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Tasting spoons: Assessing how the material of a spoon affects the taste of the food

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ABSTRACT

This study investigated the effect that the taste of certain metals has on the perception of food. Four spoons plated with different metals (gold, copper, zinc, and stainless steel) were used to taste cream samples having different tastes: sweet, sour, bitter, salty, and plain. The results revealed that the zinc and copper spoons, in addition to transferring a somewhat metallic and bitter taste, enhanced to a greater or lesser extent, each cream's dominant taste. Contrary to our expectations, the metallic taste of the copper and zinc spoons did not seem to affect the pleasantness of the samples significantly. These findings reveal that the effect that the metals from which cutlery can be made have on food perception differs from that found when the metal salts are added to the composition of the food itself.

1. Introduction

During consumption, many different factors affect, either directly or indirectly, how people interact with, and consequently perceive, food. Apart from the physical properties of the food itself, contextual variables also play an important role (e.g., King, Meiselman, Hottenstein, Work, & Cronk, 2007; King, Weber, Meiselman, & Lv, 2004; Reisfelt, Gabrielsen, Aaslyng, Bjerre, & Møller, 2009). In a direct way, and in most developed regions, people interact with food via the medium of cutlery, which is used while cooking, to serve, and eventually to move the food thus prepared from plate to mouth.

The wide variety of different cutlery designs available nowadays serves not only to meet the functional needs of consumers, but also to transmit certain feelings to the person who is using it. In many contexts, the physical food is just one of several elements that help to construct the intended eating experience for the consumer (Schifferstein, 2010). As Aldersey-Williams (2011, p. 257) reports: "*We know the lighter aluminium spoon is easier to use, yet we prefer the silver because it 'gratifies our taste*".

That such non-food implements can impact on us in a semiotic manner is hinted at by Ariely's (2008, pp. 159–160) finding that the containers in which the paraphernalia that often goes along with coffee (e.g., the sugar bowl, the milk flask or jug, the cinnamon and chocolate shakers, etc.) exert a significant influence on people's liking of coffee. Ariely argued that when higher quality containers were used (i.e., when made of glass-and-metal, set on a crushed metal tray, and accompanied by silver spoons and nice labels), people were more likely to report that they liked the coffee a lot and that they would pay more for it, than when the very same coffee was accompanied by the same condiments placed in Styrofoam cups with the labels written on with a felt-tip pen.

Similarly, in a pilot study, we recently demonstrated that consumers' quality and liking judgments concerning identical yoghurt samples differed significantly when tasted either with a plastic spoon having a metallic finish versus a stainless steel spoon, the latter resulting in significantly higher scores. However, it remains unclear whether these results were attributable to any differences in the physical properties of the spoons (i.e., in their weight, temperature, etc.) or to the overall semiotic appraisal (of plastic versus metallic spoon). Despite these two examples, little of the research on food perception that has been published to date has, as yet, placed much of an emphasis on the cutlery that people typically use while eating.

Throughout recent history, cutlery has been manufactured out of various materials. Historically, wood, bone, and ceramic spoons were commonly used because of the fact that the only metals that were affordable were iron, brass, bronze, and pewter, which, it is said, often gave an unpleasant flavor to food (Miodownik, 2008). According to Himsworth (1953, p. ix), stainless steel was introduced as a metal for cutlery in 1914. The subsequent success of this material resulted in a radical reduction in the range of materials

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used for cutlery, so that nowadays, stainless steel is by far the most commonly used material for cutlery.

The tastes (or sensations) of metals and their impact on food perception and quality judgments have been studied extensively (e.g., Epke, McClure, & Lawless, 2009; Hettinger, Myers, & Frank, 1990; Hoehl, Schoenberger, & Busch-Stockfisch, 2010; Keast, 2003; Lawless, Stevens, Chapman, & Kurtz, 2005; Lawless et al., 2004; Lim & Lawless, 2005; Schiffman, 2000; Stevens, Smith, & Lawless, 2006). However, the majority of these studies were performed on aqueous solutions, with metal salts that are usually incorporated in fortified foods, food supplements, and drinks, and hence easily soluble. To date, metallic tastes emanating from solid metals have not been studied in any great detail, especially metals that might come into contact with the mouth during eating (or, for that matter, drinking). The flavours of these metals might also have significant practical implications (i.e., when it comes to the materials out of which cutlery is made) and cannot be extrapolated directly from the data associated with the tasting of metallic solutions. Though most metals used as food utensils are chosen nowadays for their inertness and for being tasteless, the taste that other metals could transfer to food could act as an enhancer or inhibitor of a food's natural flavours, hence potentially modifying (that is, improving or lowering) a person's perception of the sensory-discriminative and/or hedonic attributes of the food in their mouth.

Recently, Laughlin, Conreen, Witchel, and Miodownik (2011) investigated the sensory-discriminative and hedonic effects of metallic tastes arising from seven spoons plated with different metals: gold, silver, zinc, copper, tin, chrome and stainless steel. Whilst wearing blindfolds, participants evaluated the taste of each of the spoons (note that there was nothing actually presented on the spoons) and rated the following attributes on a 7-point scale: cool, hard, salty, bitter, metallic, strong, sweet and unpleasant. Laughlin et al.'s (2011) results demonstrated that the gold, chrome, tin, silver, and stainless steel spoons did not differ significantly for any of the rated attributes, but they were significantly different from the zinc and copper spoons. Gold and chrome were rated as the least metallic, least bitter, and least strong tasting of the spoons, whereas zinc and copper spoons had the strongest, most metallic, most bitter, and least sweet taste. However, to the best of our knowledge, no studies have as yet reported whether the taste of the cutlery is sufficiently strong that it can affect the perceived flavour of the food tasted using that cutlery (nor the taste interactions that might occur; Keast & Breslin, 2003).

Considering the fact that the perceived flavour of a food or beverage results from the combination of olfactory, gustatory, somatosensory, auditory, visual, and trigeminal cues (Auvray & Spence, 2008; Stevenson, 2009), and that our perception of food also depends on the way in which that food or beverage is consumed (and the utensils with which we interact with it), the primary aim of the present study was to explore the influence of the taste of the metals that can be found in cutlery on the gustatory and hedonic perception of food of consumers. Specifically, our aims were: (1) To test the influence of the different metals on the perception of bitterness, sweetness, saltiness, and metallic sensation of five creams (bitter, sour, salty, sweet, and plain), under blindfolded conditions; (2) To evaluate the hedonic responses to these combinations; and (3) To determine whether the visual appearance of the spoons affected the perception of the food (that is, when the participants had their eyes open and hence could see the spoons). This was investigated using a gold-plated and a stainless steel spoon which, according to Laughlin et al. (2011), did not have significantly different tastes (when assessed blindfolded), but have a strikingly different visual appearance.

2. Materials and methods

2.1. Subjects

Thirty participants (nine male) ranging in age from 18 to 50 years (M = 27 years: SD = 7.4) took part in this study. The participants were randomly recruited at the Department of Experimental Psychology (University of Oxford) and other public places, based on their interest in taking part. At the recruitment stage, no information about the specific aims of the study were provided. All of the participants confirmed that they had no cold or flu, that their senses of smell and taste were not impaired, and that they did not suffer from any allergies to dairy products. The procedures were explained to all participants in detail and informed consent was obtained prior to participation. The experimental procedure was approved by the Ethics Committee of the Department of Experimental Psychology, University of Oxford. The experiment lasted for approximately 15 min and the participants were given a 5 GBP gift voucher in return for taking part in the study.

2.2. Stimuli

2.2.1. Spoons

The spoons used in this study were the same as those used in Laughlin et al.'s (2011) study, each of exactly the same size, shape, and texture. Given Laughlin et al.'s results, four of the same teaspoons were used: three stainless steel spoons electroplated with either gold, zinc, or copper to a thickness of 10 microns (0.01 mm), and a fourth spoon that remained as stainless steel (see Fig. 1). According to Laughlin et al., 10 microns provides a homogeneous layer with no possibility of exposure to the stainless steel lying beneath the electroplating. Thus the spoons had almost exactly the same weight, since the electroplated layer is thin enough to contribute very little extra weight to the spoons. These metals were selected on the basis of their non-toxic status, suitability for contact with human skin and mucus membranes, their susceptibility to electroplating, and the ease with which they could be sterilized.

2.2.2. Food stimuli

Four creams were prepared by adding 20 g of table sugar (sweet), 5 ml of freshly squeezed lemon juice (sour), 5 g of lemon pith (bitter), and 5 g of table salt (salty) per 100 g of extra thick double cream (50.5% fat; Tesco, UK) to obtain creams of distinguishable tastes/flavours. Plain cream was also used as a "control" sample.

2.3. Procedure

The participants were seated in front of a screen and were given the instructions orally and in written form prior to the start of the study. The experiment followed a full-factorial (4×5) design, resulting in a total of 20 tastings with the participants' eyes closed during tasting. The order in which the spoons were presented was randomized between participants, and the order in which the samples were presented was also randomized for each of the spoons. At the start of the experiment, participants were asked to rinse their mouths with still spring water (Harrogate Spa, UK) served at room temperature. After the instruction screen, a three digit random number appeared on the screen, indicating to the experimenter which sample and spoon to give to the participant. Approximately five grams of cream were served during each tasting. The participants were instructed to close their eyes. Once they had done this, the handle of the first spoon was placed in their hand. Note that the participants were not informed that spoons of different materials would be given to them. The participants

Fig. 1. The spoons used in this study. From left to right: Copper, zinc, gold, and stainless steel.

were instructed to place the spoon into their mouth in order to taste/evaluate the sample.

After each tasting, the spoon was returned to the experimenter and the participants could open their eyes and rate the sample on a rating scale from 1 to 9 in accordance with the following adjectives (in sequential order): sweet, bitter, metallic, salty, and pleasant. Participants were familiar with all the attributes. The only attribute that was not as understandable for some of the participants was "metallic", which was explained as "a taste similar to that of placing a penny in the mouth" (Lawless, Rapacki, Horne, & Hayes, 2003). The order in which the adjectives were presented was always the same. The instructions were phrased: "Please rate each sample according to your perception of each attribute on the scale provided", and each attribute appeared on top of each scale. The scales were anchored with 1 = "not at all" to 9 = "extremely". Participants were frequently reminded of the nature of the scale. At the end of this block (with their eyes closed), participants rated again the plain cream sample with the gold and stainless steel spoons, but this time with their eyes open, in order to check for any effect of visual appearance. Spring water was available for each participant. They were instructed to drink and rinse between samples.

Once the participants had finished the experiment, they were fully debriefed as to the nature and purpose of the study. The spoons were washed in hot soapy water, sterilized, and prepared for the next participant, according to the methods outlined in Laughlin et al. (2011).

2.4. Data analysis

In order to determine whether the different metals of the spoons exerted a significant influence on the perceived bitterness, saltiness, sweetness, metallic sensation, and pleasantness of the food samples being tasted, an analysis of variance (ANOVA) was performed on the data considering these factors as independent variables, and consumer, type of spoon, taste sample, and their interaction, as sources of variation. In addition, separate ANOVAs were performed on the ratings of the gold and stainless steel spoons in the two conditions (eyes open and eyes closed) in order to determine whether the appearance of the spoons influenced their ratings. When the effects were significant, honestly significant differences were calculated using Tukey's test. Differences were considered significant when $p \leqslant .05$. Statistical analyses were performed using XLStat 2011 (Addinsoft, NY, USA).

3. Results

3.1. Bitterness

The results indicate that the type of spoon exerted a significant effect ($p < .001$) on the perceived bitterness of the samples. The effect of the sample and the sample∗spoon interaction were also significant (both $p < .001$), demonstrating that the differences between the samples depended on the type of spoon used as well. As illustrated in Fig. 2A, in general, the food samples tasted from zinc and copper spoons were rated as significantly more bitter than those tasted from the stainless steel and gold spoons. What is more, the results of Tukey's test revealed that not only the samples of those spoons were rated as significantly more bitter, but also that these differences varied between samples. For instance, all the samples were rated as tasting significantly more bitter when tasted using the copper or zinc spoons ($p < .001$), except for the sweet sample, where the bitterness was rated similarly regardless of the spoon that was being used. Across samples, the stainless steel and gold spoons did not differ significantly, neither did the copper and zinc spoons, suggesting that at least in terms of bitterness, the spoons within these pairs affected the samples similarly.

3.2. Sweetness

Sweetness ratings did not vary significantly as a function of the spoon used to taste the samples ($p = .054$). The sample∗spoon interaction was not significant either ($p = .115$), indicating that the variation in sweetness across the samples was mainly attributable to the taste of the samples themselves ($p < .001$). Surprisingly, however, as depicted in Fig. 2B, the sweet sample was perceived as being slightly sweeter when tasted with the zinc and copper spoons.

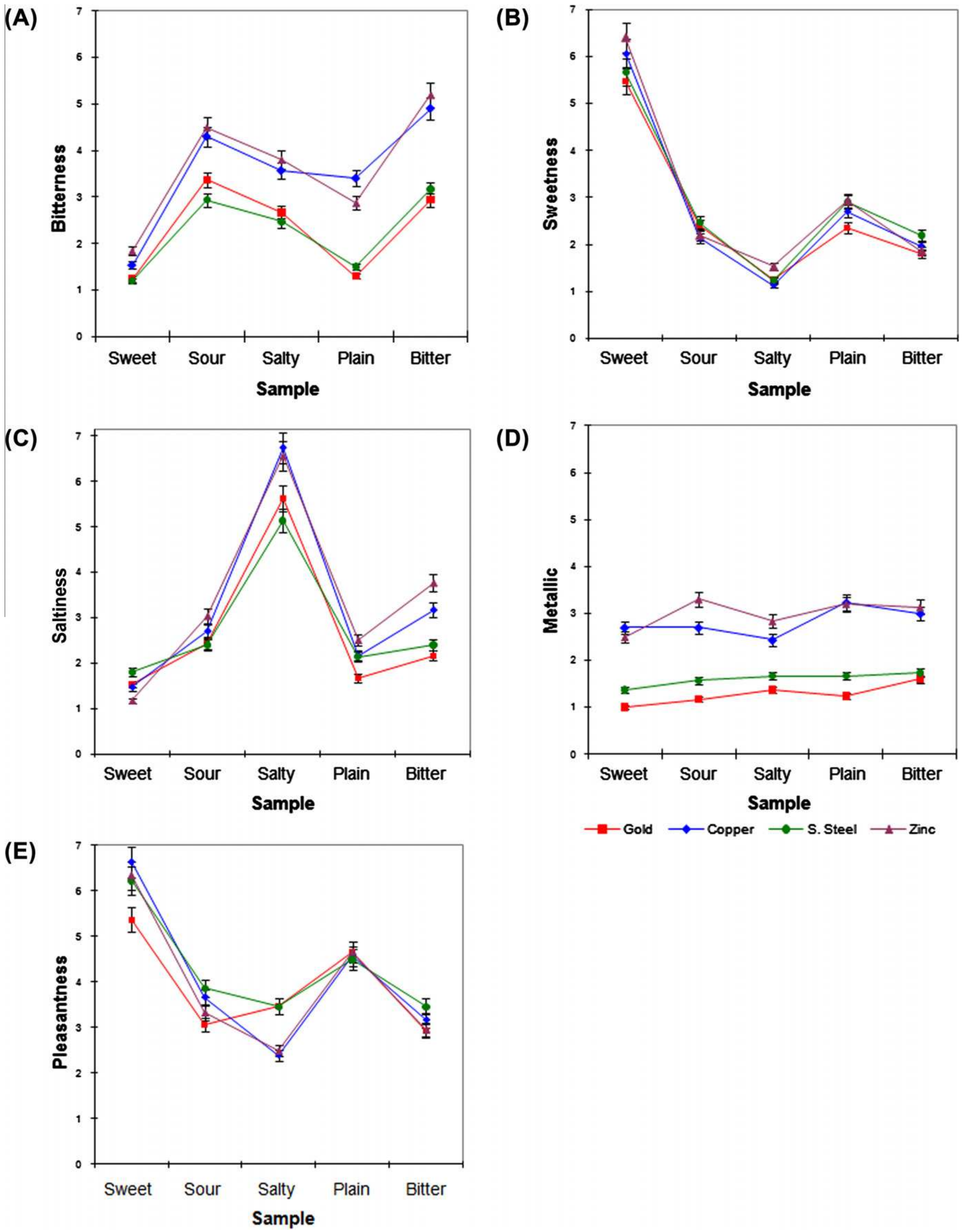

Fig. 2. Representation of the mean ratings (on a 1 to 9 scale) of each spoon and cream. (A) Bitterness; (B) Sweetness; (C) Saltiness; (D) Metallic; and (E) Pleasantness. Vertical bars represent Tukey's HSD at $p < .05$.

3.3. Saltiness

The type of spoon exerted a significant effect ($p < .001$) on the perceived saltiness of the samples. As in the case of bitterness, the effect of the sample and the sample∗spoon interaction were also significant (both $p < .001$), demonstrating that the differences in perceived saltiness between the samples depended on the type of spoon used as well. As illustrated in Fig. 2C, the zinc and copper spoons ($p > .05$ between them) differed significantly ($p < .05$) from the other two spoons ($p > .05$ between them) only for the saltier cream. For the bitter, sour, and plain creams, the samples tasted from the zinc and copper spoons were rated as higher in saltiness, though the differences were not significant between the four spoons, except between the zinc and gold spoons ($p = .008$) for the sour sample. The various spoons did not affect the perceived saltiness of the sweet sample, where surprisingly the zinc and copper spoons rated slightly lower than the gold and stainless steel spoons.

3.4. Metallic sensation

In the case of metallic sensations, significant differences were found between the spoons ($p < .001$), and in the spoon∗sample interaction ($p = .022$). As shown in Fig. 2D, the samples from the copper and zinc spoons were perceived as tasting significantly more metallic (both $p < .001$) than those tasted from the stainless steel and gold spoons ($p > .05$ between them, across samples). However, in the case of these latter spoons, the metallic sensation did not vary significantly as a function of the cream being tasted, whereas the perception of the metallic taste of the copper and zinc spoons varied significantly as a function of the cream being tasted. The zinc spoon seemed to transfer a significantly stronger ($p < .001$) metallic sensation when the participants were tasting the bitter ($M = 3.3$), plain ($M = 3.2$), and sour creams ($M = 3.1$), and a lower sensation to the sweet one ($M = 2.5$). In contrast, the copper spoon transferred a significantly stronger ($p < .001$) metallic taste when tasting the plain ($M = 3.2$) and sour creams ($M = 3.0$) than when tasting the salty cream ($M = 2.4$).

3.5. Pleasantness

Finally, the type of spoon also affected the pleasantness ratings significantly ($p < .05$). In addition, the sample∗spoons interaction was significant ($p < .001$), demonstrating that the differences among the samples were influenced by the spoon. The sweet sample was the most liked, tasted with the copper and zinc spoons, which gave it a slightly sweeter sensation. By contrast, the salty cream samples tasted with these spoons were the least liked. The sweet and sour creams were similarly liked (see Fig. 2E). However, the differences between the spoons were not significant across samples, according to the results of Tukey's test.

Table 1
Mean ratings of the plain cream sample taken from the gold and stainless spoons under the two conditions: Eyes closed and eyes open.

	Gold spoon				Stainless steel spoon			
	Eyes open		Eyes closed		Eyes open		Eyes closed	
	M	SE	M	SE	M	SE	M	SE
Bitterness	1.5	0.15	1.4	0.11	2.0	0.32	1.8	0.27
Sweetness	3.0	0.33	2.4	0.40	2.5	0.31	2.9	0.35
Saltiness	1.6	0.18	1.7	0.32	1.7	0.18	2.1	0.29
Metallic	2.2	0.18	2.4	0.18	2.3	0.24	2.1	0.30
Pleasantness	4.1	0.30	4.3	0.20	4.3	0.27	4.4	0.35

3.6. The effect of the appearance of the spoon

Finally, the results demonstrated that the appearance of the spoon did not exert a significant effect ($p > .05$) on the mean ratings of the sample for any of the attributes (see Table 1).

4. Discussion and conclusion

The results of the experiment reported here complement and extend those of Laughlin et al.'s (2011) recent study by showing that cutlery coated with different materials (metals) really does taste different, and that these differences were sufficiently large that they could influence the perception of the taste and pleasantness of food consumed from them.

In comparison to the gold and stainless steel spoons, the stronger metallic taste of the copper and zinc spoons enhanced the bitterness of the sweet sample. However, unexpectedly, these spoons also slightly enhanced its sweetness and inhibited the saltiness. To a greater extent, these spoons boosted the bitterness and the saltiness of the bitter and sour creams. This finding contrasts with those of Keast (2003). He found that zinc added to sweet and bitter solutions strongly inhibited their sweetness and bitterness, respectively. A similar effect was observed for the salty cream, where the copper and zinc spoons increased the perceived bitterness and saltiness of the sample and consequently decreased its pleasantness. Finally, in the case of the plain cream, these "stronger metallic" spoons only seemed to increase the perceived bitterness of the samples. These results suggest that the zinc and copper spoons, apart from transferring a somewhat metallic and bitter taste, enhanced to a greater or lesser extent the dominant taste that each cream had. In addition, the type of spoon also exerted a significant effect on the hedonic ratings. However, contrary to our expectations, the effect was not driven by the differences of taste of the zinc and copper spoons.

Hence these results also revealed that the effect that certain metals have on food perception when added to the actual food composition is quite different from that that the metals of cutlery might exert. However, this study was not designed to investigate the underlying perceptual mechanisms that drove the taste interactions observed. In their review, Keast and Breslin (2003) describe three levels of interaction that may occur when multiple taste stimuli are presented together in foods: chemical, oral physiological, and cognitive. In our study (and highlighting that one of the stimuli was not a food compound), given the short amount of time that the food stimulus came into contact with the spoons, it could be hypothesized that the taste interactions observed were primarily of a physiological nature. However, further research is recommended to explore this suggestion in the future.

Though this study constitutes a first attempt to investigate the effect that the taste of certain metals has on our perception of food, the findings could be relevant in terms of helping to deliver specific flavours to foods by considering additionally the design of the cutlery. This might well create interesting eating experiences, similar, for example, to Denis Martin's "Rien" dish, consisting of a spoon coated with an "invisible" flavour. One could imagine these findings as well in food marriages (a particular material of spoon or cutlery being paired with a specific food taste) or even in drinks' cans, where the material of the inside (or lip) of the can could impact upon the flavour of the drink. For example, it has been reported that people actually came to like the taste of the metal in tins of tomatoes so much that when the cans were improved and filmed internally to avoid any transference of the metallic taste to the contents, manufacturers had to add the "tin" taste back to avoid consumer complaints (see Rosenbaum, 1979, p. 81).

In addition, further research in this direction could also potentially be relevant in terms of helping decrease the intake of salt or sugar for people in specific diets, if the use of certain metals in the cutlery were found to reliably enhance the perceived intensity of these tastants. The present study focused on participants' ratings of food (cream). The prepared food stimuli were therefore very simple, and participants were only required to rate their perception of some basic tastes (e.g., sweet, bitter, and salty) in order to keep the experiment simple. Hence it would be interesting to consider the impact of metallic sensations on more complex flavoured food, and as well to consider other food properties, such as the temperature (i.e., would the material of the spoon exert a similar impact on both hot and cold foods?).

Here it should be noted that while some researchers consider "metallic" to be one of the basic tastes (along with sweetness, bitterness, etc.; Bartoshuk, 1978), others have argued (and, by now, convincingly demonstrated) that the metallic sensation involves the combined activation of gustatory and olfactory receptors, thus meaning that metallic should more correctly be referred to as a flavour than as a taste[2]. If the metal of the spoon affects the metallic sensation, then it could be argued that the spoon could also affect the overall flavour of the food. In future research, it would be interesting to extend these findings, regarding 'sensation transference' effects to a wider range of more palatable (and desirable) flavours (i.e., fruity, meaty, etc.), and to study whether trained panellists would show a similar pattern of results to those of naïve consumers.

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[2] It is worth noting that the definition of "metallic" taste is still controversial. It has been proposed that the metallic flavour of ferrous sulfate (Fe_2SO_4) is not a purely gustatory quality but is likely to result from stimulation of the olfactory mucosa, since it generates volatile lipid oxidation products in the mouth that can be perceived retronasally as metallic flavours (Epke et al., 2009). Lawless et al. (2004) extended these findings by including copper and zinc. In particular, copper salts have been found to induce sour and salty sensations (Cuppett, Duncan, & Dietrich, 2006; Lawless et al., 2005).

Stevens et al. (2006) have shown that Fe_2SO_4 results in a markedly different sensation from the traditional basic tastes (sweet, sour, bitter, salty, and umami). Moreover, Schiffman (2000) suggested that metal salts induced taste responses and should not simply be considered as trigeminal stimuli. A vast amount of research has been carried out about the tastes of divalent salts. The basic conclusion being that they are perceptually complex.