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The vessel's shape influences the smell and taste of cola

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ABSTRACT

People's smell and taste perception is affected by different features of the vessel in which the beverage is served. In this study we focused on the container's shape and we investigated its impact on participants' olfactory and tasting ratings regarding a popular beverage, i.e., cola. We tested 100 healthy participants who evaluated both cola and sparkling water. These two beverages were presented in three different containers: a cola glass, a water glass and a plastic bottle. The results showed the presence of multisensory interactions between the smell and taste of the drinks and the type of vessel in which they were presented. Cola was perceived as more pleasant and intense when served in a typical coca-cola glass as compared to when it was presented in an incongruent container (i.e., water glass or plastic bottle). These results further support the view that our perception is modulated by the shape of the container in which the liquid is presented, strongly influencing the consumer's drinking experience.

1. Introduction

Several environmental and contextual factors have been shown to affect our taste and odour perception (Spence, Harrar, & Piqueras-Fiszman, 2012; Spence & Piqueras-Fiszman, 2014), through a process known as "sensation transfer" (Piqueras-Fiszman & Spence, 2015; Skaczkowski, Durkin, Kashima, & Wakefield, 2016). It is well-documented that gustatory and olfactory perception is altered when the characteristics of the food or beverage container are modified (e.g., colour, shape and weight). For example, changing the colour of the glass exerts a large influence on wine perception (Ross, Bohlscheid, & Weller, 2008). Similarly, hot chocolate is liked differently (Piqueras-Fiszman & Spence, 2012a) and the carbonation of a drink is rated differently (Risso, Maggiono, Olivero, & Gallace, 2014) according to the colour of the cup in which the drinks are served. Regarding the shape of the vessel, researchers have demonstrated that the ratings of the sensory properties of wine vary as a function of the glass in which the wine is served (e.g., Hummel, Delwiche, Schmidt, & Hüttenbrink, 2003; Vilanova, Vidal, & Cortes, 2008). Also, the weight of the vessel affects perception such that higher pleasantness ratings are obtained for yogurt and wine when presented in heavier containers than when served in lighter containers (Piqueras-Fiszman & Spence, 2012b; Spence, 2011). A similar effect is also detected for water, which is perceived as more carbonated when served in a heavier plastic glass (Maggioni, Risso, Olivero, & Gallace, 2015). The cross-modal influences are not surprising as food and beverages rarely are experienced without context but rather embedded in multisensory settings.

Regarding food perception, it has been shown that the colour and shape of the plate modify food flavour. For instance, the perceived taste intensity, quality, and pleasantness of a cheesecake were higher when served on plates with a particular association between shape and colour. Here, sweetness and intensity were enhanced by white round plates while more complex judgments, such as quality or liking were increased by both white round and black square plates (Stewart & Goss, 2013). Also, the taste of popcorn has been shown to be affected by the colour of the bowl in which it is presented (Harrar, Piqueras-Fiszman, & Spence, 2011). Cross-modal perceptual interactions have also been demonstrated for beverages. Here, the role of the drink receptacle seems undisputed, as evident from the increasing number of relevant articles published in the very recent years on a wide variety of beverages (e.g., wine, coffee, tea, hot chocolate, beer; for a review, see: Spence & Wan, 2015). Contextual influences on wine perception has received considerable attention (for a review, see Spence, 2011). In particular, the size, shape, weight, and colour of the glass have been proven to affect the perceived intensity and quality of a wine (e.g., Fischer & Loewe-Stanienda, 1999; Hummel et al., 2003; Vilanova et al., 2008). For example, the rated intensity of a wine's

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odour was shown to increase as the ratio between the rim of the glass and its largest diameter increased (Fischer & Loewe-Stanienda, 1999). Furthermore, the bulbous shape of glasses, compared to 'tulip' or 'beaker' glasses, seems to produce a higher intensity of wine odours which is accompanied by an increased liking of the wine odour (Hummel et al., 2003). This is especially true when participants can physically interact with the wine glass. Indeed, no differences in people's ratings of wine are observed under strict laboratory conditions (e.g., Russell, Zivanovic, Morris, Penfield, & Weiss, 2005). The findings that also physical attributes (e.g., colour) of a vessel affect beverage perception suggest that cognitive processes (e.g., prior knowledge) contribute to flavour perception (Spence, 2011). For example, in everyday life memory associations are made between specific beverages and their typical container characteristics (e.g., Sakai, Imada, Saito, Kobayakawa, & Deguchi, 2005). When a beverage/food is presented in a congruent vessel, perceptual ratings are higher as compared to when an incongruent container is used (e.g., Cardello, Maller, Masor, Dubose, & Edelman, 1985; Raudenbush, Meyer, Eppich, Corley, & Petterson, 2002; Schifferstein, 2009). According to the cognitive model proposed by Sakai et al. (2005) the associations among flavours and other cues are formed depending on their co-occurrence in the environment; they are then memorized and used later to generate an expectation of what we are about to consume. Specifically, Sakai et al. (2005) found that congruent pictures (e.g., the picture of an apple while smelling apple juice) magnify odour intensity and pleasantness more strongly than incongruent ones (e.g., the picture of a pear while smelling apple juice). Similarly, Cardello et al. (1985) observed that food acceptability was greatest within an appropriate container (i.e., both soup and a dental drink were rated as more acceptable when consumed from a container appropriate for the foodstuff: soup-bowl, dental liquid-glass). In the same vein, Raudenbush et al. (2002) found that beverages were rated as more pleasant when sampled from containers typically appropriate for those beverages (e.g., beer-bottle, orange juice-glass, hot chocolate-cup). In addition, Schifferstein (2009) demonstrated that participants' responses to different drinks (e.g., tea and soft drinks) depended on the type of cup used. For example, participants enjoyed drinking the soda from the plastic cup more than from the ceramic cup. Relatedly, research shows that the perceived intensity and pleasantness of a congruent coloured solution (e.g., red-strawberry) is judged higher (i.e., more pleasant) than of an incongruent coloured one (e.g., green-strawberry) (Zellner, Bartoli, & Eckard, 1991; Zellner, Stewart, Rozin, & Brown, 1988). Such congruency effects have been demonstrated not only for visual stimuli, but also for tactile information, such as weight (Piqueras-Fiszman & Spence, 2012b). Here, Piqueras-Fiszman and Spence (2012b) found that customers expected the wine to be more expensive and of better quality when contained in heavier bottles. All these studies suggest that people's expectations regarding a specific product exert an influence on its overall evaluation.

As the container in which a beverage is served change the overall aroma of the drink itself, beverage industries have started to develop specific glass shapes according to the type of drink in order to enhance people's drinking experience (for a review on the role of the glass as a marketing tool, see: Stead, Angus, Macdonald, & Bauld, 2014). To date, a number of contextual factors affecting common and famous worldwide drinks have been localized (e.g., wine, beer, tea, coffee: Spence & Wan, 2015). However, considering that billions of servings of cola drinks are consumed every day, it is surprising that no academic attention has been paid to the cola beverage. According to the food chemist Sarah Risch, "*if you want to indulge in a glug of Coke in its purest form then you should drink it from a glass bottle*" (Cantor, 2009). Indeed, it appears that cola would taste better from the glass bottle – as compared to a plastic bottle or a can - and this would be a matter of chemistry and not of perception, being the result of a reaction between the liquid and the container's material. However, such an assumption would be in conflict with evidence showing that the influence of the container on perception also involves the direct (visual and/or haptic) perception of the glass and prior knowledge and expectations of the glass itself (for a detailed review, see: Spence & Wan, 2015). The aim of the present study was therefore to investigate effects of the vessel on perceptual ratings of a cola beverage. According to the existing literature (e.g., Spence & Wan, 2015), we expected differences in taste and olfactory perception as a function of the type of container in which the stimuli were presented.

2. Materials and methods

2.1. Participants

A total of 100 eligible participants (51 females; mean age = 24.38 years, SD = 3.48, range = 18–34 years) were invited to the laboratory and provided written informed consent to participate in the study. All participants self-reported to be in good general physical and mental health. None suffered from any form of hormonal, neurological, or autoimmune diseases or had suffered a head trauma leading to unconsciousness in the past. Also, none of the participants smoked or took any medication. All subjects had a normal olfactory and gustatory function, as assessed by the "Sniffin' Sticks" (Hummel, Sekinger, Wolf, Pauli, & Kobal, 1997) and the taste strips (Landis et al., 2009). In addition, a detailed otorhinolaryngological questioning verified that none of the participants had any major nasal pathology. All testing was performed in a well-ventilated, quiet room in a relaxed atmosphere. After information regarding the aims of the study, participants gave written consent. All aspects of the study were compliant with the Declaration of Helsinki. The Ethics Committee of the Medical Faculty at the TU Dresden approved the study (application number EK218062014).

2.2. Olfactory testing

Participants underwent olfactory testing using the "Sniffin' Sticks" identification test (Hummel et al., 1997). Felt-tip pens filled with odours were used to deliver the olfactory stimuli. For odour presentation the cap was removed by the experimenter for approximately 3 s and the pen's tip was placed approximately 2 cm in front of both nostrils. Odour identification was assessed by means of 16 common odours (i.e., garlic, turpentine, apple, cinnamon, banana, lemon, anise, liquorice, pineapple, coffee, cloves, rose, leather, fish, orange, and peppermint). Using a multiple choice task, identification of individual odorants was performed from a list of four descriptors (one correct descriptor and three lures). The interval between odour presentations was 20–30 s. Olfactory scores were defined as the number of correct responses (0–16). The participants' scores ranged from 12 to 16 (mean: 14.3, SD: 1). Only normosmic subjects (with scores $\geqslant$ 12) participated in the study.

2.3. Gustatory testing

Gustation was assessed using the so-called taste strips (Landis et al., 2009), which consist of stripes of filter paper impregnated with taste substances. Taste strips were applied on the tongue as a whole-mouth test (allowing the participant to close the mouth and move the tongue around). Sucrose was used as sweet stimulus, sodium chloride as salty, quinine hydrochloride as bitter, and citric acid as sour stimulus. The test was based on a forced choice identification where participants had to identify the stimuli as sweet, sour, salty, or bitter. The participants' scores ranged from 9 to 16