

REVIEW

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# Leading the consumer by the nose: on the commercialization of olfactory design for the food and beverage sector

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## Abstract

Many researchers distinguish between two senses of smell—orthonasal (when we inhale or sniff) and retronasal (when volatiles are pulsed out from the back of the nose during eating). Orthonasal olfactory cues are key to setting our expectations concerning the sensory and hedonic attributes of food and drink; by contrast, retronasal olfactory cues are central to the experience of taste (or, better said, flavour). Food and beverage providers are increasingly modifying the product-extrinsic olfactory cues associated with their offerings in order to try and influence our food behaviours and hopefully enhance our multisensory product experiences. One way in which this is happening is via the introduction of olfactorily enhanced product packaging into the marketplace. A second key route is via the control and modification of the olfactory 'smellscape' in and around chain restaurants and food/beverage outlets. A third route that is slowly starting to emerge is technology-enabled olfactory marketing via scent-emitting billboards and scent-enabled plug-ins for mobile devices. Key opportunities and concerns, ethical and otherwise, surrounding the recent growth of olfactory marketing (specifically those examples incorporating food aromas) are highlighted. Ultimately, the question that we should all perhaps be asking ourselves is whether we are all being 'led by the nose', knowingly or otherwise, into unhealthy food behaviours.

**Keywords:** Olfactory design, Olfactory marketing, Orthonasal, Retronasal, Flavour, Packaging, Advertising

## Review

For many years, researchers have wanted to draw an important distinction between orthonasal and retronasal olfaction (e.g. [1, 2]). The former term is used to refer to the inhalation of external aromas, as when sniffing (just think of the Bisto Kid; see <https://en.wikipedia.org/wiki/Bisto>). By contrast, retronasal olfaction refers to the perception associated with the pulsing of air from the back of the nose (i.e. via the posterior nares) whenever we swallow [3]. While there are undoubtedly many perceptual similarities between these two kinds of olfactory experience [4–7], there are also a number of salient differences [8]. Importantly, though, both routes to smell play a key role in modulating our behaviour toward/around food as well as our experience of it when eating and drinking.

On the one hand, orthonasal olfactory (along with visual) cues are key to setting our expectations (both sensory discriminative and hedonic) concerning the likely flavours of foods and drinks and how much we like them (see [9] for a review). Olfactory cues are also dominant when it comes to judging the palatability of food (i.e. just imagine what you would do if you saw a beautifully prepared fish that just smelled off—would you eat it [10–12]?). What is not so widely known, though, at least not amongst the general public is that food-related olfactory cues also elicit a whole host of physiological responses: everything from increased salivation (e.g. [13], pp. 44–47; [14–19]) through to other cephalic phase responses such as the release of gastric acid and insulin [20, 21]. Such responses tend to be particularly pronounced in those who are hungry and/or restricting their food intake for whatever reason [22]. Such responses are often enhanced when those food aromas are combined with matching visual food cues [19, 23]. What is more, dramatic increases in cortical blood flow have been documented in hungry individuals when exposed to the

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aromas (and sight) of their favourite foods ([24], see [25] for a review).

On the other hand, retronasal olfactory cues are dominant when it comes to our experience of flavour (see [26] for a review). Given that olfactory cues play such an important role in all stages of our interaction with food, it should come as little surprise to find that aroma and fragrance cues that are extrinsic to the food itself are increasingly being used to try and modify our behaviour toward/around food and our experience of what we consume.<sup>1</sup> In this article, the discussion will be restricted to the use of food-related aromas (see [27–30] for reviews of the use of non-food-related olfactory cues in retail spaces). As we will see later, many marketers claim that food-related olfactory cues can be used to influence where consumers choose to eat, which foods they purchase (cf. [31, 32]), and even how much they end up consuming. As Wadhwa et al. [33] note, the mouthwatering smell of the bakery and the offer of a food sample in a supermarket can both trigger reward-seeking behaviours in consumers.

In a previous article, Spence and Youssef [34] reviewed the exploration of this space (of product-extrinsic olfactory design) by modernist chefs and culinary artists working in the area of what has been called ‘molecular gastronomy’ [35]. These creative individuals have certainly done a great job in terms of exploring the space of possibilities around product (by which I mean food)-extrinsic olfactory cues. The key point to stress here though is that such food experiences are, in a very real sense, elitist: both because of the rarity of the food offering itself and because of the typically prohibitive cost of such ultra-high-end culinary experiences. As such, it can be argued that the real action in terms of food-related olfactory design (that is influencing our day-to-day lives) is mostly happening elsewhere.

There have been some attempts to take the tricks and techniques from the modernist restaurant and try them out in a more mainstream dining context. As one limited but highly publicized example, just take top chef Heston Blumenthal’s use of the atomizer to deliver ‘the smell of the chippy’ (actually atomized pickled onion juice) over the fish and chips at one of Britain’s *Little Chef* motorway restaurants. Indeed, the atomized delivery of aroma has been a regular feature of the modernist restaurant landscape for quite some years now (including at Blumenthal’s flagship *The Fat Duck* restaurant) [36]. It is, though, worth bearing in mind that not all of the ideas (and multisensory design solutions) that can work so well in the context of the modernist restaurant necessarily translate straight into the mainstream restaurant environment [35].

Another trend documented in some high-end restaurants (e.g. *Per Se*, in New York; <http://www.thomaskeller.com/per-se>) has been to ban the staff from wearing any kind of scented product for fear that the smell of their perfume or aftershave might interfere with the diner’s enjoyment of the

aroma and flavour of the food (see [37], p. 22; cf. [38, 39]). However, it would seem highly unlikely that management could enforce such a policy on a large scale across the restaurant sector as a whole. And, anyway, it is unclear how diners would respond to the suggestion that they arrive at the restaurant unscented. Hence, while an interesting idea, it is likely going to be impossible to deliver a completely unscented restaurant space, be it in the high-end restaurant or in more mainstream dining environments.

Generally speaking, if one really wants to know how the everyday food- and beverage-related behaviours and experiences of westernized consumers are being affected by the new multisensory design thinking around the control and modification of food-related olfaction, one really needs to concentrate on mainstream food culture. This article focuses on three key areas where olfactory design/marketing innovations have been taking place recently: (1) in the introduction of olfactorily enabled food and beverage packaging; (2) in the contemporary interest in the control/modification of the olfactory atmosphere in, and to certain extent around, restaurants and especially food outlets [30]; and (3) in the emergence of technology-enabled olfactory marketing and advertising. Developments in all three of these areas are increasingly influencing the multisensory experiences of us all, rich or poor, gastrotourist or neophobe alike [35]. The key point that will be stressed here is that the food and beverage landscape is increasingly being modified (or augmented) by a range of olfactory interventions. If food-related olfactory cues do have as much of an effect on consumers as has been suggested (at least by some of the practitioners working in the field), then one might legitimately start to worry about the impact of such olfactory marketing on our consumption behaviours and, ultimately, on the growing obesity crisis in the western world (e.g. see [40, 41]). At the same time, one also needs to be cautious when it comes to interpreting some of the remarkable effects that have been reported in the area of olfactory marketing given that often the only evidence that one can find comes from press reports.

#### **Olfactory modification of product packaging**

Much of the food we buy is consumed directly from packaging [42]. Crucially, the sensory and semantic/semiotic perceptual aspects of the packaging influence the consumers’ experience of the product [43–45]. The olfactory attributes of the packaging are no exception here, and the last few years have seen a steady growth in the incorporation of olfactory cues into food and beverage packaging (e.g. [44, 46]).<sup>2</sup> So, for example, food aromas are now integrated into the closures of a number of sports drinks bottles [46], into the lids of coffee cups [47], and into the packaging of a whole host of other food and beverage products. In other words, olfactory cues are increasingly

being incorporated into the multisensory product experience, no matter whether consumers realize this or not.

There are several reasons as to why a company might want to introduce olfactory cues into their product packaging (not to mention their point-of-purchase displays; [48, 49]): (1) to capture the shopper's attention while wandering down the supermarket aisle [50–54]; (2) to modify the consumer's flavour expectations when they evaluate food and beverage products in pack (perhaps in the supermarket, or in the home setting); (3) to modify the flavour experience when people consume products directly from pack [26]; and (4) to control/promote consumption. Note that the focus in this review will be on summarizing the use, and influence, of orthonasal olfactory cues.

When it comes to making the olfactory experience of the product in pack better (i.e. more appealing), there would seem to be at least a couple of solutions here. On the one hand, if one has an intrinsically great-smelling food or beverage product (think of coffee or chocolate; [55]), then the question that the packaging designer may want to ask themselves is how to ensure that the consumer can get an olfactory hit of the product itself through the packaging—think only of the release valve on the front of bags of quality coffee that squirts a jet of aromatic odour in the direction of the consumer whenever they pick up such a product from the supermarket, or store, shelf [44]. The challenge is how to do this without compromising on the consumer's perception of the contents once the packaging is opened. On the other hand, many companies have also been considering whether to incorporate some more or less artificial-smelling scent into/onto the packaging. One popular solution here is the use of some form of scent encapsulation/scent release [47, 56]. ScentSational Technologies is one of the companies working to deliver scent-enabled packaging (e.g. <http://scentsationaltechnologies.com/about.cfm>). Two of the solutions that are currently offered in this space include *Encapsulated Aroma Release* which delivers enhanced aroma during opening and use and *SunScent*, a commercially printable scented packaging. It has been rumoured that pungent aromatic compounds have been integrated into the seals of some coffee containers and that at least one manufacturer has explored (and possibly also implemented) the use of chocolate aroma in the seal of their frozen chocolate ice cream bars. In short, a variety of innovative design solutions have been tried in the marketplace with varying degrees of success in recent years. There is, though, certainly a lot more room to grow here [57].

### **Beverage packaging**

One interesting example in this space relates to PepsiCo's 2013 US patent application to incorporate (or encapsulate)

aroma compounds into the closure mechanism for their ready-to-drink (RTD) beverages, concentrates, syrups, shelf-stable and chilled drinks, and carbonates and non-carbonates packaging [56, 58]. In this case, the idea was that the proposed 'aroma delivery system' would release one or more aroma compounds, encapsulated in gelatine capsules, which would be ruptured when the container was opened. According to the inventors Naijie Zhang and Peter Given: 'Consumers evaluate many products by the aroma emitted from the product or the container in which the product is made available...Edible products, such as juices and coffee, are expected to have a fresh aroma that replicates or evokes memory of the expected flavour of the product...Research has shown that aromas can in some instances have substantial impact on consumer perception of the taste of a beverage or other food, trigger a favourable emotional response, elicit a favourite memory, and/or otherwise improve overall product performance.' According to Zhang and Given, many companies and brands have realized that their consumers want to smell their products. Aromas are, however, often lacking because the holes that drinks come out of are too small to allow the consumer to get a good sniff, or else are covered with protective safety films. They go on to note: 'Additionally, it is often difficult to deliver adequate aroma to a headspace of a container that comes from the beverage itself, and not from the container.' (quoted in [56]).

### **Hot beverages**

Others working in this space (i.e. trying to deliver better flavour experiences for the consumer by means of enhanced olfactory packaging) include Mint Urban Technologies. A few years ago, this company introduced an aromatic coffee lid for take-away cups (called the *Aroma Lid*). According to the company, the aroma-enhanced lid improves the taste (or should that be flavour; [26]) of the hot beverage (see Fig. 1). In this case, the aromatic material was designed to enhance the pre-existing bouquet of the coffee [47]. The mechanism here is a little different from that in PepsiCo's patent, with heat from the coffee warming the lid and so releasing the 'fine' coffee aromas. One company commentator noted that: 'Coffee lids block the aroma coming from the coffee. Because taste is 95 % smell, the lids are stopping us from experiencing the full taste of our favorite morning brew.' (quoted in [47]; though see [26], on the 95 % claim). As Martin goes on to highlight, this could be big business given that the take-away coffee industry uses 100 billion lids every year.

Others, meanwhile, have tried to enhance the coffee drinking experience by redesigning the plastic lid instead. The idea here is to provide better exposure to the coffee's natural aroma (see Fig. 2). As one of those promoting the lid noted: "You spent \$4 on a cup of coffee and \$3 is trapped inside," Goffe said. Fleming said that "the vast



**Fig. 1** Mint Urban Technologies introduced an aromatic coffee lid for take-away cups, which it claims can improve the taste of coffee by enhancing its bouquet (figure from [47])

majority” of those lids “involve what we call ‘straw-like’” holes—a small, raised opening that drinkers suck the brew out of into their mouths. Not only does that minimize the amount of coffee they can smell as they drink, he said, it also concentrates a hot liquid into the mouth.’ [59]. All-in-all, then, it would appear that the packaging of coffee, and coffee drinks, is one of the areas that has seen most innovation in terms of olfactory design in recent years (see Fig. 3). Indeed, more generally according to at least one design historian working in this area: ‘coffee devices and products is “one area in our society where there’s unbelievable innovation.”’ (quoted in [59]). Presumably, the extensive innovation here is also partly driven by the fact that the smell of coffee is generally rated as one of the most popular, or liked, of food/beverage aromas [55]. It is somewhat surprising, by contrast, that tea beverages seem to attract nothing like the same interest from sensory designers/marketers, at least not thus far. This is perhaps most surprising at the high-end speciality tea end of the market.

#### **Processed foods**

There is growing concern amongst many of the manufacturers of ready meals because they are increasingly

realizing that many of their products simply fail to release the appropriate cooking aromas that, or so it can be argued, our brains have evolved to expect prior to consumption. As Avery Gilbert ([60], pp. 96–97) notes: ‘This is a big headache for manufacturers of prepared foods. The physics of microwave heating doesn’t create the toasted, roasted, and caramelized notes that signal impending “doneness.”’ Traditional packaging solutions clearly do not make the most of the aroma expectations and flavour anticipation that is such a fundamental part of our evolutionary history, elements which are (or at least should be) such a key part of the consumption experience nowadays. Indeed, one can but speculate here as to the consequences for brains that evolved to smell cooking aromas prior to consumption on contemporary food experiences/behaviours that typically occur in the absence of such preparatory sensory cues. Again, Gilbert captures the point beautifully when he states that: ‘We are a cooking species, and the smell of an impending meal is woven into our biology. Food aroma is an invitation and a spur to action. Even before the first bite, it triggers an elaborate sequence of physiological events: salivation, insulin release by the pancreas, and the secretion of various digestive juices....



**Fig. 2** Enhanced olfactory design from Viora Ltd. (<http://www.vioralid.com/>) (figure from [59])





**Fig. 3** Time to wake up and smell the coffee? Food and beverage companies are increasingly waking up to the importance of olfactory design. The figure shows the *Viora* lid, specifically designed to deliver an enhanced olfactory hit (figure from <http://www.vioralid.com/benefits/the-viora-lid-unlocks-the-aura-of-your-beverage/>)

We expect to be stimulated en route to a meal—the anticipatory smells of cooking have become almost a biological requirement.’ ([60], pp. 96–97).

To put the discussion here into some sort of context, note only that according to Eric Schlosser ([61], p. 121): ‘about 90 % of the money spent by North Americans on food is used to buy processed food’ (see also [62]). In conclusion, the examples that have been reviewed in this section show that scent-enabled packaging is slowly but surely becoming a more common feature of our everyday food and beverage packaging. Certainly, the interest from food and beverage companies, as well as packaging manufacturers, would definitely seem to be on the rise. That said, developments/innovation in this area currently seem more advanced when it comes to beverages (especially coffee) than for ready meals or other foods.

Before leaving the topic of olfactory packaging, it is perhaps worth noting how food aromas are also now being

used in general purpose packaging materials, such as bubble wrap. Just take the following as a representative example: ‘Rajapack has today released the first commercially available scented bubble wrap, which includes the aromas of bacon, sawdust, and cookies, amongst others. The new product – known as InfusionWrap™ [63]. While this example was an April Fool’s Joke (see [http://www.rajapack.co.uk/infusion\\_bubble\\_wrap.html](http://www.rajapack.co.uk/infusion_bubble_wrap.html)), the general point remains that in the years to come we are going to be exposed to more food aromas through our packaging, both the packaging of food and beverage items themselves, but also, quite possibly, and for a host of non-food items as well.

### Olfactory impact of restaurants and food/beverage outlets

A second area where olfactory design is becoming increasingly prevalent is in the restaurant and food outlet sectors. While part of the innovation here has been around the addition of an olfactory element to individual dishes (see [34, 35] for reviews), a number of top chefs such as Paul Pairet of *Ultraviolet* in Shanghai [64] and Heston Blumenthal of *The Fat Duck* in Bray in the UK have also been experimenting with scenting the restaurant itself ([35] [65] for the suggestion that the Italian Futurist F. T. Marinetti was doing something very similar back in the 1930s). Along similar lines, London-based chef Jozef Youssef recently released the scent of roses into the restaurant as part of his *Sensualità* dining concept (see <https://kitchen-theory.com/?s=sensual>). As mentioned already, though, the focus in this article will be squarely on what is happening in the mainstream restaurant/food service sector.

The last few years have undoubtedly seen a steady growth of interest in companies wanting to control/modify the olfactory experiences of their customers, both before they reach the store/restaurant and once they have arrived inside. There are several objectives here: (1) to control any undesirable or incongruent food (or non-food) odours, (2) to use aroma to capture the attention of consumers [50–54, 66] and to encourage them to enter a particular store or establishment [67], (3) to control the length of a consumer/diner’s stay in a given food environment (the underlying idea here being the longer they stay, the more they are likely to consume), and (4) the use of food aromas to make customers hungrier ([68]; see also [69, 70]).

Given estimates that 30 % of the money spent on food is eaten away from the home [71], controlling the olfactory atmosphere in/around restaurants, cafes, and other food and beverage outlets becomes all the more important. Furthermore, one occasionally comes across stories in the media of restaurants/chains that have successfully harnessed the power of smell to increase sales. In terms of the evidence that is currently available on this topic, on the one hand, we have scientific research

assessing the impact of scent and aroma on consumer behaviour in the context of the restaurant or research lab [32, 72]. On the other, we have the comments from industry professionals voicing their concerns about both the control and the optimization of the olfactory atmosphere not only in their stores/restaurants but also in the surrounding vicinity [67, 73]. While the latter are harder to evaluate critically, they do perhaps provide the most convincing evidence we have to date of the power of scent in the retail context.

### **Scientific research**

One of the most interesting studies in this area was conducted by Guéguen and Petr [72] in a small pizzeria in Brittany, France. These researchers investigated the impact of releasing ambient lemon and lavender scent via an electric fragrance diffuser (versus a no fragrance baseline condition) on the behaviour of diners ( $N = 88$ ). The study was conducted over three successive Saturday evenings in a restaurant with a maximum of 22 covers. Interestingly, those diners exposed to the lavender scent stayed around 15 % longer and, more importantly, spent approximately 20 % more. Guéguen and Petr's suggestion here was that the smell of lavender may have relaxed the diners (and, as a result, ended up in their spending more). Notice how neither of the scents used in this study was particularly congruent with most people's conception of what a pizzeria should smell like. As such, there may well be other fragrances out there that would have an even more pronounced influence on the behaviour of diners. On the flip side, however, the relatively small number of diners tested in this between-participants study means, I think, that one would be well advised to await replication before putting too much weight on these findings. Generally speaking, the aim of researchers and practitioners working in this area has been to deliver a multisensory atmosphere to customers that is truly congruent and immersive (see [28, 35] for reviews).

In a laboratory study conducted in Dijon, France, groups of participants were exposed to the odour of melon (which is typically entrée-related aroma in France), to the odour of pear (typically dessert-related; both odours presented at a very low, and imperceptible, level), or to no fragrance while performing a short behavioural task [32]. After a few minutes, the participants were invited to choose a meal from a menu, including a starter, main, and dessert. Interestingly, those who had been exposed to the melon scent tended to choose more salads and less fatty entrées (e.g. *paté*) than those who had not been exposed to an odour (although it should be noted that this difference just failed to reach statistical significance). Meanwhile, those exposed to the pear odour chose significantly more fruit desserts than those in the no odour group.<sup>3</sup> Once again, though, the sample sizes in this study were not that large: 58

participants were tested in the experiment contrasting melon scent with no scent, and 70 in the experiment contrasting pear scent with no scent.

While the use of consciously perceived scent in the restaurant setting (or elsewhere) is one thing, we should perhaps all be rather more concerned about the use of subliminal scent, that is, smells whose very presence we are unaware of. Relevant here, on being quizzed after the experiment, none of the participants who had taken part in Gaillet et al.'s [32] study remembered a scent actually having been present in the environment in the earlier part of the study. Indeed, in the laboratory setting it has been shown/suggested that scent can have more impact on our perception/behaviour when we are not aware of its presence [11, 74].<sup>4</sup>

It is worth noting here that Japanese companies have been rumoured to release the scent of food into their office buildings at different times of a day on different floors in order to more effectively manage the flow of workers into their staff canteens [75, 76]. This is, then, just one more example of how food-related olfactory cues are being used to modify people's food-related behaviours. Elsewhere, Wansink ([77], pp. 111–112) has reported on a series of studies that were conducted by the US Army in order to determine whether they could induce their troops to eat more by impregnating the plastic of their cereal bowls with a food aroma. Sadly, little detail is provided regarding the specifics of these interventions. While the latter examples would seem relatively benign, some of the uses of food-related aromas that will be covered in the next section are less so.

### **Controlling the olfactory in-store environment**

A number of food and beverage providers are becoming increasingly interested in the impact of the olfactory attributes of the store environment on the behaviour of their consumers. While many companies are understandably reticent to talk about their use of in-store aroma, for fear of appearing manipulative, several notable examples have made their way into the press over the last few years. So, for example, there was something of an uproar back in 2011 when CBS News and Time magazine both reported on a Net Cost supermarket in Brooklyn, New York, that had started pumping out the artificial aromas of chocolate and baked bread into the store. A number of scent machines had been specially mounted on the walls specifically for this purpose [78]. Sanburn [68] describes the resulting experience as follows: 'When you walk into one of the Net Cost supermarkets in Brooklyn, N.Y., you'll be greeted by hints of chocolate and grapefruit and rosemary focaccia. And while the store actually sells those products, the smells you'll smell are fake. Fake in the sense that the artificial

aromas are being piped in by five scent machines that are strategically located around the store. Chocolate scents near the candy. Fruit smells in the produce aisle.' To which, one might add, the smell of rosemary focaccia is also released by the bakery [78].

This is by no means an isolated example: Companies such as ScentAir UK (<http://scentairuk.com/>) and ScentAndrea (<http://www.scentandrea.com/scentandreaweb-main.htm>) in California are increasingly providing the olfactory backdrop for a growing number of food and beverage stores around the world. For instance, the M&M's World store in London's Leicester Square (<https://www.mmsworld.com/>), which was the world's largest sweet shop when it opened, delivers a chocolate aroma throughout the store [73].<sup>5</sup> As ScentAir UK's managing director Christopher Pratt noted: 'What they sell comes pre-packaged. So although it looked like the place should smell of chocolate, it didn't. It does now.' (quoted in [73]).

Another company who had been heavily engaged in olfactory marketing is the international bakery chain, *Cinnabon* (see <http://www.cinnabon.com/home>). According to a recent article that appeared in *The Wall Street Journal*: 'Cinnabon, the bakery chain, places ovens near the front of its stores so the enticing smell of warm cinnamon rolls escapes when oven doors open, says Kat Cole, president of Cinnabon, a unit of Focus Brands Inc. The bakeries are intentionally located in malls or airports, not outside, so smells can linger. Over time, the company has recognized that aroma is a huge part of its formula, Ms. Cole says. Putting ovens in the back of stores at a test location "significantly" lowered sales, she says. Cinnamon rolls are baked at least every 30 min. Some store operators heat additional sheets of brown sugar and cinnamon to keep the aroma in the air, she says' [67]. The aroma of the Subway chain's baking bread is also widely commented online [79, 80].

Now, as well as using scent to attract consumers to one's store, there can also be problems for those stores wanting to sell a range of different food or beverage products when the aromas of different products conflict. One illustrative example here comes from *Starbucks*. It is worth quoting *The Wall Street Journal* article at some length to get a sense of both the problem that the company faced and the solution that they came up with:

*The challenge of competing odours: "The clash of conflicting food odors is a challenge for restaurants focused on aroma to increase sales. Starbucks stores stopped selling breakfast sandwiches for six months in 2008 because Chief Executive Howard Schultz hated how the smell of cooking (and often burning) cheese engulfed the coffee aroma, the executive wrote in his 2011 book*

*"Onward: How Starbucks Fought for Its Life without Losing Its Soul.*

*Starbucks created an aroma task force to fix the odor problem, Mr. Schultz wrote in his book. The sandwiches reappeared on menus, but only after the company switched to leaner bacon and higher-quality ham and cheese, and started cooking the sandwiches at 300° or below.*

*Aroma is one of the many things Starbucks continues to take into consideration in order to offer the best possible customer experience in each of our stores," the company said in an email and declined to comment further. [67].<sup>6</sup>*

Nassauer [67] also reports that Cinnabon experienced the undesirable clash of aromas when they trialled their 'Pizzabon'. Hence, what these examples all show is that getting the aroma profile right can be a real challenge. The key point to note, though, is how many companies are now actively trying to manage the olfactory smellscape in their stores. Meanwhile, I know of one global burger chain have also looked into the release of pleasant smelling fruity/floral scent in order to try and obscure any of those greasy burger smells ([http://www.dailymotion.com/video/xr6cos\\_neuromarketing-votre-cerveau-les-interesse-1-2\\_news](http://www.dailymotion.com/video/xr6cos_neuromarketing-votre-cerveau-les-interesse-1-2_news)).<sup>7</sup> Some companies are thinking even further afield. A number of them, for example, are paying even more attention to the olfactory environment in the vicinity around their store. Apparently, 'One of Cinnabon's favorite spots in a mall is on the ground floor near a stairwell, so smell wafts to the floor above.' [67].<sup>8</sup>

In summary, it is a little difficult to know just how worried we should all be by the use of olfactory cues in, and around, food outlets. On the one hand, it is rather hard to believe some of the claims that one finds in the marketing literature, given the relatively modest effects that have been reported to date in the well-controlled, although admittedly small-scale, scientific studies (see [34, 35] for reviews). On the other hand, it is clear that many companies are now paying far more attention to the olfactory smellscape in and around their stores than ever before. These companies would certainly seem to believe in the power of food aromas to capture the attention of consumers and encourage them to visit their stores and purchase their products. And as should have been obvious from the examples just mentioned, there would seem to be an unfortunate tendency for many 'unhealthy' food to smell especially good.

Now, while it might be expected the stores of food and beverage providers to smell of desirable food aromas, what is also worth noting is that a number of other companies have been appropriating specific food aromas to deliver a



signature scent in their commercial premises of late [66, 81, 82]. According to Trivedi [29] in an intriguing article that appeared in the *New Scientist* magazine, for example, Samsung Experience electronic goods stores all use the scent of green melon. Do such food aromas provoke appetitive behaviours when experienced outside of a typical food context? This important question is one that we do not currently have an adequate answer to.

### Olfactory advertising

Now, the third means by which consumers are increasingly being exposed to food aromas is via scent-enabled advertisements. Of course, looking back, there was a time not so long ago when newspaper supplements and magazines were once inundated with scent strips. And while many of those scent strips were for perfumes, it was not unheard of to encounter food and beverage-related advertisements as well (see Fig. 4). However, the real interest here these days is in technology-enhanced plug-ins, scent cannons, and other innovative olfactory technologies. Such devices are capable of adding targeted scent delivery to add to audition-visual ads. And while our exposure to such (typically technology-led) food aromas is currently fairly limited, the evident excitement amongst sensory (scent) marketers and the scent technology providers themselves would certainly seem to suggest that this area will only grow in the years to come.

### Scent-enabled plug-ins

There are examples from both high-end restaurants and mainstream food producers exploring the opportunities around the delivery of scent by means of olfactory-enabled plug-ins for mobile devices. In terms of modernist cuisine, for example, take *Mugaritz* in San Sebastian, Spain (see <http://www.mugaritz.com/en/>). For the last season's menu, those diners lucky enough to get a booking at this world-



**Fig. 4** Back in 2006, Pepsi added the aroma of black-cherry vanilla soda to its magazine inserts for Diet Pepsi Jazz [66]

famous restaurant were sent a scent-enabled plug-in. This device released the smell of black pepper, sesame, and saffron when a soon-to-be diner virtually crushed herbs and spices using his restaurant's smartphone app. In this case, head chef Andoni Luis Aduriz's idea was to use the diner's sense of smell (orthonasal olfaction) in order to simulate one of the wonderful dishes on the tasting menu and so build up the expectant diner's anticipation and expectation concerning the food that they would soon get to taste at the restaurant [83, 84]. In terms of the more mainstream uptake of this olfactory technology, though, one can take the much-publicized example of Oscar Mayer (a Kraft-owned meat brand) from last year as a hint of what may be to come. An iPhone attachment was released that was marketed as a Bacon-scented alarm clock (see <https://www.youtube.com/watch?v=PiWdF3u9C0w> Wake Up & Smell The Bacon—from the Oscar Mayer Institute For the Advancement of Bacon, OMIFAB; [85]).

### Scent-enabled advertising

One of the more famous examples of advertising that incorporated a food aroma was the 'Got milk?' ad campaign from the California Milk Processor Board that appeared in a select number of bus shelters in San Francisco a decade ago (see Fig. 5). In this case, the marketers presumably hoped that the association with the scent of cookies provided by the outdoor scent strips that were utilized would prove irresistible to consumers. As Cuneo [86] put it: 'The subliminal scent was to entice those waiting for the bus to smell the cookies and think about having a cookie and a glass of milk.' Interestingly, though, a number of people actually complained about this ad,



**Fig. 5** A 'Got milk?' ad campaign in San Francisco a decade ago caused a public backlash due to the fact that the ad gave off the scent of chocolate chip cookies [86]. Campaigners said that the smell was likely to make people hungry and was insensitive to the homeless people who use such shelters (figure downloaded from <http://americancopywriter.typepad.com/blog/images/gotmilk120606.jpg>)



suggesting that it might encourage people to overeat.<sup>9</sup> As a result of the public uproar, the Metropolitan Transit Commission ordered the scent strips to be removed within 36 h of their installation [87].

Perhaps times have changed, or maybe things just work differently in San Francisco. Anyway, no such consumer backlash was reported in the UK when McCain recently installed ten multisensory advertising displays in bus stops to advertise the launch of their McCain Ready Baked Jackets (see Fig. 6). According to Metcalfe [87]: ‘Each billboard includes a fiberglass potato sculpture and a mysterious button: Push it, and the tuber discharges the aroma of “slow oven-baked jacket potatoes.”’ A scent-enabled taxi was also sent off to several major cities in the UK. Unsuspecting members of the public were picked up and offered a ride, during which a jacket potato would be prepared and served.

While such scent-enabled adverts currently have more of a novelty value than anything else, the real potential for growth in this area may come from scent-enabled ads that engage the consumer’s other senses as well. Let me illustrate with a couple of striking examples: According to reports, when scent-enabling technologies were introduced to pump out the smell of coffee on the forecourt, a 374 % increase in sales was observed (<http://www.scentandrea.com/scentandreawebmain.htm>; see Fig. 7). According to Pape [88]: ‘During six months of tests at stations in Nevada, Ohio, California and Florida, the scent machine released coffee aromas at the same time the digital screen was running a 15-s ad for fresh coffee. “Sales of in-store coffee jumped 300 % [during the test],” said Allen Fleisher, managing partner of Gas Pump Media. When the scent machine was removed from the area, and the digital screen was used alone to promote fresh coffee, sales were up only 75 to 80 % above average.’ (see also [87]). No surprise, then, that based on these results one company was planning to install thousands of these digital advertising displays across the country ([88]; though note that it was unclear how many of them would be scent-enabled).



**Fig. 6** Scent-enabled advertising display in UK bus shelter (figure from [87])

Another intriguing recent example of the use of olfactory marketing comes from a Dunkin’ Donuts campaign in South Korea: ‘When a company jingle played on municipal buses, an atomizer released a coffee aroma. The campaign increased visits to Dunkin’ Donuts outlets near bus stops by 16 % and sales at those outlets by 29 %.’ [89]. In summary, looking ahead, advertising that incorporates a food aroma would seem to be a big growth area. One finds mention of: ‘8,000 scent-delivery systems being introduced to in-store flat-panel screens in Kroger stores and other top retailers, including Wal-Mart.’ [66]. And that is without touching on the growing use of olfactory cues at the point-of-purchase [48, 90]. While unconfirmed media reports suggest some pretty dramatic increases in sales [88, 89], there is a general lack of data from well-controlled laboratory studies to know just how effective such scent-enabled food advertising really is. Furthermore, it is important to stress that there is likely to be a novelty effect here. Specifically, the initial introduction of scent-enabled ads will clearly have some novelty value that may increase their effectiveness in the marketplace in the short term. However, as soon as more scent-enabled ads appear, or have been installed for longer, their effectiveness is likely to decline somewhat. Figure 8 shows a final example of olfactory advertising, this time from North America. Will such multisensory food advertisements become more common in the years to come is anyone’s guess at this point.

While there has been the occasional public backlash against consumers being led by the nose in this way [86], recent case studies suggest a growing acceptance of olfactory marketing as just another legitimate modality of communication with the consumer. Perhaps the more fundamental question here, given that we are surrounded by other (mostly visual) forms of advertising currently, is whether there is anything special/unique or just plain different about advertising to the consumer’s nose rather than to their eyes [27, 30]. As yet, I would argue that a clear case has not been made that there is.

#### Health implications of olfactory design/marketing

Now, everything we have seen so far in this article would seem to revolve around a growing number of food and beverage companies trying to enhance the olfactory (and really multisensory) experience of their consumers, or to rephrase things a little, a growing number of commercial interests trying to get their customers to eat and drink more [91]. And while there is nothing really new in the use of food aromas to try and influence consumers (see [27] for a review), what is different now is the range of technical solutions that allow companies to pump out synthetic aromas in a variety of formats in a growing number of locations/situations, both related and unrelated to food. Indeed, what is clear is how desirable food aromas



**Fig. 7** According to the results of one industry study, releasing the scent of coffee in the service station apparently led to a greater than 300 % increase in sales [88]

are now appearing in packaging and in stores that do not have anything directly to do with food.

So, should we all be worried at the rise of this new form of sensory marketing [67, 91]? I would argue that we probably should, at least if we put weight in the claims and suggestions that have appeared in the media. Just take Sanburn's [68] note here regarding the artificial scents used

at one New York grocery store chain mentioned earlier: 'The scents are designed to make customers hungrier and thereby get them to buy more.' (see also [78]). Or as Melvin Oatis of New York University put it when talking about the impact of such stimuli: 'The sense of smell is so primal ... that sense of smell actually translates later into, "Oh, I wasn't even hungry, but now I want popcorn."' [78]. In

## Smells like ...

... **steak along Highway 150 in North Carolina, USA**, coming from what could be a one-of-a-kind scented billboard for a grocery store. The smell is particularly strong during the rush hour, in the morning and at around 5 p.m.

The billboard for Bloom, a division of Food Lion, is fashioned into the shape of a gigantic piece of steak on a fork. However, the most appetizing part of the billboard might not be the picture itself.

'It smells like, uh, barbecue, like hickory or something being barbecued and smells like steak,' one motorist described.

'The scent is emitted by a high-powered fan at the bottom of the billboard that blows air over cartridges loaded with the BBQ fragrance oil', said Murray Dameron, Marketing Director for Charlotte-based ScentAir, which provides custom scents and fragrance-delivery systems for businesses, including hotel lobbies, casino gambling, and retail stores.

The billboard scent is 'basically a blend of black pepper and kind of a charcoal grilling smell,' Dameron said. 'It smells like grilled meat with a nice pepper rub on it.'

A Bloom spokesperson said the company is always looking for new ways to reach the consumer. 'With all the advertising around, you want to be able to jump out and really grab the consumer's attention,' said Angie Hunter, a spokesperson for Bloom stores. The company wanted to try a multisensory approach to their advertising campaign, as a way of raising brand awareness and improving brand recognition, thus increasing consumer demand. So far the results have been good, probably because the advert is so memorable. It's an entirely new marketing concept.



**Fig. 8** A novel example of scent-enabled advertising from the USA

terms of the impact of ambient food aromas on appetite, the scientific evidence suggests that people exposed to food-related odours (especially those who are dieting) show an increase in self-reported hunger ratings [18] and consumption [70]. Exposing participants to certain appetizing smells (e.g. pizza) has also been shown to lead to increased intake of pizza, especially in chronic dieters (i.e. restrained eaters; see [92]). Interestingly, though, it would appear to be that this form of olfactory-priming is food-specific in the sense that pre-exposing participants to the smell of cookies had no impact on pizza consumption (see also [93]).<sup>10</sup>

If the impact of all this exposure to food-related olfactory cues really is having an effect on the appetite and subsequent consumption behaviour of consumers, then we may well have a problem.<sup>11</sup> Perhaps the question that we should all be asking ourselves, given the growing obesity epidemic [40, 41], is whether there is a danger here that we may all be being 'nudged,' knowingly or otherwise, toward increasing consumption (cf. [94,95]). Who knows, perhaps our growing exposure to enticing food aromas should be added to the list of other environmental triggers that may play some role in the growing obesity crisis. And while, traditionally, complaints from the public have tended to focus on the potential of olfactory stimuli to cause irritation and allergy [29, 66, 86], perhaps is it the physiological and behavioural changes that are the real problem when it comes to the controlled release of food-related olfactory stimuli? Others focus on the manipulation angle, White [73], for example, stating that: 'But is it ethical, particularly in the case of businesses selling food? Dispersing the scent of chocolate or bread through a store implies that those smells come from the products being sold, which is not the case. Surely it reeks of deceit and manipulation?'<sup>12</sup> Sanburn [68] also focuses, albeit light-heartedly, on the manipulation when talking about the NYC grocer piping artificial scents into their store: 'While we can't deny that people may enjoy their shopping experience at Net Cost more than they would elsewhere, they're also being manipulated into buying more. So next time you're at a grocery store, just remember to let your wallet guide your purchases – not your nose.' Perhaps, though, that is easier said than done. Over-and-above any concerns over the role of pleasing food aromas in getting us to eat more, it is also worth pausing here to consider the huge amount of food that is purchased that goes to waste. Clearly anything that can be done to reduce such waste would also likely be a good idea from a societal point of view.

On the other hand, however, it is also important to stress that if there is really nothing special about food aromas as compared to, say, images of delectable food, what some have chosen to call 'gastroporn' [25], then our concern might be better directed at the general increase in exposure to food-related sensory cues

rather than specifically with anything about the sense of smell. Perhaps the only way in which such olfactory marketing is special relates to the possibility of adverse effects (i.e. olfactory irritation, increased sensitivity, or allergic reaction) when consumers are exposed to synthetic aromas [96]. Furthermore, perhaps we should also be concerned about the suprathreshold olfactory stimulation increasing found in enclosed buildings/spaces with limited ventilation such as malls, where an excessive amount of scent marketing with different odorants could be well expected to have negative effects on both sales and customer satisfaction. Remember also that we certainly should not necessarily believe everything that we read in the press when it comes to the remarkable effect of olfactory cues on sales (especially given the much more modest effects that have typically been documented in well-controlled scientific studies). As is always the case, more research is most definitely needed to resolve matters here.

Finally, it is worth returning to the question of the suprathreshold versus subthreshold (or subliminal) use of olfactory food cues. Many people are understandably worried about their possible exposure to marketing communications that they have no awareness of. However, while in the lab (i.e. under tightly controlled conditions) it has been shown that subthreshold smells sometimes have a more pronounced effect on people's judgments than suprathreshold smells [74], I would argue that the real-world widespread use of subliminal smell is unlikely to be a problem, given several factors. On the one hand, the large individual differences in the sense of smell mean that an affective subthreshold aroma for one individual is likely to be suprathreshold for another. More importantly, though, there is only a narrow window in which olfactory stimuli are sufficiently intense to be effective but weak enough to fall below the threshold for awareness. It is highly unlikely that it would prove feasible to control olfactory dispersal so as to achieve this in a commercial space, given the unpredictable flow of people, and air through the space.

## Conclusions

In conclusion, recently there has been a growth of awareness concerning just how important olfactory cues (both orthonasally and retronasally perceived) are to controlling/modifying the consumer's behaviour around, and experience of, foods and beverages. While much of the most innovative, and media friendly, experimentation in this area has been conducted by the modernist chefs and culinary artists (see [34, 35] for reviews), it is really the introduction of product-extrinsic olfactory cues into the marketplace that may well end up affecting us all in the years to come. In this article, we have seen how food aromas are being increasingly introduced into multisensory product packaging. We have



also seen the increasing interest of food/beverage outlets in trying to control the olfactory smellscape [97] in and/or around their stores. This is perhaps the most dramatic, if understated, way in which we are all increasingly being 'led by the nose'. Finally, I have also reviewed the latest evidence concerning the rise of scent in advertising and billboards (see Figure 8) and scent-enabled plug-ins for mobile devices. While the delivery/control of scent obviously fits in within the broader movement toward sensory marketing [91, 98], it is worth noting the varied motives that companies have in controlling/introducing food aromas. They include (1) capturing the attention of the consumer; (2) increasing lingering, appetite, and likelihood of purchase/consumption<sup>13</sup>; and (3) enhance flavour expectations from orthonasal cues and flavour experiences from retronasal olfactory cues. One other area where food-related olfactory cues are being utilized is in multisensory experiential events and tasting rooms [98–100].

While many reports suggest that the behaviour of the consumer is being influenced to purchase/consume more food/drink as a result of the introduction/modification of olfactory cues, what we have also seen is how there is something of a mismatch between the sometimes dramatic effects claimed by those selling these technologies and the much more modest findings that have typically been obtained in well-controlled laboratory research. The truth presumably lies somewhere in between. What is clear, though, is that we are all being exposed to more food aromas than ever before [101], and further research is urgently needed to better understand their impact on our consumption behaviours. And while some complain about this form of olfactory manipulation, as far as I can tell there is no reason to believe that this particular form of sensory marketing has any more/less effect than other modalities of persuasion (especially visual).

## Endnotes

<sup>1</sup>At the outset here, it is worth stressing the fact that our responses to most olfactory stimuli (be they food-related or not) and their impact on perception/behaviour are learned following prior exposure (e.g. [29, 102, 103], though see also [12, 104]).

<sup>2</sup>Inspired, in part, by the observation that enhancing the smell of a product and/or encouraging the consumer to smell the product in the packaging has been shown to lead to a significant increase in sales across a range of product categories [46, 105].

<sup>3</sup>Here, one can only imagine what the flower-filled corridor that diners would sometimes have to pass through to reach the dining room of Grant Achatz's *Alinea* restaurant in Chicago would prime diners to order [35]. In this case, the scent could be best described as an intense sweet flowery spring smell.

<sup>4</sup>Yeomans [103] also reports in passing that the sub-threshold smell of bacon can induce salivation (though, as yet, this preliminary finding has unfortunately still not been published; Yeomans, pers. comm.).

<sup>5</sup>Verizon Wireless also wafted a chocolate scent into its stores for the launch of the LG Chocolate phone [66].

<sup>6</sup>The importance of the multisensory atmosphere to the coffee drinking experience is also highlighted by the following anecdote; in a blogpost, Dooley [106] suggested that Nespresso Experience Stores were introduced specifically because Nestle realized how much of coffee experience resulted from atmosphere: 'Research from another coffee maker, Nespresso, shows that 60 % of sensory experience of drinking espresso comes from the retail environment!' A key part of the atmosphere of that environment is delivered by olfactory cues.

<sup>7</sup>That said, according to the comments that one finds online, people apparently like the smell of the crisped fries.

<sup>8</sup>Think only of how it is no longer surprising to smell coffee in the book store [107] and you get the idea of how far the encroachment of food aromas into our everyday lives has come in recent years.

<sup>9</sup>Some also argued that the ad was insensitive to all those homeless people who sleep in bus shelters.

<sup>10</sup>The Belgian scientist Jean Effront would likely be horrified by all this olfactory design/marketing. In fact, all the way back in 1913 he was already suggesting that: "It would be a hundred times better if foods were without odor or savor. For then we should eat exactly what we needed and would feel a good deal better" (cited in [108], p. 181).

<sup>11</sup>Olfactory cues can, though, potentially also be harnessed to help us to fight our food cravings. Indeed, there are a number of anecdotal suggestions out there from those who have started to expose themselves to food-related olfactory cues specifically in order to help them control their weight [109–112]. The notion of sensory-specific satiety [113, 114] may be relevant here; it has been known for some time that food aromas are judged as less desirable after the consumption of a meal containing those foods having those aromas [115]. What is more, recent research has shown that olfactory sensory-specific satiety also occurs in natural situations [116]. In one more recent laboratory study relevant to this theme, restrained, but not unrestrained, eaters were shown to consume less chocolate chip cookies after having been exposed to the smell of baking cookies while performing another task [117]. That said, their total cookie intake (i.e. including oatmeal-raisin and double-chocolate cookies) was unaffected [70, 118].

<sup>12</sup>Here, the author has to admit that his grandfather used to drop expensive aromatic coffee beans on the floor behind the counter of his traditional grocer's store



in Idle, Bradford. The idea being that as he served a customer he would crush some of the beans, thus releasing the great fragrance that would hopefully encourage his customers to purchase some coffee. Whether this should be counted as manipulation in the marketplace is open to debate.

<sup>13</sup>In the year 2660 in Hugo Gernsback's *Scientificafe*, the guests would start their meals by inhaling 'several harmless gases for the purpose of giving you an appetite' [119].

#### Competing interests

The author declares that he has no competing interests.

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#### References

- Fincks HT. The gastronomic value of odours. *Contemp Rev.* 1886;50:680–95.
- Rozin P. "Taste–smell confusions" and the duality of the olfactory sense. *Percept Psychophys.* 1982;31:397–401.
- Bojanowski V, Hummel T. Retronasal perception of odors. *Physiol Behav.* 2012;107:484–7.
- Burdach KJ, Kroeze JHA, Koster EP. Nasal, retronasal, and gustatory perception: an experimental comparison. *Percept Psychophys.* 1984;36:205–8.
- Diaz ME. Comparison between orthonasal and retronasal flavour perception at different concentrations. *Flavour Frag J.* 2004;19:499–504.
- Pierce J, Halpern BP. Orthonasal and retronasal odorant identification based upon vapor phase input from common substances. *Chem Senses.* 1996;21:529–43.
- Voirol E, Daget N. Comparative study of nasal and retronasal olfactory perception. *Lebensmittel-Wissenschaft und Technologie.* 1986;19:316–9.
- Small DM, Gerber JC, Mak YE, Hummel T. Differential neural responses evoked by orthonasal versus retronasal odorant perception in humans. *Neuron.* 2005;47:593–605.
- Piqueras-Fiszman B, Spence C. Sensory expectations based on product-extrinsic food cues: an interdisciplinary review of the empirical evidence and theoretical accounts. *Food Qual Prefer.* 2015;40:165–79.
- Boesveldt S, Frasnelli J, Gordon AR, Lündstrom JN. The fish is bad: negative food odors elicit faster and more accurate reactions than other odors. *Biol Psychol.* 2010;84:313–7.
- Smeets MAM, Dijksterhuis GB. Smelly primes—when olfactory primes do or do not work. *Front Psychol: Cogn Sci.* 2014. doi:10.3389/fpsyg.2014.00096.
- Stevenson RJ. An initial evaluation of the functions of human olfaction. *Chem Senses.* 2010;35:3–20.
- Kerr AC. The physiological regulation of salivary secretions in man. Oxford, UK: Pergamon; 1961.
- Klajner F, Herman CP, Polivy J, Chhabra R. Human obesity, dieting, and anticipatory salivation to food. *Physiol Behav.* 1981;27:195–8.
- Pangborn RM. Parotid flow stimulated by the sight, feel and odor of lemon. *Percept Motor Skills.* 1968;27:1340–2.
- Pangborn RM, Berggren B. Human parotid secretion in response to pleasant and unpleasant odorants. *Psychophysiol.* 1973;10:231–7.
- Pangborn RM, Witherly SA, Jones F. Parotid and whole-mouth secretion in response to viewing, handling, and sniffing food. *Perception.* 1979;8:339–46.
- Rogers PJ, Hill AJ. Breakdown of dietary restraint following mere exposure to food stimuli: interrelationships between restraint, hunger, salivation, and food intake. *Addictive Behav.* 1989;14:387–97.
- Spence C. Mouth-watering: the influence of environmental and cognitive factors on salivation and gustatory/flavour perception. *J Text Stud.* 2011;42:157–71.
- Feldman M, Richardson CT. Role of thought, sight, smell, and taste of food in the cephalic phase of gastric acid secretion in humans. *Gastroenterol.* 1986;90:428–33.
- Louis-Sylvestre J, Le Magnen J. Palatability and preabsorptive insulin release. *Neurosci Biobehav Rev.* 1980;4 Suppl 1:43–6.
- Legoff DB, Spigelman MN. Salivary response to olfactory food stimuli as a function of dietary restraint and body weight. *Appetite.* 1987;8:29–36.
- Rogers J, Raimundo AH, Misiewicz JJ. Cephalic phase of colonic pressure response to food. *Gut.* 1993;34:537–43.
- Wang GJ, Volkow ND, Telang F, Jayne M, Ma J, Rao M, et al. Exposure to appetitive food stimuli markedly activates the human brain. *NeuroImage.* 2004;21:1790–7.
- Spence C, Okajima K, Cheek AD, Petit O, Michel C. Eating with our eyes: from visual hunger to digital satiation. *Brain Cogn.* 2015; doi: 10.1016/j.bandc.2015.08.006.
- Spence C. Just how much of what we taste derives from the sense of smell? *Flavour* 2015.
- Spence C. The ICI report on the secret of the senses. London: The Communication Group; 2002.
- Spence C, Puccinelli N, Grewal D, Roggeveen AL. Store atmospherics: a multisensory perspective. *Psychol Market.* 2014;31:472–88.
- Trivedi B. Recruiting smell for the hard sell. *New Scientist* 2006;2582:36–9. Downloaded from <https://www.newscientist.com/article/mg19225821-800-recruiting-smell-for-the-hard-sell/> on 29/08/2015.
- Howes D, Classen C. Ways of sensing: understanding the senses in society. London, UK: Routledge; 2014.
- de Wijk RA, Zijlstra SM. Differential effects of exposure to ambient vanilla and citrus aromas on mood, arousal and food choice. *Flavour.* 2012;1:24.
- Gaillet M, Sulmont-Rossé C, Issanchou S, Chabanet C, Chambaron S. Priming effects of an olfactory food cue on subsequent food-related behaviour. *Food Qual Prefer.* 2013;30:274–81.
- Wadhwa M, Shiv B, Nowlis SM. A bite to whet the reward appetite: the influence of sampling on reward-seeking behaviors. *J Market Res.* 2008;45:403–13.
- Spence C, Youssef J. Olfactory dining: designing for the dominant sense. *Flavour* in press.
- Spence C, Piqueras-Fiszman B. The perfect meal: the multisensory science of food and dining. Wiley-Blackwell: Oxford, UK; 2014.
- Anonymous: Big Chef takes on Little Chef. 2013. Available at <http://www.channel4.com/programmes/big-chef-takes-on-little-chef/>; Accessed 26/08/2015.
- Damrosch P. Service included: four-star secrets of an eavesdropping waiter. New York, NY: William Morrow; 2008.
- Peynaud E. The taste of wine: the art and science of wine appreciation (Trans. M. Schuster). London, UK: Macdonald & Co; 1987.
- Peynaud E. Tasting problems and errors of perception. In: Korsmeyer C, editor. The taste culture reader: experiencing food and drink. Oxford, UK: Berg; 2005. p. 272–8.
- Caballero B. The global epidemic of obesity: an overview. *Epidemiol Rev.* 2007;29:1–5.
- World Health Organization. Obesity: preventing and managing the global epidemic. Geneva: World Health Organization; 1998.
- Wyatt SL. "State of the Snack Industry", Symphony IRI.com. 2012. (accessed February 22, 2013), [available at [http://www.symphonyiri.com/Portals/0/ArticlePdfs/SNAXPO2012\\_Executive-Summary.pdf](http://www.symphonyiri.com/Portals/0/ArticlePdfs/SNAXPO2012_Executive-Summary.pdf)]
- Hine T. The total package: the secret history and hidden meanings of boxes, bottles, cans, and other persuasive containers. New York, NY: Little Brown; 1995.
- Spence C, Piqueras-Fiszman B. The multisensory packaging of beverages. In MG Kontominas (Ed.), food packaging: procedures, management and trends (pp. 187–233). Hauppauge NY: Nova Publishers; 2012.
- Stern W. Handbook of package design research. New York, NY: Wiley Interscience; 1981.
- Anonymous. Maximum appeal. *Active Intelligent Pack World.* 2010;9(3):4–8.
- Martin J. New aromatic take-away coffee lid formulated to improve the taste of coffee. 2011; August 4<sup>th</sup>. Downloaded from <http://www.gizmag.com/mint-urban-technologies-aromatic-coffee-lid/19428/> on 26/08/2015.
- Ellison S, White E. 'Sensory' marketers say the way to reach shoppers is the nose. *Wall Street J.* 2000;November, 24<sup>th</sup>. Downloaded from <http://www.wsj.com/articles/SB975016895886269171 on 29/08/2015>.
- Middleton T. Not created equal. *Market Week.* 2002;8:37–8.
- Aguillon-Hernandez N, Naudin M, Roché L, Bonnet-Brilhaut F, Belzung C, Martineau J, et al. An odor identification approach based on event-related pupil dilation and gaze focus. *Int J Psychophysiol.* 2015;96:201–9.

51. Robinson AK, Mattingley JB, Reinhard J. Odors enhance the salience of matching images during the attentional blink. *Front Integrat Neurosci.* 2013;7:77.
52. Seigneuric A, Durand K, Jiang T, Baudouin JY, Schaal B. The nose tells it to the eyes: crossmodal associations between olfaction and vision. *Perception.* 2010;39:1541–54.
53. Seo HS, Roidl E, Müller F, Negoias S. Odors enhance visual attention to congruent objects. *Appetite.* 2010;54:544–9.
54. Zhou W, Jiang Y, He S, Chen D. Olfaction modulates visual perception in binocular rivalry. *Current Biol.* 2010;20:1356–8.
55. Ayabe-Kanamura S, Schicker I, Laska M, Hudson R, Distel H, Kobayakawa T, et al. Differences in perception of everyday odors: a Japanese-German cross-cultural study. *Chem Senses.* 1998;23:31–8.
56. Bouckley B: PepsiCo seeks US patent to encapsulate beverage aromas within packaging. *Beverage Daily* 2013;September 10<sup>th</sup>. Downloaded from <http://www.beveragedaily.com/Processing-Packaging/PepsiCo-seeks-US-patent-to-encapsulate-beverage-aromas-within-packaging?nocount> on 24/07/2015.
57. Marsh S: Whiff you were here: Machine prints food smells onto postcards. *Wired* 2012;July 26<sup>th</sup>. Downloaded from <http://www.wired.co.uk/news/archive/2012-07/26/postcard-roma> on 29/08/2015.
58. Morran C: PepsiCo thinks its drinks aren't smelly enough, wants to add scent capsules. *Consumerist* 2013;September 17<sup>th</sup>. Downloaded from <http://consumerist.com/2013/09/17/pepsico-thinks-its-drinks-arent-smelly-enough-wants-to-add-scent-capsules/> on 24/07/2015.
59. Mangan G: Flipping your lid: new coffee cup aims at your nose. *CNBC* 2014;April 26<sup>th</sup>. Downloaded from <http://www.cnbc.com/2014/04/25/coffee-lid-gets-a-redesign-to-let-the-roma-in.html> on 30/08/2015.
60. Gilbert A. *What the nose knows: the science of scent in everyday life.* New York, NY: Crown; 2008.
61. Schlosser E. *Fast food nation: what the all-American meal is doing to the world.* Allen Lane: Penguin Press; 2001.
62. Moss M. *Salt, sugar, fat: how the food giants hooked us.* St Ives: WH Allen; 2013.
63. Anonymous: Bacon-scented bubble wrap launched today. *Packag Europe* 2015;April 1<sup>st</sup>. Downloaded from <http://www.packagingeurope.com/Packaging-Europe-News/62782/BaconScented-Bubble-Wrap-Launched-Today.html> on 29/08/2015.
64. Gonzalez L: Ultraviolet by Chef Paul Pairet incorporates thematic video and perfumed air into his dining experience. 2013 Available at <http://www.psfk.com/2013/05/multisensory-dining-sight-sound-smells.html> (accessed February 2014).
65. Anonymous: Futurist cooking: was molecular gastronomy invented in the 1930s? n.d. Downloaded from <http://www.thestaffcanteen.com/editorial/futurist-cooking-was-molecular-gastronomy-invented-in-the-1930s> on 01/09/2015.
66. Thompson S: Big marketers smell money in scent technology: Mars, Pepsi, others add aromas to their package goods. *AdAge* 2006;October 31<sup>st</sup>. Downloaded from <http://adage.com/article/news/big-marketers-smell-money-scent-technology/112849/> on 29/08/2015.
67. Nassauer S: Using scent as a marketing tool, stores hope it—and shoppers—will linger: how Cinnabon, Lush Cosmetics, Panera Bread regulate smells in stores to get you to spend more. *The Wall Street J.* 2014;May 20<sup>th</sup>. Downloaded from <http://www.wsj.com/articles/SB10001424052702303468704579573953132979382> on 24/07/2015.
68. Sanburn J: NYC grocery store pipes in artificial food smells. *Time* 2011;July 20<sup>th</sup>. Downloaded from <http://business.time.com/2011/07/20/nyc-grocery-store-pipes-in-artificial-food-smells/> on 26/08/2015.
69. Cornell CE, Rodin J, Weingarten H. Stimulus-induced eating when satiated. *Physiol Behav.* 1989;45:695–704.
70. Jansen A, Van den Hout M. On being led into temptation: counterregulation of dieters after smelling a preload. *Addict Behav.* 1991;16:247–53.
71. Binkley JK, Eales J, Jekanowski M. The relation between dietary change and rising US obesity. *Int J Obesity Related Dis.* 2000;24:1032–9.
72. Guéguen N, Petr C. Odors and consumer behavior in a restaurant. *Int J Hospit Manag.* 2006;25:335–9.
73. White C: The smell of commerce: how companies use scents to sell their products. *The Independent* 2011;16<sup>th</sup> August. Downloaded from <http://www.independent.co.uk/news/media/advertising/the-smell-of-commerce-how-companies-use-scents-to-sell-their-products-2338142.html> on 24/07/2015.
74. Li W, Moallem I, Paller KA, Gottfried JA. Subliminal smells can guide social preferences. *Psychol Sci.* 2007;18:1044–9.
75. Classen C, Howes D, Synnott A. *Aroma: the cultural history of smell.* London, UK: Routledge; 1994.
76. Fox K: The smell report. Social Issues Research Centre. (<http://www.sirc.org/publik/smell.html>). 2001. Downloaded from [http://www.sirc.org/publik/smell\\_human.html](http://www.sirc.org/publik/smell_human.html) on 29/08/2015.
77. Wansink B. *Mindless eating: why we eat more than we think.* Hay House: London, UK; 2006.
78. Anonymous: N.Y. grocery turns to scent marketing. *CBS News* 2011;July 18<sup>th</sup>. Accessed at <http://www.cbsnews.com/news/ny-grocery-turns-to-scent-marketing/> on 26/08/2015.
79. Rosten T: What's behind the Subway bread smell? The fast food chain's bread smell, dissected. *Food Republic* 2011;December 7<sup>th</sup>. Downloaded from <http://www.foodrepublic.com/2011/12/07/whats-behind-the-subway-bread-smell/> on 30/08/2015.
80. Spiegel A: Food chains with the most recognizable scent, in order. *The Huffington Post* 2014;May 22<sup>nd</sup>. Downloaded from [http://www.huffingtonpost.com/2014/05/22/food-chains-smell\\_n\\_5366772.html](http://www.huffingtonpost.com/2014/05/22/food-chains-smell_n_5366772.html) on 30/08/2015.
81. Griffiths S: The science of SHOPPING: round numbers, colourful adverts and cinnamon scents persuade shoppers to splash their cash. *DailyMail Online* 2015;January 22<sup>nd</sup>. Downloaded from <http://www.dailymail.co.uk/sciencetech/article-2921469/The-science-SHOPPING-Round-numbers-colourful-adverts-cinnamon-scents-persuade-shoppers-splash-cash.html> on 30/08/2015.
82. Madzharov AV, Block LG, Morrin M. The cool scent of power: effects of ambient scent on consumer preferences and choice behavior. *J Market.* 2015;79:83–96.
83. Braun MH, Pradana GA, Cheok AD, Buchanan G, Velasco C, Spence C, et al. Emotional priming of digital images through mobile tele-smell and virtual food. *Int J Food Des.* 2016;1:29–45.
84. Hickey S: Groundbreaking gadgets aim to provide a feast for the senses. *The Guardian* 2014;28<sup>th</sup> September. Downloaded from <http://www.theguardian.com/technology/2014/sep/28/groundbreaking-gadgets-feast-for-senses> on 26/08/2015.
85. Griner D: 'Wake up and smell the bacon' with free alarm gadget from Oscar Meyer. *AdWeek* 2014;6<sup>th</sup> March. Downloaded from <http://www.adweek.com/adfreak/wake-and-smell-bacon-free-alarm-gadget-oscar-meyer-156123> on 13/07/2015.
86. Cuneo AC: Milk board forced to remove outdoor scent strip ads. *AdAge* 2006;December 6<sup>th</sup>. Downloaded from <http://adage.com/article/news/milk-board-forced-remove-outdoor-scent-strip-ads/113643/> on 26/08/2015.
87. Metcalfe J: Inside smellvertising, the scented advertising tactic coming soon to a city near you. *CityLab* 2012;February 9<sup>th</sup>. Downloaded from <http://www.citylab.com/design/2012/02/inside-smellvertising-scented-advertising-tactic-coming-bus-stop-near-you/1181/> on 29/08/2015.
88. Pape P: It makes scents: olfactory marketing brings pleasant aromas to customers pumping fuel. *NACS Magazine* 2009;August:8–9. Downloaded from <http://www.scentandrea.com/MakesScents.pdf> on 29/08/2015.
89. Anonymous: Psychology: the science of sensory marketing. *Harvard Bus Rev.* 2015; March;28–29.
90. Anonymous: UK: futures—follow your nose to a more sensual future. *Design Week* 1998.
91. Spinney L: Selling sensation: the new marketing territory. *New Scientist* 2013;2934 (18<sup>th</sup> September). Downloaded from <https://www.newscientist.com/article/mg21929340-400-selling-sensation-the-new-marketing-territory/> on 25/08/2015.
92. Fedoroff I, Polivy J, Herman CP. The effect of pre-exposure to food cues on the eating behavior of restrained and unrestrained eaters. *Appetite.* 1997;28:33–47.
93. Fedoroff I, Polivy J, Herman CP. The specificity of restrained versus unrestrained eaters' responses to food cues: general desire to eat, or craving for the cued food. *Appetite.* 2003;41:7–17.
94. Thaler RH, Sunstein CR. *Nudge: improving decisions about health, wealth and happiness.* London, UK: Penguin; 2008.
95. Marteau TM, Hollands GJ, Fletcher PC. Changing human behaviour to prevent disease: the importance of targeting automatic processes. *Science.* 2012;337:1492–5.
96. Cress SM, Steinemann AC. Prevalence of fragrance sensitivity in the American population. *J Environ Health.* 2009;71(7):46–50.
97. Porteous JD. Smellscape. *Progress Hum Geography.* 1985;9:356–78.
98. Cooper L: Sensory marketing—could it be worth \$100m to brands? *Market Week* 2013;31<sup>st</sup> October. Downloaded from <http://www.marketingweek.com/2013/10/30/sensory-marketing-could-it-be-worth-100m-to-brands/> on 30/08/2015.

99. Firth P, Osborne E. Wine sense: tasting bar is quick off the block. *LSN Global* 2012;19th March. Downloaded from <https://www.lsnglobal.com/seed/article/5416/wine-sense-tasting-bar-is-quick-off-the-blocks> on 30/08/2015
100. Velasco C, Jones R, King S, Spence C. Assessing the influence of the multisensory environment on the whisky drinking experience. *Flavour*. 2013;2:23.
101. 119. Chen J. Tasting a flavour that doesn't exist. *The Atlantic*. 2015;21st October. Downloaded from <http://www.theatlantic.com/health/archive/2015/10/tasting-a-flavor-that-doesnt-exist/411454/> on 25/10/2015.
102. Meggiato R. The science of food smells. *Fine Dining Lovers* 2015;May 29<sup>th</sup>. Downloaded from <https://www.finedininglovers.com/stories/food-science-smell/> on 24/07/2015.
103. Yeomans MR. Olfactory influences on appetite and satiety in humans. *Physiol Behav*. 2006;87:800–4.
104. Khan RM, Luk CH, Flinker A, Aggarwal A, Lapid H, Haddad R, et al. Predicting odor pleasantness from odorant structure: pleasantness as a reflection of the physical world. *J Neurosci*. 2007;27:10015–23.
105. Neff J. Product scents hide absence of true innovation. *Advert Age* 2000;February 21:22. Downloaded from on 29/08/2015.
106. Dooley R. Sensory marketing to jolt espresso sales. November 1<sup>st</sup>, 2007. Downloaded from <http://www.neurosciencemarketing.com/blog/articles/espresso-sensory-selling.htm> on 29/08/2015.
107. Parsons A. Use of scent in a naturally odourless store. *Int J Retail Distribut Manage*. 2009;37:440–52.
108. Belasco WJ. *Meals to come: a history of the future of food*. Berkeley, CA: University of California Press; 2006.
109. Frank S, Linder K, Fritsche L, Hege MA, Kullmann S, Krzeminski A, et al. Olive oil aroma extract modulates cerebral blood flow in gustatory brain areas in humans. *Am J Clin Nutr*. 2013;98:1360–6.
110. Innes E. Could olive oil be the key to weight loss? Scientists discover even the SMELL of it can make us feel full. *DailyMail Online* 2013;15<sup>th</sup> March. Downloaded from <http://www.dailymail.co.uk/health/article-2293948/Could-olive-oil-key-weight-loss-Scientists-discover-SMELL-make-feel-full.html> on 17/08/2015.
111. Kirkova D: 'I sniffed my way thin!' Baker loses 7 STONE while still enjoying cakes (but now she just smells them instead). *Daily Mail Online* 2013;26<sup>th</sup> August. Downloaded from <http://www.dailymail.co.uk/femail/article-2402165/Baker-Lynne-Gadd-South-Wales-lost-7-STONE-sniffing-cakes-instead-eating-them.html> on 26/08/2015.
112. Walters J: Heaven-scent diet. *London Evening Standard* 2004;18<sup>th</sup> May.
113. Guinard JX, Caussin J, Campo Arribas MC, Meier J. Effect of exposure to the aroma of a preload on subsequent intake of a food with the same aroma. *J Sensory Stud*. 2002;17:351–63.
114. Rolls ET, Rolls JH. Olfactory sensory-specific satiety in humans. *Physiol Behav*. 1997;61:461–73.
115. Duclaux R, Feisthauer J, Cabanac M. Effets du repas sur l'agrément d'odeurs alimentaires et nonalimentaires chez l'homme [Effect of eating a meal on the pleasantness of food and non-food odors in man]. *Physiol Behav*. 1973;10:1029–33.
116. Fernandez P, Bensafi M, Rouby C, Giboreau A. Does olfactory specific satiety take place in a natural setting? *Appetite*. 2013;60:1–4.
117. Coelho JS, Polivy J, Herman CP, Pliner P. Wake up and smell the cookies. Effects of olfactory food-cue exposure in restrained and unrestrained eaters. *Appetite*. 2009;52:517–20.
118. de Wijk RA, Polet IA, Boek W, Coenraad S, Bult JHF. Food aroma affects bite size. *Flavour*. 2012;1:3.
119. Gernsback H. *Ralph 124C 41+*. Minnesota, MN: Fawcett Publications; 1911.

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