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Flavour

REVIEW Open Access

Constructing flavour perception: from destruction to creation and back again

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Abstract

We review the evidence suggesting that the bistable/multistable percepts that exist in the so-called higher senses of vision, audition, and touch do not seem to occur in the chemical senses (e.g. taste, aroma, and flavour). While we can undoubtedly be mistaken about our interpretation of chemical stimuli and while certain aromas/flavours do support multiple 'correct' interpretations, the perceptual switches occur only rarely rather than repeatedly. In fact, the interpretational changes that chemical stimuli occasionally undergo seem to have more in common with the phenomenon of the Gestalt principle of 'emergence' than with multistable perception. We highlight a number of potential differences in information-processing/attention between the senses that may underpin such perceptual differences. Finally, we describe a new dish created by chef Jozef Youssef in order to illustrate the concept of emergence and support discussion of the theme of gastronomy, just like art, as a matter of interpretation. The Picasso dish was served recently at the Gastrophysics dining concept delivered by Kitchen Theory in London.

Keywords: Bistable/multistable perception, Emergence, Perceptual organization, Information processing, Taste, Aroma, Flavour

Review

Introduction: cooking as a creative act of destruction

As Pablo Picasso once memorably said: '*Every act of creation is first an act of destruction.*'[1] And nowhere is this truer than in the kitchen; after all, cooking very often involves first an act (or, more likely, acts) of destruction, the death of the animal, the dissection of the product[2] etc. Modernist cuisine, note, often deliberately chooses to separate the elements and sometimes intentionally leaves them that way (e.g. [46, 88]).[3] Even the language of the kitchen is all about 'pounding', 'beating' etc., the ingredients, expressions and descriptions that can be seen as both macho and aggressive (e.g. [33, 72]). Normally, however, the deliberate acts of destruction that take place in the kitchen eventually lead to the next act of creation—that is, the dish placed before the expectant diners sitting there at the table. In the latter case, the processed ingredient(s) is/are used by the chef as a component in their culinary creation. This transformation is aimed at producing an outcome that is both aesthetically pleasing to the senses and satiating for their diners (see [44]).

All this before the next cycle of destruction is initiated as the diner tucks into their food. A situation that is captured perfectly by the following description of one of food artist, Sean Rogg's, beautifully prepared dishes: '*The chef was no doubt an artist, and the food no doubt art, but there was an unsettling realization: no matter how beautiful the food, it had to be destroyed in order to be eaten.*' [45]. But, in that second cycle of destruction, there is, of course, yet another act of creation waiting to occur: For perception, and that includes the diner's belief concerning, and experience of, that which they are about to eat, is always an act of construction.

Perception as an act of construction

Indeed, as stressed by the famous British psychologist, Richard Gregory, perception is, at heart, a matter of hypothesis generation and prediction (e.g. see [28]). That is, our brains take the various external cues, derived from each of the senses, and attempt to reconstruct what the world out there is really like (here, just think of the diner sitting at the table trying to figure out what exactly is on the plate, or in their mouth). Of course,

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normally, it does not feel that way to us. Rather, it feels as though we know what we perceive and that does not change over time. And yet there are stimuli that highlight the brain's workings, generating predictions and, on occasion, changing what we perceive 'on the fly', as it were. While most of the work in this area has involved vision (and to a lesser extent audition and touch), as gastrophysicists are interested in multisensory flavour perception, one can certainly ask whether or not similar phenomena cannot also be demonstrated/experienced in the case of the chemical senses as well. After all, is not flavour perception one of the most multisensory of our experiences, potentially involving, as it does, the combination of inputs from all of the human senses (see [79])?[4] As a number of psychologists and cognitive neuroscientists have noted in recent years, the brain creates, or constructs, multisensory flavour perception (e.g. [65, 66, 70, 78]). However, before getting to the hypothesis generation that lies at the heart of multisensory flavour perception, let us take a look at some of the intriguing examples demonstrating the brain's construction of our perceptual experience that have been reported in the so-called higher senses of vision, hearing, and touch.

On the psychology of bistable/multistable perception

Take a look at Fig. 1a. What do you see? For most people, this simple line drawing from psychologist Roger Sheperd is consistent with one of two possible interpretations: Either people see a martini (with an olive) or else they report seeing the lower half of a woman wearing a bikini (and her belly button; [61]). However, if you keep staring at the image, you should hopefully be able to 'see' both interpretations; not at the same time, mind you, but one after the other. And knowing about the two possible 'readings' of this particular image, your interpretation of what exactly it is that you are looking at may well flip back-and-forth over time.

Next, take a look at the Necker cube shown in Fig. 1b. This crystal structure, first drawn by the geologist Ernst Necker in an article published back in 1832, constitutes another example of bistable perception [47]. What do you see? An outline of a wire cube (or crystal), right? However, this visual stimulus can also be interpreted in one of two ways—sometimes with one corner appearing to poke out of the image and at other times seeming to recede to the back of the figure instead. Now, as you keep staring at the figure, you may well find that the alternative interpretations pop into your consciousness (once again, not both at the same time, but one after the other). And, as you keep staring at the image, your perception will most likely alternate back-and-forth.[5]

Psychologists have conducted research to measure the frequency with which such spontaneous reversals take place find that the Necker cube spontaneously oscillates back-and-forth every 2.5–3.0 s or so, on average (see [53], pp. 55–58). It has been argued that this form of spontaneous, or involuntary, reversal provides evidence for the existence of competing representations in the visual system vying for dominance during perception. In fact, this is but one of the pieces of evidence that Richard Gregory and others have put forward in order

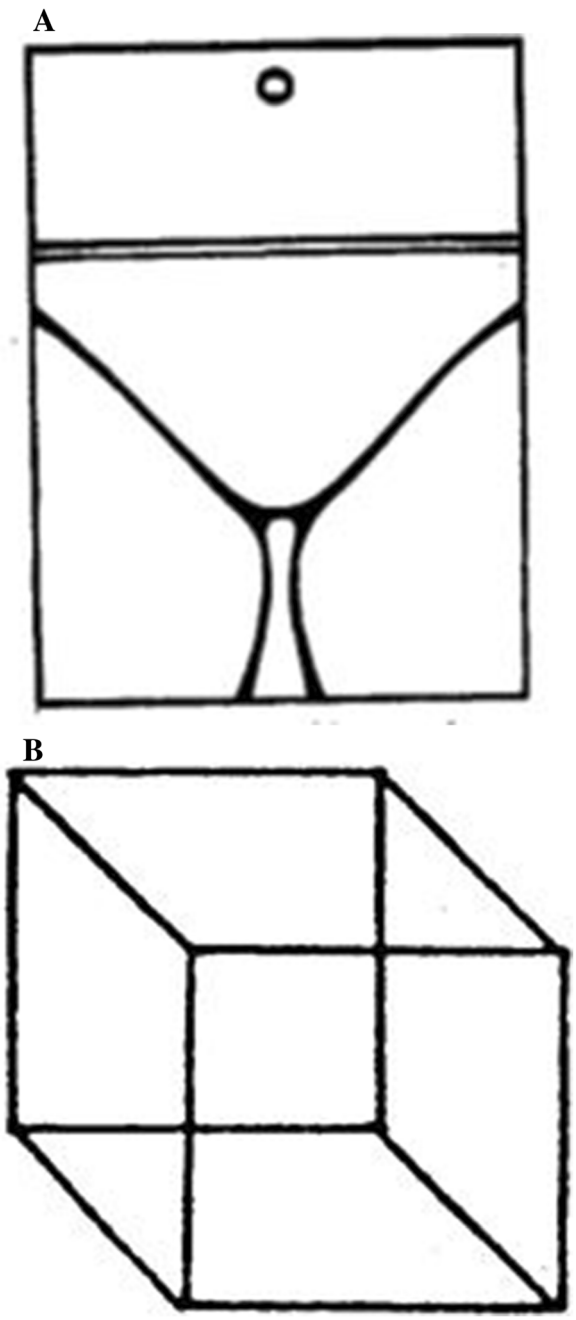

Fig. 1 **a** The bikini-martini illusion. Both interpretations are possible. This 'classic' bistable figure from Roger Shepard [61]. **b** The Swiss naturalist Ernst Necker first recognized the bistable nature of this crystal that he drew back in 1832 [47]

to support their argument that perception should be viewed as a process of active hypothesis generation, rather than merely of the passive interpretation of the incoming sensory signals (see also [35]).

There are, in fact, many such bistable visual stimuli. Examples that one finds commonly referred to in the psychology literature include the duck/rabbit and the chef puppy.[6] Intriguingly, a subset of visual stimuli has been reported that can actually have more than two interpretations; such stimuli are referred to as multistable (e.g. see [5, 55]). While it is certainly true that bistable, or multistable, perception has most often been reported in the visual modality, such phenomena are by no means restricted to this sense. Numerous examples of bistability have, for example, also been reported in the auditory and tactile modalities as well (e.g. see [8, 23, 84]).

So, for example, in the case of audition, if a sequence of lower-pitched sounds is presented to one ear and a sequence of higher-pitched sounds to the other, then at low rates of stimulus presentation, people perceive a single sound source moving back-and-forth between their ears. However, as the rate of stimulus presentation increases, there comes a point at which the streams segregate and people now report hearing a low-pitched sound source in one ear and a separate higher-pitched sound source in the other [9, 43, 49, 80, 81]. There exists a range of presentation rates at which the same auditory stimuli can be perceived in either way (see [77], for a review). Crucially, the research suggests that in this region, people's perception will tend to flip back-and-forth spontaneously.

As far as touch is concerned, researchers have taken bistable apparent motion quartets and demonstrated that they also occur on the skin surface when presented at the appropriate, though likely differing, rate from vision (e.g. [11]; see also [23]). Although less frequently studied, there has been a recent growth of interest in bistable/multistable perception in the multisensory case as well (e.g. [10, 36, 59, 60]; see [69], for a review).[7]

To summarize, what we have seen so far: Numerous examples of bistable, or, on occasion, multistable, perception have been reported in the literature, over the last century or so. They have been demonstrated in vision, in hearing, and in touch; they even occur in the case of multisensory perception. One characteristic of such stimuli is that they flip back-and-forth spontaneously. It is at this point, then, that one can ask: '*What about the chemical senses? Do similar perceptual phenomena exist there? That is, are there bistable/multistable tastes, aromas, or even flavours?*'

Multiple interpretations of stimuli in the chemical senses

Rozin [58] was perhaps the first to highlight the disappointment that so many coffee drinkers have experienced on tasting a cup of coffee that initially smelled great but somehow just did not seem to deliver when we took the first taste. Of such experiences, one can certainly say that they really seem to change between two different interpretations over time—the orthonasal sniff just much more pleasant than the retronasally experienced flavour. According to some researchers, these alternative responses may well be mediated by whether the olfactory stimulus is perceived via the orthonasal or retronasal routes.[8]

Alternatively, one might think of classic modernist dishes, such as Heston Blumenthal's beetroot and orange jelly (e.g. see [7]). On initial visual inspection, and even on first tasting this dish, most diners are led by their eyes into believing that the purple-coloured jelly is beetroot-flavoured whereas the orange-coloured jelly must be orange-flavoured (see Fig. 2). However, in this case, the colours are actually deliberately misleading.[9] The idea being that hopefully at some point in tasting the dish, the inversion of the normal colour-flavour relation is finally realized. Sometimes this requires the waiter to come back to the table and ask the diner whether they were paying attention and had started with the orange-flavoured as suggested. The waiter might perhaps suggest that the diner tries closing their eyes and tasting from the two sides of the dish again. At that point, a reversal takes place (see [52, 72] on the notion of surprise and disconfirmation of expectation in modernist cuisine).

Fig. 2 The 'beetroot and orange jelly' as served at The Fat Duck restaurant in Bray a few years ago. This represents a classic example of hidden sensory incongruity (see [52]). Heston Blumenthal ([7], p. 237) had this to say: "A new sensory experience or additional piece of information, however, can jog the brain out of this state and give it the opportunity to find a new attractor state and new viewpoint. Our brain assesses the food we eat and makes a best guess as to what it is according to the sensory inputs it receives. As Orange and Beetroot Jellies show, this approach isn't always accurate. I had always hoped to create a dish that didn't just surprise diners but made them flip between different sensory perceptions, jogging the brain into new attractor states." [Picture coutersy of Heston Blumenthal / Lotus PR.]

In this case, it is not that people forget their former beliefs; they most certainly still remember what they thought only a moment earlier. It is just that now, their perception of the taste of the dish is fixed on the actual flavour, not on their former illusory beliefs based on the misleading colours of the jellies. However, the interesting thing to note here is that once the diners have ascertained the correct colour-flavour combination, it is not clear that they are able to switch back and perceive the dish in the way they had originally (i.e. just a moment ago). In other words, the beetroot and orange flavours do not switch back-and-forth as the diner continues to sample the dish, in the way that they so obviously do in the case of the bistable visual figures shown in Fig. 1. (As far as we are aware, nowhere in the literature on the chemical senses do you find evidence of spontaneous reversals occurring in perception.) It can be argued that when our perception changes from one state (or interpretation) to another, without the possibility of returning to the prior state, then it is more like 'emergence' than bistable, or multistable, perception (see below, for more on the phenomenon of 'emergence'). Bistable/multistable percepts flip back-and-forth over time, whereas dishes like the beetroot and orange jelly do not; there is more of a unidirectional change in the diner's experience. In the visual case, there are two 'correct' interpretations. By contrast, in the beetroot and orange jelly case, there is one clearly erroneous interpretation, and one correct one.[10]

In his classic 1982 paper, Rozin also pointed to another example of an odour that can have multiple interpretations (once again, one pleasant and the other not). This is an example that many others have subsequently also researched. In this case, the chemosensory stimulus is isovaleric acid; a smell that can either be interpreted as ripe French cheese or else remind one more of a sweaty teenager's trainer (see also [16, 17, 31]). There is also benzaldehyde, an aroma that is reminiscent of both cherry and almond (see [14], for psychophysical research using this odorant). Depending on the sensory cues that are provided, people may spontaneously identify the aroma as either cherry or as almond. Normally, it is then possible to get people to recognize the other interpretation given a verbal (or other) prompt. However, it is also true to say that even when people recognize both interpretations of this aroma, then they tend to settle on one flavour, or aroma, interpretation, and they do not spontaneously report that at one moment in time it smells like cherry and the next that it smells like almond. Notice how, in both of the cases just mentioned, the two alternative interpretations of the aroma are both potentially 'correct'.

Do bistable/multistable percepts occur in the chemical senses?

In terms of basic taste, there is an oft-documented confusion between the descriptors 'sour' and 'bitter' (e.g. [6, 32, 50]). A number of studies from the field of sensory science have, over the years, noted that some people often seem to choose the attribute 'sour' in order to describe what is actually a bitter-tasting solution (e.g. consisting of PROP or PTC).[11] And yet, in this case, the descriptions make it sound as though people perceive it as one thing or the other. Their perception of the taste, once again, does not switch back-and-forth in anything like the same way as it does for the other, higher, senses (of vision, hearing, and touch).[12]

There are also potentially relevant genetic differences, such as selective anosmias, that can give rise to multiple different responses concerning perceived flavour, or aroma of compounds such as cilantro/coriander and androstanol, resulting from the stimulation of the chemical senses. However, in these cases, people are genetically predisposed to one interpretation versus another and have no possibility of switching spontaneously between interpretations (e.g. [20, 42, 56, 87]).

Why might bistable/multistable percepts not occur in the chemical senses?

If the claim that bistable/multistable percepts do not occur in the chemical senses turns out to be true, as hypothesized here, then one might well ask the question of why this should be so? Is there some fundamental difference in mental chronometry between the chemical senses and the other, so-called, higher senses (of vision, audition, and touch)? Or could it be that the bottom-up contribution to perception is simply much richer (and hence more capable of sustaining multiple different interpretations) in the case of vision and the other higher senses than it is for the chemical senses? Alternatively, it might be that attention switches too slowly between stimuli or interpretations when it comes to the chemical senses?[13] There is evidence from a number of sources that is consistent with each of these suggestions.

Across a range of different metrics, it turns out that far more of the brain's computational resources are given over to the processing of information in the higher senses, especially vision, and to a lesser extent audition and touch, than to the chemical senses (see Table 1). The much smaller percentage of primary sensory cortex (and lower apparent potential for attentional capture etc.) devoted to the processing of chemical stimuli might somehow mean that there is simply insufficient computational power to compete with any top-down interpretations of what is being perceived in the case of the chemical senses (see [35]). In particular, several lines of evidence converge on the suggestion that bottom-up input is simply not rich/strong enough to compete with the top-down interpretation.

One other potentially relevant factor here concerns the speed at which we can shift our covert attention between stimuli (or between different interpretations of the same stimuli). Researchers have measured the speed with which people can shift their attention between the

Table 1 Table summarizing the number of sensors, number of afferents, information transmission rates/channel capacity (from [89]), % of attentional capture (from [30]) and % of neocortex [21] relative to each sensory modality. Reprinted from Gallace et al. [24]

Sensory system	N. of sensors	N. of afferents	Channel capacity (bits/s)	Psychophysical channel capacity (bits/s)	% attentional capture	% neocortex
Vision	2×108	2×10^6	10^7	40	70	55
Audition	3×10^4	2×10^4	10^5	30	20	3.4
Touch	10^7	10^6	10^6	5	4	11.5
Taste	3×10^7	10^3	10^3	1(?)	1	0.5
Smell	7×10^7	10^5	10^5	1(?)	5	n.a.

senses. In terms of the spatial senses of hearing, vision, and touch, it turns out that touch is, in some sense, 'sticky', that is, covert shifts of attention (see [68]) to/from the tactile modality are simply much slower than between audition and vision, say (see [34, 74]).[14] When researchers have measured the speed of attention-shifting from smell to vision, it does indeed appear to be slower than for the other senses ([73, 75, 76]).[15] There has been some attempt to measure attention switches involving taste and flavour though the research here is pretty limited, and we are not aware of any robust comparative data between the senses on this score (see [3, 4], for the closest). Given the limited evidence currently available on the speed of attention-switching between stimuli in the different senses, this should probably remain as a possible explanation.

Of course, a third possible explanation for the lack of published examples of bistable, or multistable, stimuli in the chemical senses might simply be the lack of research into the principles of perceptual organization in this area! Certainly, you will find virtually no mention of the chemical senses in any of the textbooks on perceptual organization/scene segregation (e.g. see [48, 82], for a couple of recent examples).

Interim summary Thus far, the existence of bistable/multistable stimuli in vision, audition, and touch and in multisensory settings has been summarized. This evidence contrasts with the apparent absence of such stimuli in the chemical senses. While there are undoubtedly many examples of situations where people's perception of some taste, aroma, or flavour changes during the course of a tasting experience, what is lacking is any real sense of bistable, or multistable, stimuli in the chemical senses. And of the various examples that have been discussed from the chemical senses, aromas such as isovaleric acid and benzaldehyde would seem to be most similar (to traditional examples of bistable stimuli), offering as they do two potentially 'correct' interpretations of the sensory input. However, nowhere in the literature does one find the suggestion of spontaneous reversals taking place in the chemical senses. Rather, the other examples that have been mentioned are a little more like 'emergence'.

Emergence

Under certain conditions, it may take an observer longer to separate a figure from its ground. A classic example of this concept is shown in Fig. 3. This image often appears in textbooks of visual perception whenever the Gestalt principles are discussed (and, in particular, the concept that a figure is more than merely the sum of its parts; e.g. [40]). Look closely and you should certainly be able to see a Dalmatian dog sniffing the ground [28].[16] For those who have not seen this image before, the perceptual separation between the dog and its background can take a while. Importantly, however, once the figure has been correctly interpreted, it will immediately be perceived on future viewings (no matter how long the gap between exposures). This example clearly shows how previous experience with a given stimulus can, at least on occasion, play an important role in figure/ground segregation in the visual system (see [1]). Once again, there is no reason to believe that emergence is a

Fig. 3 The classic picture of a Dalmatian dog sniffing the ground covered by patches of snow often used as a demonstration of the principle of 'emergence' in Gestalt psychology. Note that while most people typically initially struggle to make sense of the image, once they do, they will forever after immediately 'see' the dog in the picture. Reproduced from Marr ([40]; p. 101, Figure 3-1)

concept that should be restricted only to the visual modality.[17]

One can think of flavour identification and segregation (i.e. multisensory flavour perception) as a kind of emergent property resulting from the stimulation of the chemical senses. This is perhaps most apparent under blind tasting conditions: Just take the situation of a tutored blind wine tasting, for example (i.e. under those conditions where none of the normal top-down, or cognitive, interpretational cues are provided). One sometimes hears things of the sort: '*I am not quite sure what I am tasting, what I am getting on the palate.*' And then suddenly it gels. '*I get the asparagus, the gooseberry.*' I may even recall the particular wine. And then, whenever I come back to that same taste experience again (at least if I am an experienced wine taster), it is fixed in perception in something like the same way that the Dalmatian dog is in Fig. 3.

There is a sense of 'chunking' here, a bit like the expert chess players in the classic cognitive psychology research. They are the ones who are able to memorize complex board positions by chunking the meaningful configuration of several pieces into a single unit. By contrast, the less experienced player codes the position of each piece individually and is thus able to correctly remember the position of fewer pieces (e.g. [13, 26]; though see [27]). Suddenly, by grouping the information in a meaningful way, one is able to get much more out of the tasting experience. Who knows whether this could perhaps help to explain the discrepancy between those psychophysical studies in which people are only able to extract and identify a maximum of two or three out of a six-element olfactory mixture (e.g. [37–39]), and the seemingly much richer experience of those wine experts who can happily write 1000 words or more describing the sensory properties of a wine (e.g. see [67]; see also [29]). There is a much greater possibility of chunking and perhaps emergence in the case where the elements in the experience are somehow meaningfully related (i.e. in a wine) than when they are combined in a random fashion (as in Laing and colleague's psychophysical studies).

It is worth noting, though, that while many examples of emergence have been documented behaviourally, like many of the other Gestalt grouping principles, the neural mechanisms underpinning this kind of transformation, or reorganization, have not yet received much interest from the cognitive neuroscientists (see [77]).

The Picasso dish, as served at Kitchen Theory's Gastrophysics dining event

The Picasso dish was served as part of the recent Gastrophysics dining concept (see the Appendix for the recipe). As for most of the dinners at Kitchen Theory, the format was a single sitting of 20–25 diners. Before the plates have even been placed down before the diners, the hostess instructs the guests to: '*Look for the face in your dish.*' She then continues that: '*Gastronomy, like art, is all about your perspective.*' Next, she apologetically informed the diners that: '*The dish may be running late as the chefs are still trying to catch the ducks.*' At this point, an audio track entitled 'duck theatre' is played over the loudspeakers in the restaurant. The soundtrack presents the sounds of agitated ducks quacking followed by an ominous-sounding thud (hinting at the said duck's, or ducks', demise, given that no more quacks are heard). This is followed by the dish being brought out from the kitchen (see Fig. 4).

Thus, the diners have been instructed to look for the face in their food, and yet most of them fail to see it spontaneously when their plate is placed down before them. Importantly, Picasso's half-stencilled face has been inverted to slow the diner's recognition—given the literature showing that people find it harder to recognize inverted faces than when in their normal orientation (e.g. [54, 57]). For those who continue to struggle to make sense of what exactly they are looking at (and where exactly the face is to be found), the head of

Fig. 4 The Picasso dish as served at Kitchen Theory's Gastrophysics dining concept in 2016 (https://kitchen-theory.com/)

service would then go around the table and suggest that the diner looks at the plate of the person sitting opposite them. For most diner's, it is at this point, Picasso's face suddenly 'appears', staring out at them from across the table. Picasso's stencilled image has been plated upside down for every diner to see. The development of this dish is based on the notion of emergence (immediate perception of the face being made less likely by the stencilling of only half of the inverted face on the plate).

The intention with this dish is that it illustrates the point about gastromony being a matter of perspective. Picasso's face was chosen given his oft-cited line with which we started this piece that: '*Every act of creation is first an act of destruction.*' And, much like the example shown in Fig. 3, once people see Picasso in the plate (first in the plate opposite them on the table, and only then on their own plate, upside-down), they will most probably see the famous artist whenever, hopefully, they are again exposed to this particular dish, thus highlighting the role of stored knowledge in the interpretation of what we perceive (see [1]). Over two lunches and two dinners held in The Andaz Hotel restaurant in London in August 2016, a total of 90 diners were served the dish. Based on a show of hands, only three of whom saw the face on being presented with the dish initially. However, all but three recognized the face after a couple of minutes, many letting out an audible gasp.

Conclusions

Rather than wishing to assert any particular conclusion, our aim in writing this review has instead been to raise the question of whether examples of bistable, or better still, multistable, perception exist in the chemical senses, specifically in the world of multisensory flavour perception. If they do not, this observation would seem to be theoretically interesting as far as our understanding of the cognitive mechanisms underlying cognition/perception are concerned; specifically in relation to any fundamental differences in information processing between the senses (one can easily get the sense from the literature that researchers expect that the same organizational principles should be observed, regardless of the sense, e.g. [2, 62–64]). And, if examples of bistable/multistable stimuli do exist in the chemical senses, then one can easily imagine that they would be of interest to the modernist chef, given the surprise that such an experience would deliver to the diner (see [52, 72]). We are currently trying to develop just such a stimulus.

However, while as we have hopefully made clear, it seems clear that we are sometimes confused about what we perceived when it comes to the chemical senses (be it in the case of taste, aroma, and/or flavour); And while sometimes our belief or experience of the taste (or more often flavour) of a dish might well change over time—either spontaneously or else perhaps as the result of the provision of some new external information such as the waiter or wine expert providing some additional hint, about a dish (or drink)—we are currently unaware of any examples of the spontaneous reversal of people's interpretation of the stimuli that one finds in the chemical senses in the way that they are known to flip under the appropriate conditions in the so-called higher senses of vision, audition, and touch. While it should be noted that this conclusion is based mostly on anecdotal evidence, unfortunately, that would appear to be the only information that is currently available. So, as is so often the case, it is a matter of more research needed!

More generally, though, and regardless of this specific example relating to bistable/multistable perception, we would like to suggest that there may be a number of thus-far neglected, yet potentially fruitful, avenues for research in the area of modernist cuisine that are likely to emerge from a consideration of whether/how the Gestalt principles of perception (e.g. perceptual segregation and/or scene perception; see [48, 82, 83]) that have for a century now been studied in the so-called higher senses of vision, hearing, and latterly touch can be extended to the chemical senses (e.g. [8, 22, 85, 86]). The Picasso dish is offered as a token example of how intriguing perceptual phenomena from the higher senses can, on occasion, be translated onto the plate, if not necessarily in the mouth (thus stimulating the lower senses).

Endnotes

[1]http://www.brainyquote.com/quotes/quotes/p/pablopicas108723.html.

[2]Something that now has something of a cult following in terms of videos designed to elicit an Autonomous Sensory Meridian Response (ASMR). See, for example, https://www.youtube.com/watch?v=jxT59kF4jVw.

[3]Though it is worth noting that the consumer is not always impressed [15].

[4]Titchener ([79], p. 135), one of the godfathers of experimental psychology put it thus: "*Think, for instance, of the flavour of a ripe peach. The ethereal odor may be ruled out by holding the nose. The taste components—sweet, bitter, sour—may be identified by special direction of the attention upon them. The touch components—the softness and stringiness of the pulp, the pucker feel of the sour—may be singled out in the same way. Nevertheless, all these factors blend together so intimately that it is hard to give up one's belief in a peculiar and unanalyzable peach flavour. Indeed, some psychologists assert that this resultant flavour exists.*"

[5]Once the viewer has identified, or become aware, of the alternate interpretations, then people typically find it very difficult, if not impossible, to maintain a single interpretation. Heston Blumenthal's mind had obviously been travelling along very similar lines, and the chef is

worth quoting ([7], p. 237) : *"If you stare at a drawing of The Necker cube two possible perspective interpretations present themselves – a cube with the front, top and right-hand face on view; or one of which the front, base and left-hand face can be seen. The brain flips between the two interpretations…That flipping between two perspectives continued to fascinate me, especially once I began investigating how the brain makes sense of the sensory data it gets from the food we eat."*

[6]Interestingly, expertise (e.g. such as those working the field of visual design) does not seem to play much of a role in how one perceives such stimuli (e.g. see [12]).

[7]Remember here that most people consider flavour to be a multisensory construct (see [78]).

[8]Some have been tempted to go even further, suggesting that we may be smelling something physically different in the retronasal case due to saliva stripping off a number of the volatile compounds while the coffee is in the oral cavity (see [25]). However, while this remains a theoretical possibility, we have yet to see any solid evidence to back up this particular claim!

[9]The dish has been made with golden beetroots and blood-red oranges. Notice how the colour reversal is achieved 'naturally' in this case (i.e. without the use of any artificial colourings).

[10]Note that here, though, much of the discourse around the dish revolves around illusion and error (in this case, perhaps, driven by visual dominance; see [71]). That is, diners are initially "tricked", or led, into one "false" interpretation, before eventually coming to settle on the objectively correct flavour descriptors for each side of the dish.

[11]According to Blakeslee and Fox [6], there might be an intriguing link to a person's taster status here.

[12]In fact, it is unclear from the literature what happens to those who mistakenly describe a bitter solution as tasting sour.

[13]According to Driver and his colleagues, the switch in interpretation of many bistable visual stimuli (they focused on the case of figure/ground segregation) can be attributed a switch in the focus of a person's attention (e.g. [18, 19]).

[14]One suggestion here being that this reflects a difference between distal and proximal senses; vision and hearing falling in the former category and touch primarily in the latter (see [41]; [74]; see also [51]).

[15]Though, that being said, perhaps the more relevant figure here is the speed with which attention can be shifted between stimuli presented within the same sensory modality.

[16]Notice here how the animal cannot be recognized by first identifying its parts (feet, ears, nose, tail, etc.), and then inferring the dog from those components. Instead, the animal is perceived suddenly as a whole (i.e. all at once).

[17]That said, we are not aware of any such similarly effective examples of emergence in audition or touch. Meanwhile, in the sense of touch, one might think only of the example when the tap drips on your foot while lying in a hot bath. You may initially judge the water to be hot only for you to subsequently realize that it is cold.

Appendix

Recipe

Duck liver parfait: 3 garlic cloves; 300 g shallots; 1 bunch thyme; 700 g madeira; 700 g brandy; 100 g Chivas 18; 600 g duck liver (cleaned); 600 g Chicken liver (cleaned); 12 eggs; 1.2 kg unsalted butter; salt to taste; soak livers in milk overnight; marinate sliced shallot, chopped garlic and thyme in alcohol overnight; reduce shallot, garlic and alcohol down to a syrup (remove thyme); bring eggs, livers (drained from the milk), butter, and syrup all to around the same temperature (above room temperature) before mixing to ensure a smoother blend; blend all ingredients except for the butter in the thermomix at 50 °C, speed 6; gradually add butter while mixing; blend at speed 10 for 5 min; pour into container, cling-film, cook in oven at 120 °C, place the bain marie in the oven, and cook until the core temp reaches 65 °C.

Duck breast: brine overnight in 3 % brine (salt, sugar, star anise, clove, cinnamon stick); remove from brine, pat dry, vacuum pack, and cook in a water bath at 57 °C for 1 h; chill in ice bath, store in fridge; gently score skin. Cook skin side down only in a pan to crisp up skin.

Beetroot puree: dice beetroot and vacuum pack, cook for 3 h at 95 °C. Blend in thermomix and then pass through a fine sieve or chinois.

Beetroot tuile: 100 g beetroot puree; 10 g isomalt; heat the oven to 90 °C. Put the beetroot puree and isomalt in a pan and place on the stove, warming just enough for the sugar to fully dissolve, stirring continuously; blend until fine and pass through a sieve; on a silicon mat, spread the mixture evenly with a pastry knife and dehydrate for 45 min to an hour (till set); use a pastry knife to lift the tuile from the mat and dehydrate a further hour or until crispy; you can then break into shards.

'Oaxacan' duck mole: 4 parts—duck stock (made with duck carcass, grilled onion, roasted carrot, dried shitake mushrooms, fresh button mushrooms, kombu); 1 part—Oaxacan black mole paste; kuzu—simmer and reduce to taste, add kuzu to thicken and add velvet finish to the sauce.

Confit duck: brine legs in 3 % solution for 18 h; remove and pat dry; place flat in trays and submerge in olive oil, crushed garlic, and thyme. Cook at 70 °C for at least 12 h/or 85 °C for 6 h.

Brick pastry roll: lay out the 'fuille de brick' pastry and cut into strips of 4 cm, brush with melted butter on both sides and wrap around a cannellini tube mould, cook for 4 min at 180 °C; leave to cool, remove, and store carefully.

See Fig. 4 for plating.

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Competing interests
CS is a director of Kitchen Theory. The authors declare that they have no other competing interests.

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