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2 RUNNING HEAD: DO MEN & WOMEN REALLY LIVE IN DIFFERENT TASTE WORLDS?

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4 **Do men and women really live in different taste worlds?**

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ABSTRACT

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20 In this review, I highlight what is currently known about the sensory, psychological, and
21 physical/nutritional, differences between men and women in terms of their sensory-
22 discriminative and hedonic responses to multisensory tasting experiences. However, despite
23 the evidence for there being numerous individual differences in tasting, few neatly support the
24 claim that men and women live in different worlds of taste. The one situation in which
25 consumed products directed specifically at men and women would appear to succeed is when
26 they are advertised as providing some sort of nutritional benefit to the end user.

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28 **KEYWORDS:** Sex differences; Individual differences; Physical; Sensory; Psychological;
29 Nutritional.

30

Introduction: Different worlds of taste

If men really are from Mars and women from Venus, as the title of John Gray's bestselling book (Gray, 1992) would have us believe, then one has to question whether they should be given the same food and beverage products to consume, the same dishes to eat at restaurants, and the same drinks to imbibe. That said, while people seem reasonably happy to accept that the two sexes wear different clothes, shoes, and jewellery, use different home and personal care products, not to mention mostly choose different fragrances (Lindqvist, 2013), when it comes to the world of food and drink, *unisex* offerings are the norm, and seemingly always have been. Perhaps, then, sex differences really aren't so dramatic when it comes to the chemical senses, and men and women might actually live in more or less similar taste worlds after all.

At the outset, it has to be said that talking about sex/gender¹ differences is controversial territory for the experimental psychologist as much as it is for those food and drinks brands that have launched products explicitly targeting female consumers in recent years. The key question here, is whether any differences between the sexes as far as the chemical senses are concerned are really the most important of the factors differentiating people's responses to food and drink, be it in the restaurant, bar, supermarket, or wherever else the consumer happens to select and/or consume them. Given the growing interest amongst consumers in the field of personalized nutrition (e.g., see van Ommen, van den Broek, de Hoogh, van Erk, van Someren, Rouhani-Rankouhi, et al., 2017, for a recent review), it would seem pertinent to address the question of whether targeting food products at specific groups of consumers (e.g., in this case at women and/or men) represents a sensible marketing strategy for food and drink providers in the years ahead. Alternatively, one might wonder whether it is an approach that, at least in the case of food and beverage offerings targeted specifically at men or women, is likely to fail in the marketplace, no matter how it is introduced.

This review begins by looking at a number of the individual differences in the world of taste/flavour perception that have been identified over the years. While assessing the sex/gender differences that pertain to the chemical senses, a distinction is made between genetic and psychological influences (e.g., Drewnowski, 1990). It is worth stressing that sex/gender differences may show up in terms of differences in sensitivity and/or in terms of taste preferences/hedonics. Females are generally reported to exhibit greater olfactory abilities than men, no matter whether assessed in terms of sensitivity, identification, familiarity, and/or the recognition of odours (see Brand & Millot, 2001, for a review). Evidence concerning sex-specific differences in colour vision is then considered, premised on an understanding that what we see is perhaps the single most important sensory cue in terms of setting our expectations concerning the likely flavour of food and drink. Documented sex/gender differences in neural responses to visual food cues are also discussed briefly. Subsequently, any physical/nutritional differences between the sexes that may potentially be relevant as far as the future design of targeted food and drink products are concerned are discussed. Ultimately, it would seem that while implicitly sexist approaches have a long history, explicitly targeting one sex in new food

¹ Note that sex and gender represent distinct constructs, the former a biological construct and the latter a psycho-social-cultural one (Rubin, 2009). However, as noted recently by Chao et al (2017), it is a particularly challenging issue to try and separate the biological versus social causes of any differences between men and women. Hence, use of the term sex/gender is intended to reflect this overlap (Fausto-Sterling, 2008).

and beverage product development is a difficult path to tread successfully unless, that is, one can appeal to nutritional differences between the sexes.

Sensory and psychological differences

Let us start by considering some of the well-established individual differences with regard to the chemical senses (e.g., gustation, olfaction, the trigeminal system, and oral-somatosensation) that have been shown to affect both the sensory-discriminative and hedonic response to food and drink. A number of the genetically-determined differences will be examined first, all the while questioning whether psychological influences might actually provide a better explanation for any of the sex differences that are observed given, for example, the literature on acquired taste preferences and flavour-nutrient learning. Thereafter, the question is posed as to whether or not any individual differences that are found are equally prevalent in both sexes. There is, after all, a long history of research highlighting sex differences in the fields of both perception and cognition (e.g., Baker, 1987; Greenberg, Warrier, Allison, & Baron-Cohen, 2018; Witkin, 1949), and a number of these are presumably relevant to the world of food and drink (cf. Bender, 1976).

At this point it is important to stress that there are, of course, also various salient age-related changes in sensory perception, many of which are attributable, at least in part, to the inevitable decline of the chemical senses as we age (see Cowart, 1981, 1989; Laird & Breen, 1939; Mojet, Heidema, & Christ-Hazelhof, 2003; Nusbaum, 1999).² However, such differences fall outside of the scope of the present article (see Spence, 2012, for a review), and anyway, it is not clear that such age-related decline affects one sex any more than the other (though see Brand & Millot, 2001; Doty & Cameron, 2009). Genetically-determined differences in food preference that vary by cultural group have also been reported (e.g., Abbott, 2012; Mauer & El-Sohemy, 2012; Piratsu, Robino, Lanzara, Athanasakis, Esposito, Tepper, et al., 2012), though again, sex-related differences are not a central feature of the results that have been obtained.

Individual differences in gustation

There are well-established differences in terms of an individual's taster status and the population can be segmented into supertasters, medium-tasters, and non-tasters (see Blakeslee & Fox, 1932; Blakeslee & Salmon, 1931, for early research). This tripartite grouping is normally established by documenting people's responses to a strip of filter paper that has been soaked in a bitter-tasting compound such as phenylthiocarbamide (PTC) or 6-*n*-propylthiouracil (PROP). Roughly 25% of the population are classed as supertasters, 50% as medium-tasters, and the remaining 25% as non-tasters. Supertasters are significantly less likely to find the bitter taste of alcohol (e.g., in beer), or the bitter-taste of caffeinated hot beverages, such as coffee, appealing (e.g., Bartoshuk, 1980, 2000). While the different worlds of taste in which we all live is most apparent for bitter-tasting food and drink items, an individual's taster status also affects their rating of the intensity of the other basic tastes as well (see Blakeslee &

² Such differences potentially being more noticeable than those affecting the other senses, given that currently there are no sensory augmentation devices, equivalent to the glasses and hearing aids that can be used to counteract the age-related decline in the senses of vision and audition, respectively.

Salmon, 1935). That said, some have argued that it may be time to move beyond the focus on supertasters and instead talk in terms of hypergeusia; e.g., see Hayes & Keast, 2011; Reed, 2008; see also Puputti, Aisala, Hoppu, & Sandell, 2018).

As far as any sex-differences are concerned, one large survey of taster status ever conducted involved testing more than 400 individuals at a North American science museum (Garneau, Nuessle, Sloan, Santorico, Coughlin, & Hayes, 2014). According to the research, females are somewhat more likely to be supertasters than men (34% female vs. 22% males; see also Bartoshuk, Duffy, & Miller, 1994; McAnally, Poulton, Hancox, Prescott, & Welch, 2007). Similarly, Spence Velasco, and Knoeferle (2014) also reported that the female participants in their study rated a standard PTC strip as tasting significantly more intense (note that ratings were acquired using a simplified bitterness intensity scale, not the Labelled Magnitude Scale that is typically used in this area). In the latter study, responses were collected from almost 2,900 men and women as part of an experiential wine-tasting event held in London, UK in 2014. In terms of the rating of the wine itself, clear sex differences were also highlighted: Women tended to rate the red wine as having a significantly more intense flavour, while the male participants reported liking it significantly more (see also Mora, Urdaneta, & Chaya, 2018). Some wine professionals have even tried to use differences in taster status to predict people's wine preferences (Blank, 2008; see Hayes & Pickering, 2012; Pickering & Robert, 2006, for some of the underpinning research).

Separately, the population also divides in terms of their hedonic response to sweetness. In particular, there is a section (c. 60%) of the population who can be classified as 'sweet-likers'. Another section (c. 30%) are classified as sweet neutral/dislikers, while the remaining 10% of the population appear to show the same response to sweetness regardless of its intensity (e.g., Frayling, Beaumont, Jones, Yaghootkar, Tuke, Ruth, et al., 2018; Keskitalo, Knaapila, Kallela, Palotie, Wessman, Sammalisto, et al., 2007; Kim, Prescott, & Kim, 2014; Looy, Callaghan, & Weingarten, 1992; Yeomans, Tepper, Rietzel, & Prescott, 2007). The popular press often portrays women as reaching for sweet treats such as ice-cream and chocolate when they are depressed. There is certainly some evidence for gender differences in responses to sweet taste (e.g., Connor & Booth, 1988; Enns, VanItallie, & Grincker, 1989; Laeng, Berridge, & Butter, 1993; Nisbett & Gurwitz, 1970). Consistent with such a view, the empirical research shows that when it comes to comfort eating, women do tend to reach for the ice cream and chocolate (sweet + fat). Men, by contrast, tend to go for more savoury foods such as mac and cheese, pizza, burger and fries/chips (that is, they prefer the combination of salt + fat; see Drewnowski, Kurth, Holden-Wiltse, & Saari, 1992; Wansink, Cheney, & Chan, 2003). It is, though, important to note that such differences are likely more psychological than genetic/sensory in origin (see Spence, 2017a, for a review).

The differences in food choices/cravings that women experience at different times of the month (Rozin, Levine, & Stoess, 1991), likely also have psychological/cultural roots. Consistent with such a view, it has recently been reported that a third of women (in a sample of 275 university students) born to US parents reported craving confectionary (e.g., chocolate) around the onset of menstruation. This figure increased to 41% in second generation immigrants to the US (Hormes & Niemiec, 2017). However, the fact that this figure drops down to 6% for Egyptian women (Parker, Kamel, & Zellner, 2003), and falls to 17% across the young women born in 25 other countries hints at the cultural underpinnings of this effect. According to Osman and Sobal (2006), such differences might, in fact, be taken to reflect the causal role of internalized

cultural norms. Specifically, in those societies where female beauty is more closely equated with being thin, it is possible that women consider menstruation to provide a socially sanctioned excuse to indulge in foods that might otherwise be forbidden, or restricted (Weingarten & Elston, 1991; see also Buffenstein, Poppitt, McDevitt, & Prentice, 1995; Wardle, Haase, Steptoe, Nillapun, Jonwutiwes, & Bellis, 2004). Such an explanation would, then, help to explain such cyclic increases in reported craving frequency of chocolate and other ‘taboo’ foods in e.g., North American samples (Henrich, Heine, & Norenzayan, 2010). Pregnancy, too, can also alter gustatory sensation. For instance, Duffy, Bartoshuk, Striegel-Moore, and Rodin (1998) reported that women tend to perceive bitter tasting stimuli as more intense early on in pregnancy, but as less intense later in pregnancy, compared to the responses given by women who are not pregnant.

Individual differences in olfaction

According to estimates, somewhere between 70 and 95% of what we think we taste we really smell (see Spence, 2015, for a review of the literature on this controversial statistic). Olfaction is undoubtedly hugely important to our selection and consumption of food and drink, (Small & Prescott, 2005) and that includes both the orthonasal sense of smell when we sniff/inhale, as well as the retronasal sense of smell when the volatile-rich air is pulsed out of the back of the nose whenever we swallow (Rozin, 1982). The latter is the ‘silent’ contributor to multisensory flavour perception, inasmuch as few people realize just how much of a contribution it actually makes to their tasting experience (e.g., see Griffiths, 2008). As such, one might expect that any individual differences in olfactory perception would turn out to have at least as important an influence (as any differences in gustation) when it comes to assessing the question of the extent to which people (e.g., men and women) live in different taste worlds.

A large number of individual differences in the ability to smell certain odorants have been identified (for instance, see Blakeslee, 1918, for an early report concerning individual differences in response to the fragrance of the verbena flower). The sensitivity to certain food-relevant aromas shows an especially wide variation across the population. So, for example, 2,4,6-trichloroanisole, a compound related to cork taint in wine, can be detected at levels of parts-per-billion by some highly sensitive individuals, whereas others require a much higher concentration in order to detect its presence (Buser, Zanier, & Tanner, 1982; Mazzoleni & Maggi, 2007; Prescott, Norris, Kunst, & Kim, 2005). There are even some people who are completely anosmic to cork taint. In fact, according to commentators, we are all anosmic to (that is, unable to smell) some number of volatile aromatic compounds (Jaeger et al., 2013; McRae et al., 2013; McRae, et al., 2012; see Reed & Knaapila, 2010, for a review). The relevant question here is what percentage of the population is affected, and how common that compound is in everyday food and drink products (or rather, is identifiable therein). So, for instance, 1% of the population are anosmic to the scent of vanilla, while others cannot smell violet.

There is also the well-established difference in people’s ability both to produce (i.e., to excrete), but more importantly for present purposes, to smell, the distinctive odour of asparagus in urine (Pelchat, Bykowski, Dule, & Reed, 2011). Boar taint is another of those food-relevant smells

that divides the population.³ Some (roughly 35% of the population) report that androstenone, the key compound giving rise to boar taint, has a stale, sweaty, urinous smell, while another 15% or so describe it as smelling sweetly floral, musky, and/or woody. A few people experience it as smelling ‘chemical’). Meanwhile, the other half of the population are simply anosmic to the scent (Amoore & Buttery, 1978; Lunde, Egeland, Skuterud, Mainland, Lea, Hersleth, & Matsunami, 2012; Wysocki & Beauchamp, 1984).

Separately from the widespread selective anosmias, there are also a few olfactory stimuli that give rise to qualitatively different percepts in different people. So, for example, 20% of the population experience coriander/cilantro as tasting soapy while the remaining 80% (depending on the ethnic group) describe it as smelling fragrantly herbal instead (e.g., McGee, 2010; Spence 2017b). Intriguingly, researchers have recently established the genetic underpinnings of this particular individual difference in olfactory perception (Eriksson, Wu, Do, Kiefer, Tung, Mountain, Hinds, & Francke, 2012). In fact, the genetic underpinnings of many of these individual differences in olfactory perception, and, in extreme cases, selective anosmias (within olfactory, or odorant, receptor genes) have recently been uncovered (e.g., see Jaeger, McRae, Bava, Beresford, Hunter, Jia, et al., 2013; Keller, Zhuang, Chi, Vosshall, & Matsunami, 2007; McRae, Jaeger, Bava, Beresford, Hunter, Jia, et al., 2013; McRae, Mainland, Jaeger, Adipietro, Matsunami, & Newcomb, 2012, for a few representative examples). Importantly however, the above-mentioned studies do not draw attention to any sex differences in the incidence of specific anosmias.

According to a number of researchers, women have better olfactory abilities (both in terms of their sensitivity to odorants as well as in terms of their ability to identify odours) than males across the adulthood (e.g., Brand & Millot, 2001; Dorries, 1992; Doty et al., 1984; Ship & Weiffenbach, 1993; see also Toulouse & Vashide, 1999a, b). Furthermore, women have also been reported to exhibit a somewhat different hedonic response to certain odorants (Royet, Plailly, Delon-Martin, Kareken, & Segebarth, 2003). It has also been suggested that males may decline in terms of their olfactory abilities more rapidly with aging than do women (e.g., Barber, 1997; Lehrner, 1993; Ship, Pearson, Cruise, Brant, & Metter, 1996). That said, it is worth stressing that such sex/gender-based changes in detection/identification have not always been documented in subsequent research (e.g., see Brand & Millot, 2001; Larsson, Finkel, & Pedersen, 2000). Indeed, Larsson et al. (2000, p. 308) concluded that: “*our results reveal no reliable influence of gender on the two olfactory measures*” while Brand and Millot highlight the odorant-specificity of this sex/gender difference. Part of the problem when trying to answer the aging question comes from disentangling genuine aging effects from cohort effects in longitudinal data (as reported by Ship et al., 1996).

Researchers have shown that women can sometimes acquire a sensitivity to certain olfactory stimuli that, at the start of an experiment, they may have been functionally anosmic to (see Dalton, Doolittle, & Breslin, 2002). That said, this ability appears to be restricted to body/sex-related olfactory stimuli, and so probably does not have all that much relevance as far as explaining any sex differences in food and drink preferences are concerned.

³ Or at least it used to do. Note that male pigs are typically castrated nowadays in order to eliminate this taint for that section of the population who perceive it.

The hedonic valence of sex-related odorants such as androstenone also varies in a predictable manner over the course of the menstrual cycle (e.g., see Hummel, Gollisch, Wildt, & Kobal, 1991; Krug, Plihal, Fehm, & Born, 2000). By contrast, olfactory thresholds (i.e., sensitivity) and preferences (i.e., hedonic valence) for other olfactory stimuli (e.g., those related to food and drink) do not seem to vary much across the menstrual cycle. Hence, while this reflects a genuine sex difference it is again not one that has much relevance to the consumer's everyday experience of food and drink (see also Doty & Cameron, 2009).⁴ Finally here, sex differences in the physiology of eating have also been reported (see Asarian & Geary, 2013, for a thorough and extensive review). Such differences have been suggested to contribute to human obesity, anorexia nervosa, and binge eating. Women tend to show a slightly higher incidence of obesity than men (Flegal, Kruszon-Moran, Carroll, Fryar, & Ogden, 2016), while eating disorders are also three times more common in females than in males (Hudson, Hiripi, Pope, & Kessler, 2007). However, this topic, while undoubtedly important, falls beyond the scope of the present article.

Individual differences in the response to oral-somatosensory and trigeminal stimuli

As far as the responsive to trigeminal irritants is concerned, early work suggesting that women might be more sensitive to such stimuli (Fillingim & Ness, 2000; Hummel, Barz, Pauli, & Kobal, 1998; McGrath, 1994; Opatz, Soiffer, & Hummel, 2000) has not always been observed in latter studies involving olfactory trigeminal delivery (Hummel, Futschik, Frasnelli, & Hüttenbrink, 2003). In certain cultures, men have been reported to exhibit a higher propensity to consume hot chiles, a particularly effective trigeminal stimulant (see Spence, 2018, for a review). Alley and Burroughs (1991), for instance, noted that North American men tended to exhibit more of a preference for hot, spicy and unusual foods than did their female counterparts (one might, perhaps think of this in terms of sensation seeking; Kish & Donnenwerth, 1972). One other area where one finds reports of sex difference relates to food rejection and food aversions. In one study, such responses were found to be significantly more common in Swedish women (69 and 38%, respectively) than in Swedish men (47 and 18%; see Nordin, Broman, Garvill, & Nyroos, 2004). Women were also found to be more disgust-sensitive than men (see also Wallen, 1943). However, that said, recent reports concerning adult picky-eating (Kauer, Pelchat, Rozin, & Zickgraf, 2015) tend to make little mention of sex differences.⁵ Here, though, it is important to stress that such sex differences in, e.g., the conspicuous consumption of chile, tend to be much more apparent in those countries/cultures like North America and the UK, where this ingredient is not a core component of the local cuisine, than in the case, of, for instance, Mexico, where such sex differences in consumption are not seen (Adapon, 2008). Recently, Spinelli, De Toffolia, Dinnella, Laureati, Pagliarini, Bendini, et al. (2018) also documented significant sex differences in the frequency of chile consumption in a sample of 1146 individuals as a part of the Italian Taste project. Taster status has also been reported to influence the perception, and hence presumably also the consumption,

⁴ Or, as the latter authors put it: "We conclude that the relationship between reproductive hormones and human olfactory function is complex and that simple associations between circulating levels of gonadal hormones and measures of olfactory function are rarely present." (Doty & Cameron, 2009, p. 213).

⁵ Eldeghaidy, Marciani, McGlone, Hollowood, Hort, Head, et al. (2011) have reported that supertasters experience an enhanced response to the oral-somatosensory properties of foods, such as the oral fat that one might expect to experience on tasting a salad dressing or ice-cream, say (see also Yackinous & Guinard, 2001).

of chile (Bartoshuk, 1993; Karrer, Bartoshuk, Conner, Fehrenbaker, Grubin, & Snow, 1992; though see Törnwall, Silventoinene, Kaprio, & Tuorila, 2012, for a null result).⁶ Nevertheless, any sex differences with regard to trigeminal stimulation would seem to have more of a psychological, rather than genetic, origin bearing in mind that the sex difference in the case of chile consumption, is seemingly restricted to just those cultures where conspicuous consumption acts as some kind of proxy for masculinity.

In fact, in some cultural contexts, such as that found in North America, the consumption of chilli is linked to a range of male personality traits (Rozin & Schiller, 1980). Relevant here, Bègue, Bricout, Boudesseul, Shankland, and Duke (2015) have demonstrated (in the laboratory) that the consumption of spicy food is predicted by levels of endogenous salivary testosterone (though see Granger, Shirtcliff, Booth, Kivlighan, & Schwartz, 2004). The 114 males who took part in this study were offered a 150g portion of mashed potato together with numerous sachets of Tabasco sauce (a popular peppery sauce/condiment) and salt. The participants were encouraged to season their food to taste before they began to eat. The results revealed that salivary testosterone was correlated with how much Tabasco the participants added to their food and to their self-rated spiciness of the food. By contrast, no such correlation was observed in the case of salt.

One other issue that might be relevant here would be any sex/gender differences in food neophobia/neophilia. However, it has to be said that the results to date in this area are both complex and conflicting. As such, it is difficult to draw any simple conclusions concerning gender effects from the available data (e.g., see Jaeger, Rasmussen, & Prescott, 2017; Meiselman, de Graaf, & Leshner, 2000; Tuorila, Lähteenmaki, Pohjalainen, & Lotti, 2001). That being said, clear sex differences were documented in Jaeger et al.'s (2017) study.

Individual differences in colour vision

Visual cues exert a profound influence over the experience of taste. Colour cues in food and drink set taste and flavour expectations that then often anchor the subsequent tasting experience (see Piqueras-Fiszman & Spence, 2015, for a review). What is more, nowadays many people seem to be choosing their food and drink (e.g., when they eat out) as much for its looks as for what it tastes like (see Spence, Okajima, Cheok, Petit, & Michel, 2016, for a review). Consequently, sex differences in colour perception might be expected to be relevant here. There are, for instance, some women who have one more class of colour receptor, or cone, in their retinas than do the rest of the population with three. The suggestion that one finds in the literature is that such tetrachromats may find it easier to discriminate subtle differences in shading, especially at the red end of the spectrum (e.g., Jameson, Highnote, & Wasserman, 2001; McCrone, 2002; Spence, 2010). Tetrachromacy is, though, still fairly rare, even amongst women (with an estimated incidence of just 12%; see Deleniv, 2015; Jordan, Deeb, Bosten, & Mollon, 2010), and its impact on the appearance properties of real foods has yet to be elucidated.

⁶ Consistent with the view that men are somewhat less likely to be supertasters and hence may need to consume more chile in order to achieve the same sensation of chile burn.

The more important difference to be aware of relates to the fact that one in ten men suffer from some form of colour blindness. That being said, it is surprising how little research/discussion this anomaly has generated amongst food scientists to date. Specifically, with regard to how this likely affects how appetizing different food and drink looks (e.g., Broackes, 2010; see Spence & Piqueras-Fiszman, 2014, for a review). How disturbing a complete loss of colour vision can be for one's appetite was, though, effectively captured by Oliver Sacks when he described the case of an artist who lost colour vision following a car accident.⁷ Note, though, that while colour blindness only affects men, it would presumably make more sense if one was going to launch, or target, a product in this space to do so specifically for this section of the population, rather than try and use colour blindness as a justification for a product specifically targeting men (given that the majority of men are not colour-blind). What is more, given that there are, in fact, several different types of colour blindness, the problem of how to target a particular group becomes all the more challenging (e.g., for the food marketer).

Beyond any differences in colour vision that are attributable to tetrachromacy or colour blindness there are also frequently reported sex differences in colour preferences (e.g., Hurlbert & Ling, 2007). However, once again, note that while many of the sex-based colour conventions (such as pink for girls/blue for boys in clothing say; Alexander, 2003), while firmly entrenched in a number of cultures today, were often quite different in the not so distant past (see Grisard, 2017, for a review). One company who played on these gender stereotypes earlier this year was *BrewDog* when they launched a new *BrewDog IPA* with a pink bottle label for women. This contrasted with the regular blue label. The company claimed that it would sell the pink labelled 'beer for girls' at a discount to anyone who identified as female, to highlight gender pay inequality in the workplace. However, this use of colour stereotypes attracted considerable criticism (see Sweney, 2018).⁸

Individual differences in response to visual food cues

Chao et al (2017) recently conducted a systematic review of functional neuroimaging studies assessing any sex/gender differences in the neural correlates of food stimuli (see also Cornier, Salzberg, Endly, Bessesen, & Tregellas, 2010). Taken together, the results of the 15 studies that they identified demonstrated that females were more responsive to visual images of food. In particular, female participants were found to exhibit greater neural activation than males in frontal, limbic, and striatal brain areas, as well as in the fusiform gyrus.⁹ It can be speculated

⁷ As Sacks (1995, p. 5) puts it: "The 'wrongness' of everything was disturbing, even disgusting, and applied to every circumstance of daily life. He found foods disgusting due to their greyish, dead appearance and had to close his eyes to eat. But this did not help very much, for the mental image of a tomato was as black as its appearance. Thus, unable to rectify even the inner image, the idea of various foods, he turned increasingly to black and white foods – to black olives and white rice, black coffee and yoghurt. These at least appeared relatively normal, whereas most foods, normally coloured, now appeared horribly abnormal."

⁸ It is also worth noting how this kind of approach runs the danger of setting the wrong expectations regarding the likely flavour of the product itself, if the consumer takes the colour cue to refer to product qualities (see Spence & Velasco, 2018, on the well-established impact of packaging colour on taste/flavour expectations, and thereafter, product perception).

⁹ According to the results of one Danish study, females also prefer modern to traditional plating of food (Reisfelt, Gabrielsen, Aaslyng, Bjerre, & Møller, 2009).

that this may link to the slightly increased rates of obesity seen in women as compared to men. However, further research is needed to unequivocally support such a claim.

Acquired preferences

Most people acquire a liking for foods and flavours that they may not have liked initially. So, for example, many supertasters acquire a liking for bitter-tasting foods later in life, think only of the popularity of drinks such as coffee and beer amongst adults. In other words, despite the fact that we may be borne into somewhat different taste worlds, we often acquire a liking for those flavours and tasting experiences that are paired with a rewarding stimulus such as sugar, alcohol, caffeine, and fat (see Rozin & Zellner, 1985; Zellner, Rozin, Aron, & Kulish, 1983; see also Gould, Zandstra, & Yeomans, 2018). Note that such conditioning effects are likely to override many of the more subtle, and possibly sex-based, differences in tasting that have been identified.

That said, not all tastes/flavours are responded to in the same way following repeated exposure. Cilantro/coriander is one of the most intriguing examples here. As we have seen already, roughly 20% of the population experiences this ingredient as soapy. This is unfortunate given that it is found in a wide range of Eastern cuisines (Rozin, 1983), and occurs in many dishes in the west these days. Perhaps because it tends to be added as a garnish (i.e., more often it is added at the end of dish preparation), it can be left out of a dish more easily. For whatever reason (note that there is a paucity of empirical research on flavour-nutrient learning in the case of cilantro), there is little evidence for the emergence of conditioned liking in this case (despite, for example, the fact that dishes like Thai green curry that contain coriander combine both sugar and fat).

One other factor here that likely works to smooth over any genetic differences in chemical sensitivity relates to the fact that many odorants come to take on the sensory-discriminative and hedonic properties of those tastes with which they are paired in food and drink (e.g., see Blank & Mattes, 1990; Stevenson & Boakes, 2004; Stevenson, Boakes, & Prescott, 1998; Stevenson, Boakes, & Wilson, 2000). So, for example, the aroma of vanilla, caramel, and strawberries, are all often paired with sweetness in food and drink, and thus soon come to take on sweet associations/properties. As such, the preference for such aromas also tends to increase (i.e., a preference may be acquired for these aromas (see Blank & Matter, 1990). The evidence suggests that people also learn to associate the other tastes with specific aromas, such as salty smells, and bitter aromas. Hence, to the extent that men and women are exposed to the same range of products/flavours during development, they are presumably likely to acquire many of the same preferences for those food aromas (remember here the importance of olfaction, as compared to gustation, to what most people refer to as the ‘taste’ of a food or beverage product; Spence, 2015). Importantly, there does not appear to be any evidence suggesting a sex/gender difference in terms of the speed or strength at which olfactory-taste associations are acquired (what Stevenson & Boakes, 2004, call ‘learned synaesthesia’, though see Auvray & Spence, 2008).

Physical & nutritional differences

Before concluding, it is worth briefly considering the one category of nutritional products/recommendation where sex differences are well-established, and where separate products are often targeted at women and men. What is more, the commentators in this area do not appear to have any problem with the idea that nutritional supplements should be targeted specifically at men and women (e.g., see <https://www.vitabiotics.com/wellman>; <https://www.vitabiotics.com/wellwoman>; see also the Seven Seas Perfect 7 nutritional supplements for men and women, Malone, 2018). Women need more iron than men, because they lose iron when menstruating.

Given that men are, on average, larger than women, there are differences in terms of the recommended daily intake of calories for the two sexes. However, these recommendations are usually based on the quantity rather than on the quality (or taste/flavour) of what is consumed (or offered). As the Harvard Medical School put it when considering calorie intake: “*Men and women are 98.5% identical in their DNA, and their nutritional needs are more similar than different. That’s certainly true of calories; in this case, at least, men act just like big women.*” (Anonymous, 2006). So, for example, a moderately active 125-pound woman needs 2000 calories a day compared to 2,800 calories for a similarly-active 175-pound man (Anonymous, 2006). In terms of the recommended daily allowance of vitamins and essential macro- and micro-nutrients, there are also sex differences but these are often small. Intriguingly, one area where clear sex differences in recommended allowance do emerge is in relation to cancer-causing ingredients/foods such as alcohol for women (associated with an increased risk of breast cancer, and hence have a recommended allowance half that of men). For men, the concern is with dietary fat (specifically alpha-linolenic acid, ALA) and calcium (both associated with an increased risk of prostate cancer). However, it would seem unlikely that any marketer would want to enter into a discussion with the consumer about which product (or product size) was associated with a lower-risk of cancer (see Anonymous, 2006).

As these various examples (both successful and unsuccessful) hopefully make clear, any company hoping to launch a new product specifically for one sex needs to think carefully about, and may need to make a commitment to, the kind of sex difference that their product is targeting, and its cause(s) – i.e., is it a genetically-determined sensory difference, a psychological difference resulting from disparities in socialization between the sexes, or a physical, and/or nutritional difference.

Conclusions

The evidence reviewed here clearly supports the existence of a number of genetically-determined individual differences in the perception of taste (gustation), smell (olfaction), trigeminal and oral-somatosensory stimulation, and well as in terms of colour perception that might be thought relevant to the perception of food and drink in men and women. However, excepting the latter visual differences, the other genetically-determined individual differences do not clearly divide men and women. And while it is true that women are somewhat more likely to be supertasters than men, the difference (34% vs 22%) is too slight to justify launching a food or beverage product specifically for women, or men. Furthermore, given the fact that many of our food likes and associations are actually acquired as a result of experience (i.e., learning), the impact of at least certain of these individual differences in the hedonic response to food and drink is likely reduced.

As such, the marketer interested in targeting a food or beverage product at a specific group of consumers would presumably be best advised to focus on the specific individual difference (food for supertasters,¹⁰ drinks for the colour-blind, etc.) rather than on trying to justify a claim based on genetically-determined sex differences in sensory perception.¹¹ That said, a number of examples have been documented in this review where sex differences in comfort foods, and in the conspicuous consumption of spicy food, would seem to have a psychological basis that likely emerges from the different sociocultural environments that men and women are exposed to over the course of development. Given that this is most often the case, the danger is that any food or drink product that is explicitly targeted at one or other sex can all too easily be seen as supporting those sociocultural inequalities/differences. What is more, given the sexist food and beverage advertising of yesteryear, such approaches can all too easily come across as outdated. Ultimately, though, as this review has hopefully made clear, when it comes to food and drink, rather than suggesting that the two sexes live in different taste worlds, it would seem more appropriate to suggest, as we have seen, that in fact men and women actually live in highly overlapping worlds of taste, and taste buds and other sensory receptors are not gendered. Finally, here, it is once again worth stressing that the variance between individuals (e.g., within each gender) is typically far greater than the average difference separating men from women.

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¹⁰ Though it would presumably be important to avoid the suggestion that those for whom the product is targeted are in some way deficient (see Snyder, 1931).

¹¹ On reviewing the evidence concerning putative sex differences in food perception, Logue and Smith (1986, p. 110) conclude that: "the studies on sex differences in adult human food preferences have differed so much in methodology and in the types of foods examined that it is impossible to say whether their findings can or cannot be reconciled".

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