Brain and Cognition 110 (2016) 53–63

Contents lists available at ScienceDirect

Brain and Cognition

journal homepage: www.elsevier.com/locate/b&c

Eating with our eyes: From visual hunger to digital satiation

Charles Spence [a,*], Katsunori Okajima [b], Adrian David Cheok [c], Olivia Petit [c], Charles Michel [a]

[a] Crossmodal Research Laboratory, Oxford University, UK
[b] Yokohama National University, Japan
[c] Imagineering Institute, Malaysia

ARTICLE INFO

Article history:
Received 26 May 2015
Revised 23 August 2015
Accepted 24 August 2015
Available online 1 October 2015

Keywords:
Vision
Food intake
Visual hunger
Virtual
Gastrophysics
Food aesthetics
Technology
Digital
Behaviour
Food porn
Gastroporn
Cognition

ABSTRACT

One of the brain's key roles is to facilitate foraging and feeding. It is presumably no coincidence, then, that the mouth is situated close to the brain in most animal species. However, the environments in which our brains evolved were far less plentiful in terms of the availability of food resources (i.e., nutriments) than is the case for those of us living in the Western world today. The growing obesity crisis is but one of the signs that humankind is not doing such a great job in terms of optimizing the contemporary food landscape. While the blame here is often put at the doors of the global food companies – offering addictive foods, designed to hit 'the bliss point' in terms of the pleasurable ingredients (sugar, salt, fat, etc.), and the ease of access to calorie-rich foods – we wonder whether there aren't other implicit cues in our environments that might be triggering hunger more often than is perhaps good for us. Here, we take a closer look at the potential role of vision; Specifically, we question the impact that our increasing exposure to images of desirable foods (what is often labelled 'food porn', or 'gastroporn') via digital interfaces might be having, and ask whether it might not inadvertently be exacerbating our desire for food (what we call 'visual hunger'). We review the growing body of cognitive neuroscience research demonstrating the profound effect that viewing such images can have on neural activity, physiological and psychological responses, and visual attention, especially in the 'hungry' brain.

1. Introduction: The brain and food

It was Apicius, the 1st Century Roman gourmand (see Apicius, 1936), who purportedly coined the phrase "*We eat first with our eyes*" (Delwiche, 2012). Nowadays, a growing body of evidence from the cognitive neurosciences is revealing just how true this aphorism really is (e.g., see Van der Laan, De Ridder, Viergever, & Smeets, 2011, for a review). By allowing early life forms to probe and sense their environments at ever greater distances (that is, by allowing them to perceive those stimuli situated in extrapersonal space), eyes, and the visual systems that those eyes feed into, evolved in order to increase a species' chances of survival, by enhancing the efficient detection of energy (food) sources, or nutriments, from within a given environmental niche (e.g., Allman, 2000; Gehring, 2014).

Foraging – the search for nutritious foods – is one of the brain's most important functions. In humans, this activity relies primarily on vision, especially when it comes to finding those foods that we are already familiar with (see also Laska, Freist, & Krause, 2007). In fact, it has been suggested that trichromatic colour vision may originally have developed in primates as an adaptation that facilitated the selection of more energy-rich (and likely red) fruits from in-amongst the dark green forest canopy (e.g., Bompas, Kendall, & Sumner, 2013; Regan et al., 2001; Sumner & Mollon, 2000). Certainly, a complex interplay of animal signalling designed to capture the attention (often visual) of pollinators and/or repel predators has been a central part of the co-evolution of both the visual systems of animals and the colouration schemes utilized in both the animal and plant kingdoms (e.g., see Barth, 1985; Cott, 1940; Poulton, 1890; Rowe & Skelhorn, 2005; Schaefer & Schmidt, 2013).

Finding nutritious sources of food is undoubtedly essential for human well-being, an activity where vision plays a central role, one that is mediated by the attentional, pleasure, and reward systems, as well as by complex physiological cycles of hunger

Abbreviations: SOA, stimulus onset asynchrony; OFC, orbitofrontal cortex; BMI, body-mass index; EFS, external food sensitivity; AR, augmented reality; VR, virtual reality.

* Corresponding author at: Department of Experimental Psychology, University of Oxford, Oxford OX1 3UD, UK.

E-mail addresses: charles.spence@psy.ox.ac.uk (C. Spence), okajima@ynu.ac.jp (K. Okajima), adrian@imagineeringinstitute.org (A.D. Cheok), oliviapetit@imagineeringinstitute.org (O. Petit).

http://dx.doi.org/10.1016/j.bandc.2015.08.006
0278-2626/

(e.g., Berthoud & Morrison, 2008; Kringelbach, Stein, & van Hartevelt, 2012; LaBar et al., 2001; Masterson, Kirwan, Davidson, & LeCheminant, 2015; Shin, Zheng, & Berthoud, 2009; Van den Bos & de Ridder, 2006). It should come as no surprise, then, that the visual appeal exerts an important influence on the overall pleasure that food elicits (e.g., Hurling & Shepherd, 2003; Spence & Piqueras-Fiszman, 2014).[1]

2. The hungry brain

That the vast majority of animal species have evolved a mouth that is situated close to their brain is presumably no coincidence; As the famous British scientist J.Z. Young (http://en.wikipedia.org/wiki/John_Zachary_Young) once put it: "*The fact that the brain and the mouth are both at the same end of the body may not be as trivial as it seems.*" (Young, 1968, p. 22). In fact, some have taken this observation to suggest that the brain may have evolved in animals as the gut's means of controlling its nutrient intake, and by so doing, increasing the chances of survival and reproduction (e.g., Allman, 2000). Put another way, by determining which nutritious foods to accept (that is, to ingest) and which potentially harmful (e.g., poisonous) foodstuffs to avoid or reject (Piqueras-Fiszman, Kraus, & Spence, 2014), the mouth may ultimately have played an important role in guiding cortical development (e.g., Allman, 2000). Once again, it was J.Z. Young who captured the idea in the opening sentences of one of his papers: "*No animal can live without food. Let us then pursue the corollary of this: Namely, food is about the most important influence in determining the organization of the brain and the behavior that the brain organization dictates.*" (Young, 1968, p. 21).

The brain is the body's most energy-consuming organ, accounting for somewhere in the region of 25% of blood flow, or rather, 25% of the available consumed energy (e.g., see Wenk, 2015, p. 9; Wrangham, 2010). Note that this figure is even higher in the newborn human, where the brain absorbs up to two thirds of the energy that is consumed by the developing organism. As Brown notes: "*In embryos, the first part of the neocortex to develop is the part which will represent the mouth and tongue*..." As the brain grew in size over the course of human evolution, the demands on the visual system to efficiently locate nutrients in the environment would likely also have increased.[2]

It is undoubtedly the case that the food landscapes inhabited by those of us living in the western world today are very different from those that our ancestors had to deal with; In particular, the human brain evolved during a period when food was much scarcer than it is now (Caballero, 2007), and it would appear that our genetic make-up still seemingly drives us toward consumption whenever food is readily accessible (e.g., Marteau, Hollands, & Fletcher, 2012; Pinel, Assanand, & Lehman, 2000; Wenk, 2015). It could well be argued that 'visual hunger' – a concept that we define here as a natural desire, or urge, to look at food – could well be an evolutionary adaption: Our brains learnt to enjoy seeing food, since it would likely precede consumption. The automatic reward associated with the sight of food likely meant another day of sufficient nutrients for survival, and at the same time, the physiological responses would prepare our bodies to receive that food. Our suggestion here is that the regular exposure to virtual foods nowadays, and the array of neural, physiological, and behavioural responses linked to it, might be exacerbating our physiological hunger way too often. Such visual hunger is presumably also part of the reason why various food media have become increasingly successful in this, the digital age.

Before discussing the potential role of visual hunger in public health, we take a brief look at the evidence suggesting that the exposure to appetizing images of food (the majority of which are presented digitally, and hence in a unisensory manner) is becoming an increasingly important source of enjoyment for many people in society today (e.g., see Prince, 2014; Spence, 2015, for a recent commentary). We then take a look at the evidence from the cognitive neurosciences highlighting the effect that viewing food images has on both the physiological and neural levels.

3. Virtual food for hungry eyes

The last 50 years or so have seen a widespread growth in the popularity of various culinary practices, as well as the rise of the celebrity 'chef' (Hansen, 2008). This has led to an inevitable exposure to visually succulent cooking procedures and beautifully-portrayed dishes, often making use of foods that are less than healthy.[3] Every day, it feels as though we are being exposed to ever more appetizing (and typically high calorie) images of food, what some (perhaps pejoratively) call 'gastroporn'[4] or 'food porn' (McBride, 2010; http://en.wikipedia.org/wiki/Food_porn).[5] Moreover, the shelves of the bookstores are increasingly sagging under the weight of all those cookbooks filled with high-definition and digitally-enhanced food images (Spence & Piqueras-Fiszman, 2014; see Myhrvold & Young, 2011, for one particularly spectacular example). It has been suggested that those of us currently living in the Western world are watching more cookery shows on TV than ever before (Bellman, 2004; de Solier, 2005; Prince, 2014; Ray, 2007). Such food shows often glamorize food without necessarily telling a balanced story when it comes to the societal, health, and environmental consequences of excess consumption (Caraher, Lange, & Dixon, 2000; Ketchum, 2005; Meister, 2001). Moreover, the number of hours of TV a person watches is positive correlated with their body-mass index (BMI; see Boulos, Vikre, Oppenheimer, Chang, & Kanarek, 2012).[6] Indeed, laboratory studies have shown that watching food-related TV programs can affect people's patterns of energy intake from a given set of available foods (Bodenlos & Wormuth, 2013). It also leads to an increased consumption of calories in the food that people end

[1] While the appearance of food is not itself a primary reinforcer, food images may acquire such positive properties through Pavlovian-Instrumental Transfer (e.g., see Talmi, Seymour, Dayan, & Dolan, 2008). Note also that the exposure to familiar food images is likely to result in cognitive processes such as the retrieval of relevant memories and hedonic evaluations that have been stored during the previous exposure(s) to, and experiences with, the food in question (e.g., Berthoud & Morrison, 2008; Shin et al., 2009).

[2] Though, of course, mention should also be made here of Wrangham's (2010) intriguing suggestion that the introduction of fire (cooking) would have dramatically increased our ancestors food-related energy efficiency, by allowing them to spend less time foraging, chewing, and digesting. *Homo erectus* would thus have developed a smaller, more efficient digestive tract which would have freed up more energy, thus enabling further brain growth (see also Aiello & Wheeler, 1995).

[3] Howard, Adams, and White (2012) found that TV chefs' recipes were higher in fat, saturated fat, and sodium than recommended by the World Health Organization's nutritional guidelines.

[4] This term, which has now made its way into the Collins English Dictionary, is defined as '*the representation of food in a highly sensual manner*'. The term was first introduced by Alexander Cockburn, in a 1977 article that appeared in the *New York Review of Books*, and was used to emphasize on the visual appearance of food (see Poole, 2012, p. 59).

[5] According to one commentator, the contemporary concern with the presentation of food can be traced back to the early 1970's, with the simultaneous emergence of food photography and food media: "*Really, the concern with how the food looked can be traced back to the emergence of nouvelle cuisine. The pictures of these dishes have set themselves in the mind of the public. Nouvelle cuisine was essentially photogenic*... *Think of the glorious coloured photographs of these dishes, which have become eponymous with the purveying of recipes.*" (Halligan, 1990, p. 121; see also Smart, 1994). In terms of the food porn on TV, Ray (2007) describes it as occurring "*when we imagine cooking and eating while watching other people actually doing it*". Others describe it as 'foodatainment' (Finkelstein, 1999).

[6] Pinel et al. (2000, p. 1112) put it thus: "*From the perspective of our evolutionary analysis, the reason humans living in modern industrialized societies tend to overeat is that the presence, the expectation, or even the thought of food with a high positive-incentive value promotes hunger.*"