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EDITORIAL

CARLOS VELASCO
BI Norwegian Business School

CHARLES MICHEL
Institut Paul Bocuse

CHARLES SPENCE
University of Oxford

Gastrophysics: Current approaches and future directions

1. INTRODUCTION

What everyone seems to agree on is that the emerging science of gastrophysics, however it is defined, aims to integrate diverse perspectives on gastronomical sciences into a unified field of academic inquiry. According to Peter Barham (2013: 3):

> …gastrophysics should be to gastronomy as astrophysics is to astronomy. Astronomers observe the planets and stars, they note how they move and even predict future movements; but astrophysicists explain why the stars are where they are and how they got there, and they also supply the sound scientific basis for the whole subject.

However, where researchers clearly differ is in terms of whether their focus is on the food science, incorporating the latest insights and approaches from the physical sciences (including physics, biophysics, chemistry, etc.; see Pedersen et al. 2021) or whether instead the emphasis is placed on the behavioural sciences (including psychophysics, cognitive neuroscience, behavioural economics, anthropology, design, etc.; see Spence 2017a).

In announcing this Special Issue in the *International Journal of Food Design*, we called for investigations in the field of gastrophysics. Given the aims and scope of the journal, we were particularly interested in receiving those articles that incorporated applied insights and aspects of design. More specifically, we were interested in those works that looked to integrate food design with other disciplinary approaches, such as experimental psychology, cognitive neuroscience, design, marketing, economics, anthropology and culinary arts, among others, in the context of gastrophysical investigation.

As gastrophysics aims to expand our knowledge on the phenomena observed in relation to gastronomy, we are also interested in evidence-based solutions to urgent human and planetary health issues. Our hope is that at the intersection of science, technology and design we can foster awareness, behavioural change and inspire novel strategies for innovation in the food industry that are so urgently needed. The much-publicized EAT-Lancet report has clearly brought to the fore the urgency with which our whole approach to food needs to be redesigned (Willett et al. 2019). As such, we welcomed empirical and theoretical work, as well as case studies documenting initiatives that were relevant to the field. In the end, the call for articles attracted a broad range of submissions on everything from 3D food printing (see Caulier et al. 2020; Manstan et al. 2020; Manston and McSweeney 2020; Pérez et al. 2019; Zolfagharifard 2014), to the historical changes in 'tablescapes' (Horowitz and Singley 2004; see also Sobal and Wansink 2007, on the latter term) over the centuries and its relation to philosophical notions of 'taste' (see also Smith 2007; Visser 1991). Contributions came in from a wide variety of countries/continents hinting, perhaps, at the broad and growing interest in the field in recent years.

Four of the eight submissions to the gastrophysics Special Issue were eventually accepted for publication. We believe that the articles that eventually made it through the rigorous peer-review process highlight the vibrant and challenging (not to mention controversial) nature of the field currently. Below, we present a summary of these works, together with some reflections concerning their implications for the field.

2. ON THE MULTIPLE MEANINGS OF THE TERM 'GASTROPHYSICS'

As made clear by one of the accepted submissions (Pedersen et al. in this issue), the very term 'gastrophysics' is one that currently has at least two distinct associations/meanings amongst different researchers. According to one group of researchers, the term should be used to refer to research at the interface of gastronomy and physics (Mouritsen 2012; Mouritsen and Risbo 2013, 2015; Vilgis 2013). However, others use the term to refer to the combination of gastronomy and psychophysics (Spence 2017a, 2017b, 2018, 2020a, 2021a; Spence and Piqueras-Fiszman 2014). A closer look at this debate reveals that neither use of the term 'gastrophysics' is entirely unproblematic. The first appearance of the term 'gastrophysics' in print appears in Parker (2004), while 'gastrophysicist' is first used when referring to the eminent Hungarian-born

Oxford physicist Nicholas Kurti (Richards 1998; see also Weiss 2001). Thus, the terms very definitely emerged in relation to physics and physicists.

It is, however, important to note that linking the definition of gastrophysics so closely to food physics may be in danger of being criticized for much the same reason that molecular gastronomy (which tends to focus on food chemistry; Barham et al. 2010; Edwards-Stuart 2012; This 2009; Vega and Ubbink 2008) has been criticized; namely, that this combination of gastronomy and chemistry is nothing more than a sexy neologism for, or rebranding of, the longstanding study of food science (see Spence and Youssef 2018 for a review). Roosth (2013: 4), a professor in the History of Science at Harvard University, has described molecular gastronomy as: 'a food movement whose practitioners – chemists who study food and chefs who apply their results – define as the application of the scientific method and laboratory apparatuses [sic] to further cooking'. The same criticism could presumably equally well be applied to the use of the term 'gastrophysics' to refer to the narrow focus on the study of gastronomy through the lens of food physics. Perhaps aware of this concern, Pedersen et al. (2021), in their review, press for a much more inclusive account that goes well beyond food physics. Notice, though, that in doing so, they increasingly diverge from the original use of the term 'gastrophysics' which, they argue, is a key part of what gives their definition precedence/legitimacy.

According to Dennis Heldman (2006: 11), former Director of the Institute of Food Technologists, food science is: 'the discipline in which the engineering, biological, and physical sciences are used to study the nature of foods, the causes of deterioration, the principles underlying food processing, and the improvement of foods for the consuming public'. Meanwhile, according to the fifth edition of the *Food Science* textbook, the discipline can be defined simply as: 'the application of basic sciences and engineering to study the physical, chemical, and biochemical nature of foods and the principles of food processing' (Potter and Hotchkiss 1998: 1).

What is undoubtedly common to the combinations of gastronomy with food physics, molecular gastronomy, and the much older field of food science, is that all these fields share the same interest in trying to understand food, and flavour, through the lens of scientific analysis (see Spence and Youssef 2018 for a review). By contrast, the emphasis in the gastronomy plus psychophysics definition favoured here is very much on the mind of the person who is doing the tasting. After all, as world-leading chef Heston Blumenthal notes in his Forward to Spence's *Gastrophysics: The New Science of Eating*: 'the pleasures of the table reside in the mind, not the mouth' (Spence 2017a: xiii). The science of flavour perception, and the manifold factors that affect it, has undoubtedly largely been neglected by those interested in the field of gastronomy until very recently. What is more, while neurogastronomy (Shepherd 2012) has also developed rapidly, most of this research on the brain and flavour has been conducted within the confines of the brain scanner, and hence lacks the ecological validity that comes from testing diners in more naturalistic contexts such as restaurants, cafés and coffee shops (e.g. Spence and Carvalho 2019; Spence and Youssef 2016).

The different meanings attached to the term 'gastrophysics' are leading to confusion amongst some authors (e.g. Dunn and Sanchez 2021). Naming confusions are unfortunately widespread in the scientific literature (see also Stein et al. 2010). Furthermore, all too often in the popular press, terms such as 'gastrophysics' and 'neurogastronomy' would appear to be

used interchangeably (e.g. see Berčík et al. 2021; Robinson 2015). Ultimately, though, pronouncements by those in favour of one definition or another are unlikely to sway public opinion in the long-term, and hence it may simply be a matter of waiting to see which term gains ascendency in the court of public opinion and peer-reviewed academic literature such as represented by this journal. What is clear, though, is that in order to solve current urgent global food issues, both the food science and the psychophysics-inspired approaches to the study of gastrophysics are urgently needed.

Beyond the aforementioned debate, which is undoubtedly of interest to the field, we would like to suggest that the potential we see for gastrophysics goes much further. Inspired by this new approach to food experience, food design is, for example, one area of inquiry that has broad potential applications in the design of more enticing experiences that are more effective in *seducing* the mind of consumers, and can inspire better strategies for food innovation aiming to put forward novel ingredients and food processes. There is also an important role for gastrophysics in enhancing the provision of flavourful and nutritious food options to the growing elderly population (Spence et al. 2019; Spence and Youssef 2021).

Food education, on the other hand, is pretty much non-existent in curricula for kids and young adults in many countries (though see exceptions in France and Denmark; Trubeck 2008). How *fun* it would be to entice youngsters to learn about food – and hence, educate the more informed food consumers of the future – through the lens of gastrophysics, a unifying field of enquiry inspired by natural and social sciences applied to gastronomical enquiries. Here one might only consider the phenomenal success of the molecular gastronomy approach to studying soft matter physics organized by Harvard University over the last decade (e.g. McCafferty 2020; see also Spence and Youssef 2018).

In addition, there is a great need for science-backed decision-making in policy-making when it comes to shifting the population's consumptions towards healthier diets for both people and the planet. For instance, the EAT-Lancet Commission (Willett et al. 2019) forcefully argued that the global adoption of healthy diets is a fundamental requirement to help preserve natural ecosystems in the face of the climate crisis, and improve the health and future of billions. At the same time, however, many of the recommended changes in diet are towards the increased consumption of foods that are less sensorially appealing. One inspiring example of the potential for gastrophysics insights to support policy-makers can be found in Norden's Solutions Menu (Halloran et al. 2018).

According to Project Drawdown (DRAWDOWN 2021), coined as the 'most comprehensive plan to reverse climate change', the three most effective ways to reduce carbon emissions are (1) Reduced Food Waste, (2) Health and Education – arguably both of which are directly related to food and eating habits, and (3) Plant-Rich Diets. According to some projections, focusing on these three categories of solutions can, together, have the potential to sequester up to 240 gigatonnes of greenhouse gases by 2050 (Frischmann 2021). Implementation of strategies towards a lower-footprint food system following these verticals will need to include the combined efforts from academia, as well as both the private and public sectors. At the edge of culinary innovation today, restaurants and food labs all over the globe are hinting at new approaches to designing food experiences that generate equal amounts of pleasure while reducing the negative impact of production and service (Youssef and Spence 2021a). As we know, some of the changes that are so urgently

needed are often not the most popular as far as the consumer is concerned, hence the need for approaches that give equal importance to understanding how to generate more pleasure at a lower environmental cost, but also on strategies for behaviour change through elevating, for instance, plant-based foods (Papies et al. 2020; see also Spence 2021d).

As Pedersen et al. (2021) eloquently highlight, gastrophysics has the potential to make sustainable food more palatable and broadly accepted by connecting the fundamental mechanisms of gastronomic phenomena to design and practice, hopefully influencing in a positive way both the impact of the modern food industry and academics concerned with the field. Spence (this issue) also investigates the potential for innovative food formulation as a means of maintaining a desirable flavour profile while reducing the presence of less healthy, and potentially less sustainable, ingredients. Others, meanwhile, have been investigating the potential of virtual and augmented reality solutions to address the imminent problems of the loss of certain of our most favoured ingredients (see Robertson 2013; Spence 2017a; Spence et al. 2016; Ueda et al. 2020). Such works, note, operate more at the interface of artistic and scientific approaches to behaviour change.

Gastrophysics will need to be inspired by both food physics and food psychophysics to provide any serious insight to shifting the dietary dilemma the world is currently facing. Together, these disciplines attached to gastronomy ('gaster' stomach, and 'nomos' the study of) should cooperate in designing more sustainable and healthier foods, at all levels in the food industry (see also Scourboutakos et al. 2013). According to the World Economic Forum (WEF 2019, 2020): 'Today's food systems require a fundamental transformation to meet human needs within planetary boundaries in 2030'. Arguably, it is through the design of better food products, more convincing marketing narratives and strategies, and by educating consumers that we can be of service to support the bettering of the food landscape for humans.

3. FOOD COMPUTING AND COMPUTATIONAL GASTRONOMY

One of the areas that has grown rapidly in recent years relates to the emerging field of food computing and computational gastronomy (Min et al. 2018; Obrist et al. 2018), one strand of which concerns itself with the analysis of online content, from tweets, social media posts, online restaurant reviews, menus, recipes and, even increasingly, food images (Jurafsky et al. 2014; see Spence 2021e). There is no doubt that such approaches may increasingly come to provide insights that are relevant to both gastrophysicists and food practitioners alike.

One of the contributions to this Special Issue fits right in here. Analysing tweets over a decade from Latvia (Kāle et al. 2021), the researchers detected and analysed the frequency of collocations denoting foods and multiple sensory attributes in tweets and from this was able to infer the corresponding frequency of the sensory categories in question. Through this innovative analysis, they detected some multisensory seasonality and cultural aspects related to traditional Latvian cuisine (cf. Spence 2021b, 2021c). This innovative tool to analyse a population sentiment about popular foods, the day of the week, when they tend to be consumed, their valence, etc. could, for instance, be used to correlate eating behaviours, collective sentiments and market efforts in order to produce more effective strategies – whether through advertisement, policy-making or education – to support climate-friendly choices (lower carbon footprint, for instance) and further help and be of use to food

practitioners, as well as food marketers and advertisement (e.g. how food messages resonate in society).

The aforementioned kinds of tools can, of course, equally well be used for the purposes of digital marketing pushing, or nudging, consumers towards unhealthy patterns of food consumption. Therefore, we suggest that policy-makers and conscious business should be ahead of the curve and set a standard and reference point for technology use in the context of food.

At the same time, it is important to recognize the emerging role of computational gastronomy, otherwise known as food computing, is likely going to play in the years ahead (see Spence 2021e). A number of intriguing insights concerning our food behaviour have already emerged from the analysis of online sources of food-related data (see Arellano-Covarrubias et al. 2019). There is also a rich vein of research in human-computer interaction focused on food, namely, human-food interaction research (e.g. Altarriba Bertran et al. 2019; Choi et al. 2014; Velasco et al. 2018). At one extreme, this starts to intersect with future solutions to helping deliver social dining solutions for those who may need assistance (see Spence et al. 2019).

4. ON THE OPTIMAL DESIGN OF MULTISENSORY FOOD EXPERIENCES

A third contribution to this Special Issue from one of the editors (Spence) focuses on the question of how to optimize the design of foods and/or food consumption experiences, as seen through the lens of food rituals and other stereotypical food behaviours. Here, though, an absence of relevant evidence is highlighted concerning the question of whether the manner, or way, in which consumers choose to consume typical food and beverage products, such as semi-covered chocolate biscuits, or asymmetrically seasoned Pringles potato chips affect the multisensory flavour experience. Looking to the future, as the population is slowly nudged towards consuming more algal cuisine (Mouritsen 2012), and legume-based proteins (Nasrabadi et al. 2021), building on the insights from some of the world's leading food brands/producers (see Nestle 2013; Spence 2017a) is likely going to be key to building consumer acceptance in the long-term (see also Cadario and Chandon 2019; Purnhagen et al. 2016).

A fourth contribution to this Special Issue, from Thompson-Bell and colleagues (Thompson-Bell 2021) explored the developing of a cross-domain model for multisensory artistic practice linking food and music, through an artistic project entitled 'Unusual ingredients'. In particular, the authors forwarded a model for multisensory artistic practice, together with a taxonomy of cross-domain creative strategies that capitalized on the identification of sensory affordances in the domains of food and music. The authors proposed that multisensory artistic works can support extended forms of sensory awareness by blending stimuli across domains, in order to develop novel sensory relationships. This article, then, provides an example, of the increasingly fruitful art/science crossover that was mentioned earlier.

5. CONCLUSIONS: ON THE FUTURE OF FOOD DESIGN

Given the growing interest in sustainability across all sectors of food design (Deng et al. 2021; Spence 2020b), it was a shame not to receive more submissions on this important and current topic, beyond the discussion of jellyfish in Pedersen et al.'s article. Nevertheless, that undoubtedly remains an area close

to your editors' hearts, especially for chef Charles Michel. The other editors' of this Special Issue have also been active in trying to understand those gastrophysical factors that may help nudge consumers towards alternate, and more sustainable, sources of food, be it jellyfish (see Youssef et al. 2019, on the multisensory experiential design approach), leafy greens (see Spence 2020a, for a review) or insects (see Deroy et al. 2015; Motoki et al. 2020; Park et al. forthcoming; Youssef and Spence 2021b; cf. Legendre and Baker 2021).

A number of researchers have now started to turn their attentions to evaluating the role of nudges, value orientation, and information provision on motivating sustainable food choices (e.g. Campbell-Arvai et al. 2014; cf. Thaler and Sunstein 2008). Clearly, evidence from the EAT-Lancet report (Willett et al. 2019) highlights the urgent need for the world's population to radically change its diet, be it to promote individual health and well-being and/or global sustainability. The COVID-19 pandemic has, of course, also thrown up its own challenges (and, on occasion, opportunities) for the food industry (Plata et al. 2021; see Spence et al. 2021 for a review).

Here, it is perhaps interesting to note that while scientists may make the pronouncements about what consumers should do, the evidence suggests that the latter are largely immune to such information/instruction. As such, it becomes increasingly important to work with food design and food education, be it the creatives of the kitchen (i.e. chefs, food artists or food designers), higher education (cookery schools and innovative approaches for kids and young adults) and other industries, in order to try and encourage the consumer to eat differently. Our thinking in this space may be facilitated by a more ludic, or playful, approach to food (Altarriba and Wilde 2018; Stummerer and Hablesreiter 2019; Wang et al. 2019). At the opposite extreme, food reformulation strategies may help to reduce the need for unhealthy ingredients in our foods (see Anon. 2016).

While food science is undoubtedly a part of the solution (as highlighted by Pedersen et al.'s submission), it is our firm belief that food design and culinary artistry also constitute another crucial element. As but one example of the latter, we would point to the collaboration between creative chef and food scientist (or, if you will, gastrophysicist) that led to the 'Taste of Kandinsky' dish (Michel et al. 2014). This represents an intriguing approach to 'nudging' diners (or, for instance, neophobic kids in an educational context) towards eating more vegetables and leafy greens. Furthermore, the concept of 'visual hunger' could be leveraged by policy-makers to drive a population's cravings beyond the high-fat, high-sugar gastroporn or food porn (see Spence et al. 2016).

Regardless of the success of importance of such examples, it would seem clear that there is a rich vein of research at the interface of gastronomy, food design and gastrophysics (e.g. Chen et al. 2018; Fooladi 2020; Fooladi et al. 2018; Hopia and Fooladi 2019; Mesz and Tedesco 2021; Michel et al. 2015; Velasco et al. 2016; Wang et al. 2019). It is perhaps also worth noting how the research has highlighted the value of creativity to food consumers (e.g. Reinoso Carvalho et al. 2015; Roque et al. 2018). Indeed, according to research from Reinoso Carvalho and colleagues, people rated a chocolate as tasting better when accompanied by a matching piece of music if they believed that the music had served as inspiration for the chocolate's creation than if they were told that, according to science, the combination was meant to be particularly good. That said, while diners appreciate creativity on the plate, that does not necessarily mean that they are always willing to pay for it (see Roque et al. 2018; Rowley and Spence 2018; Velasco et al. 2016; see Spence 2019 for a review).

Whilst the field of gastrophysics is still relatively new, it is possible to see that it is already producing much interesting and relevant research, as well as promoting a number of healthy discussions across the food chain. It is our earnest hope that this Special Issue may help to inspire further much-needed debate as well as inspiring new research in the field.

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CONTRIBUTOR DETAILS

Carlos Velasco is an associate professor at the Department of Marketing, BI Norwegian Business School (Norway), where he co-founded the Centre for Multisensory Marketing. He also holds a research fellowship at the SCHI Lab, Sussex University (United Kingdom). Carlos received his D.Phil. in experimental psychology from Oxford University. He works at the intersection between psychology, marketing and human–computer interaction, and focuses on understanding, and capitalizing on, our multisensory experiences and their guiding principles. Carlos has worked with a number of companies from around the world on topics such as multisensory experience design, food and drink, branding and consumer research. For more information, visit https://carlosvelasco.info/.

Contact: Department of Marketing, BI Norwegian Business School, Nydalsveien 37, 0484 Oslo, Norway.
E-mail: carlos.velasco@bi.no

https://orcid.org/0000-0002-4864-2315

Charles Michel works at the intersection of food education and food activism. He connects art, gastronomy, psychology, crossmodalism, human-centred design, theory of change and ritual to catalyse communities and foster human development. He was recently selected as 'one of the best chefs in the world' to participate in Netflix's Global Culinary Competition 'The Final Table'. He has published a number of articles in peer-reviewed academic journals on multisensory science as 'chef-in-residence' of the Crossmodal Research Laboratory, University of Oxford. He has collaborated on a variety of projects inspired by gastrophysics such as multisensory VR experiences,

immersive crossmodal art, consulting for high-end hospitality and designing food products for markets. He is co-founder of *Michel/Fabian*, a design studio looking at the future of cutlery, has worked with the World Food Programme in Colombia, and teaches culinary leadership, sensorial exploration and transformational hospitality at the Institut Paul Bocuse in Lyon. Michel has given over 50 talks on the future of food and eating, including at venues such as The Royal Society with Professor Brian Cox, The Royal Institution, TEDxHackney, TEDxMogadishu and TEDxBucharest, amongst others. Charles aims to inspire solutions for important challenges in the relationship between humans, food and environmental challenges. For more information, visit www.charlesxmichel.com.

Contact: Institut Paul Bocuse, Château du Vivier, 1A Chemin de Calabert, 69130 Ecully, France.
E-mail: contact@charlesxmichel.com

https://orcid.org/0000-0002-2040-4518

Charles Spence is the head of the Crossmodal Research Laboratory, Department of Experimental Psychology, University of Oxford. He is interested in how people perceive the world around them. His research focuses on how a better understanding of the human mind will lead to the better design of multisensory foods, products, interfaces and environments in the future. Charles has been awarded the 10th Experimental Psychology Society Prize, the British Psychology Society: Cognitive Section Award, the Paul Bertelson Award, recognizing him as the young European Cognitive Psychologist of the Year, and the prestigious Friedrich Wilhelm Bessel Research Award from the Alexander von Humboldt Foundation in Germany, not to mention the 2008 IG Nobel prize for nutrition, for his groundbreaking work on the 'sonic crisp'. Professor Spence has published more than 1000 academic articles over the last couple of decades and edited or authored fifteen books including, in 2014, the Prose Prize-winning *The Perfect Meal* (2014, Wiley-Blackwell), and the international bestseller *Gastrophysics: The New Science of Eating* (2017, Penguin Viking) – winner of the 2019 Le Grand Prix de la Culture Gastronomique from Académie Internationale de la Gastronomie. His latest book *Sensehacking* (2021, Penguin Viking) was published in January 2021.

Contact: Department of Experimental Psychology, Anna Watts Building, University of Oxford, Oxford, OX2 6BW, UK.
E-mail: charles.spence@psy.ox.ac.uk

https://orcid.org/0000-0003-2111-072X