinoso Carvalho, Wang, Van Ee, & Spence, 2016; Wang & Spence, 2016). However, there has been no research published to date with the goal of delineating the possible mechanisms that underlie the auditory modulation of taste. Therefore, the second aim of the research reported here is to verify whether spicy-congruent soundtracks might enhance spiciness ratings by acting on participants' sensory expectations.

First, we adapted the method from Knoeferle, Woods, Käppler, and Spence (2015) for constructing music that corresponds to one of the basic tastes. Namely, we conducted a study in which the participants had to answer a series of questions where they would choose from multiple musical segments that differed in terms of only one auditory parameter. In Experiment 1, an online study was conducted in order to explore the extent to which individuals would consistently associate different musical parameters with spiciness. A spicy soundscape was then composed, based on the findings from Experiment 1, and was used in Experiments 2–4 in order to determine whether sound can influence participants' expected and actual taste ratings of real food.

2. Experiment 1

2.1. Methods

2.1.1. Participants

44 participants (27 women, 17 men) aged between 25 to 65 years of age (M = 38.47, SD = 9.81) took part in the study. The participants gave their informed consent, and reported no hearing impairments. The participants were recruited from mailing lists. The experiment was approved by the Central University Research Ethics Committee of Oxford University (MSD-IDREC-C1-2014-205).

[2] There is also evidence that the smell of pepper, an approximate olfactory analog to the trigeminal spicy sensation, is matched with angular, rather than rounded, shapes (Seo et al., 2010).

2.1.2. Auditory stimuli

Short sound clips were composed by iV (an audio branding consultancy) to reflect different variations of specific musical parameters. Short musical segments (2–10 s) were composed with three levels each for articulation (staccato or legato), distortion, tempo, pitch height, complexity, length of attack, length of decay, length of both attack and decay, and harmony. Musical segments were also composed with two levels of difference for modality (major/minor). We also included three questions to explore cultural associations reflected in a series of ambient, classical, and percussion music samples. Three ambient samples were presented: the first was bass heavy and rhythmical, the second was relaxing and high pitched, and the third was sharp and sporadic with stuttering drum beats. The classical music samples included Mozart's violin concerto No 3 Movement 1 (with a regular 4/4 rhythm) and Saint-Saëns' violin concerto No 3 Movement 3 (featuring a high-pitched and tempestuous string solo). Percussion samples included a Native North American drumming pattern and a Brazilian samba percussion pattern. All-in-all, there were 36 music segments. The segments can all be heard at https://soundcloud.com/janice-wang09/sets/sound-of-spiciness-online-test.

2.1.3. Procedure

The experiment was programmed on the Qualtrics online survey platform. Before the study began, the participants had to correctly answer an acoustically-presented question to ensure sound playback was functional and to allow them to adjust the volume to a comfortable listening level.

To take part, the participants answered 13 questions, one for each musical attribute tested. For each question, the participants had to choose the sound clip that best matched spicy foods (see Fig. 1 for question format). In the test itself, it was further clarified that spicy meant piquant foods like chilli pepper or hot sauce. For the attributes of articulation, distortion, tempo, pitch height, complexity, length of attack, length of decay, length of attack and decay, and ambient music, there were 3 sound clips to choose from. For the attributes of modality, classical music, and percussion music, there were 2 sound clips to choose from. Each sound clip was labelled with a random 3-digit number. For each question, the order in which the sound clips were presented was randomised.

After the trials, the participants were asked how many years of musical training they had, their enjoyment of spicy food (on a scale from 1 – hate it, to 7 – love it), and the frequency with which they ate spicy food (never, less than once a month, once a month, 2–3 times a month, once a week, 2–3 times a week, daily).

The study lasted for approximately 15 min.

2.2. Data analysis

A chi-squared goodness of fit test was conducted to assess whether the distribution of choices for each question were random. We also analysed the results based on musical expertise and spiciness liking.

2.3. Results

A chi-square test of goodness of fit was calculated for each musical attribute to determine which of them induced a distribution of spicy matches that was significantly different from chance (see Table 1). The auditory features with non-random distributions were distortion ($X^2(2,44) = 16.41$, $p < 0.0005$), tempo ($X^2(2,44) = 13.68$, $p = 0.0011$), and pitch ($X^2(2,44) = 11.23$, $p = 0.0036$), where the sound clip with the most distortion, fastest tempo, and highest