Food in motion: Lively display of freshness or last spasms of living beings?

Schifferstein, Hendrik N.J.; Lemke, M.; Huisman, G.

DOI
10.1016/j.foohum.2023.06.002

Publication date
2023

Document Version
Final published version

Published in
Food and Humanity

Food and Humanity 1 (2023) 391–403

Contents lists available at ScienceDirect

Food and Humanity

journal homepage: www.editorialmanager.com/foohum/journal_overview.html

Food in motion: Lively display of freshness or last spasms of living beings?

Hendrik N.J. Schifferstein*, Mailin Lemke, Gijs Huisman

Department of Human Centered Design, Delft University of Technology, Landbergstraat 15, 2628 CE Delft, the Netherlands

ARTICLE INFO

Keywords:
Movement
Disgust
Fear
Empathy
Fascination
Insect foods
Liveliness
Aliveness

ABSTRACT

The movement of food may suggest the food is very fresh but may also indicate the source of food is still alive. In this study, we explore the responses that different kinds of food movements can evoke among consumers. In an online study, we presented participants with 14 videos in which a food product changed shape or moved, before or while being eaten. They rated their emotional responses to the food (disgust, fear, fascination), their tendency to empathize with the beings in the video, characteristics of the movements, and how they experienced the food. Most foods that moved in the videos elicited more disgust than expected for those food items. Many product aspects that elicited disgust also evoked empathy, while fascination showed opposite patterns. Products elicited empathy and disgust when they seemed to be alive and potentially harmful, and their movements were twitchy. Participants empathized mainly with larger animals, while disgust was particularly high for smaller animals like maggots in cheese and crawling coconut worms. People became fascinated with foods they found safe, nutritious, and that looked attractive, while the food movements were subtle and looked natural with the food. These results showed that the movements of foods that appeared to be alive were different from what was considered natural for the food, and so they also evoked different emotional responses.

1. Introduction

Freshness is an important aspect of food, and its importance has only increased in recent years, as evidenced by the ever-expanding fresh food sections in today's supermarkets. Products may be kept on ice or in large refrigerators to secure a high level of freshness. Sometimes humidification machines disperse water vapor to keep vegetables and fruits fresh in a supermarket environment, where freshness can be a key driver of sales (Wyman, 2013). Some animal foods, including oysters, lobsters, and snails, are typically bought alive and thus their movements are indicators for the food's freshness. In several Asian countries, such as China and Vietnam, it is still common practice to buy various live animals on markets to serve as a source of food. In some of these wet markets, customers can select an animal, which the vendor then slaughters on the spot (Woo, Lau, & Yuen, 2006; Zhong, Crang, & Zeng, 2020). Similarly, some European and North American restaurants offer the shortest possible route from live animal to consumption, by allowing consumers to choose the animal that they would like to eat, for example by picking a live fish or lobster from a tank that is part of the restaurant's interior. But here we are approaching the limit of what the diners consider acceptable, because the direct confrontation with eating an animal that was alive just minutes ago could make people aware of the consequences of their food choices. Relating to an animal and feeling a sense of connection to other living beings can make people refrain from eating them. For example, the practice of boiling lobsters alive has been subject to criticism based on scientific reports that they can experience pain just like vertebrates (Horton, 2021) and several petitions have tried to ban their sale from overcrowded tanks in supermarkets.

Usually, before consuming animal meat, the animal is killed, large animals are cut into smaller pieces, and the meat can be cooked in various ways. So, although live animals move around to obtain the resources they need for living, such as oxygen, water, and nourishment, consumers do not expect to observe the meat to move anymore. Movements in plant foods are even less expected, as growing plants are typically tied to a specific location, though they may grow slowly toward promising food, water or light sources and their fruits and vegetables will still respirate post-harvest. However, these processes are so slow that they are usually not registered by the human eye. Therefore, if a food moves the eater may be surprised and may wonder if it is alive? Will it suffer when one eats it? Is the food likely to defend itself and harm the eater? Knowledge of the food source and its characteristics can help answer some of these questions and reassure the eater. For example, when does the food move and what kind of movement is shown: Before cooking, while preparing, on your plate, in your mouth? How does it move: Slow or fast? Continuously? Does it move on its own

* Corresponding author.
E-mail address: h.n.j.schifferstein@tudelft.nl (H.N.J. Schifferstein).

https://doi.org/10.1016/j.foohum.2023.06.002
Received 31 January 2023; Received in revised form 5 May 2023; Accepted 5 June 2023

or does it respond to actions? Which parts of the food move? Do these movements also occur in real life if the animal or plant is alive?

Previous studies examining the role of movement in food have often focused on the advertising context, where movement is used to increase liveliness, which in turn is associated with freshness. For instance, when sauce seems to be dripping off pancakes the item is more likely to be fresh than when the sauce is no longer dripping. Similarly, products can be steaming, sizzling, bubbling, boiling, or melting. Alternatively, someone can pour, sprinkle or splash liquids and cut or manipulate solid foods. For instance, images of drinks being poured into a glass (Gvili et al., 2015), splashing drinks (Li & Liu, 2022; Yu, Droulers, & Lacoste-Badie, 2022), cornflakes or pretzels being poured into a plate (Gvili, Tal, Amar, & Wansink, 2017), or a fish jumping out of the water (Amar, Gvili, & Tal, 2021) have yielded higher ratings for product freshness, healthiness, product appeal and tastiness compared to images without implied movement. Amar et al. (2021) obtained similar differences when comparing a video of a beverage being poured with a video of a motionless glass. Some authors investigated specifically the effects of implied movement on the sensory perception of taste and smell: van Rompay, Fransen, and Borgelink (2014) showed that some visuals suggesting an upward movement lowered odor intensity ratings in a study on washing powders. However, it should be noted that all these studies were conducted with relatively simple stimuli, implied movement being one of the few cues that made the images interesting or engaging. In a study using richer images from publicly available photo databases in which foods were presented in their usage context and often with appropriate garnish, the motion effects were only found in individual cases, but could not be demonstrated for the stimulus set as a whole (Mulier, Meersseman, Vermeir, & Slabbinck, 2021).

Toet, van Schaik, Kaneko, and van Erp (2019) also started out from publicly available food pictures. They investigated whether seeing actual movement in the picture had a positive effect on the perception of food products compared to observing a still with implied movement. They used the pictures to create cinemagraphs in which most of the frame was static while some details were animated in a seamless loop. Animating part of the image significantly affected appetitive and affective responses in only 6 cases (out of 48), with 1 effect being negative. When analyzing the free associations about what initially came to mind when viewing the image, 15 cases (out of 96) were significant, of which 9 animations elicited more negative or less positive responses. Hence, animating the motion only had a positive effect for some foods (e.g., ice cream with coffee and poured sauce, sizzling pizza, boiling noodle soup, or honey poured on waffles), but negative effects for others (e.g., pancakes with dripping syrup, steaming shrimps, bubbling iced tea, or steaming coffee). Thus, also in this case the effect of movement can be both positive and negative, depending on the product and the type of movement.

In culinary applications, movements are typically introduced in the context of dining to make the experience livelier and more engaging. Just think about the 'Le Petit Chef' animations, with a little chef who seems to prepare a dish right on your plate (see https://lepetitchef.com). It has been shown that animations can affect the taste of your food. For instance, Huisman, Bruijnes, and Heylen (2016), who projected animations on top of a cup of yoghurt, found that animation speed affected taste perception, with faster movements enhancing perceived sourness. However, in such cases clients or participants are probably aware that the food itself is not moving. In some applications of digital gastronomy, the food itself plays a more central role. For instance, Deng, Olivier, and Mueller (2023) enable food items to regulate their flavor and visual presentation as they are designed as computational artefacts. Others have combined digital prototyping technologies with material experiments to create food that changes shape during cooking (e.g., Tao et al., 2021) or on the plate (e.g., Van Doleweerd & Bruns Alonso, 2023). Chef Joaquim Sousa created a chocolate desert in the shape of a flower whose pedals started to move and open as hot ingredients were added (Basildon, 2015). Unlike projects that only try to improve the eating experience, other projects use movement to trigger debate on current and future challenges. The aim of such speculative design projects is to hypothesize alternative futures rather than being ready for production (Dunne & Raby, 2013). For instance, Minsu Kim was inspired by developments in synthetic biology, which researchers can use to bring artificial, digestible organic shapes to life. In her project "Living Food", she proposed dishes that behaved like living creatures, appearing to puff, wave, or breathe (Etherington, 2013).

Around the world there are numerous dishes that use alive or seemingly alive ingredients that may be appreciated by their local clientele but would generate negative responses elsewhere. For example, in Japan people eat Odori Ebi - dancing shrimp – a shrimp that is eaten alive and dipped in soy sauce. Some people in Southern India eat small live sardines in the belief that they cure asthma (Warwick, 2015). Some dishes even use special ingredients to purposefully evoke movement. For example, the Korean dish San-nakji consists of a small octopus, which is killed just before eating and then served to the diner in sesame oil, causing the octopus's nervous system to react and the arms to move. On the other hand, oysters that are commonly eaten alive and are consumed worldwide show little movement once the shell is opened and are less likely to be perceived as disgusting. The conclusion that eating something living always elicits a disgust response therefore seems premature. Rather, it appears that movement in this context evokes the paradoxical response of aversion on the one hand and attraction on the other. Moreover, those responses are partly determined by which foods and methods of preparation are customary and familiar within specific cultures.

In this paper, we examine the role of food movement not just as an indicator of freshness and engagement, but also as an indicator of aliveness. Studies that highlight the positive aspects of movement mainly focus on the impact of the different ways in which food components move on food acceptance, but when a food seems alive it is likely to impact the emotions that any observers or potential eaters will experience. Therefore, we first discuss what emotional responses are likely to occur when foods move.

1.1. *Disgust, fear, or fascination*

When a food or dish contains moving parts this can be a source of aversion (Veeck, 2010). The perceived movement of the food is likely to give rise to disgust in some people, although it may be appreciated by others. Disgust is a basic human emotion (Ekman, 1999) that "contains a range of states with varying intensities from mild dislike to intense loathing. All states of disgust are triggered by the feeling that something is aversive, repulsive and/or toxic." (Paul Ekman Group, 2022). Disgust is commonly referred to as a guardian of the mouth that prevents close contact with poisons and pathogens as it decreases the appetite for food (Motoki & Sugiura, 2018). It is closely associated with feeding behavior and can evoke more cognitive, ethical/moral deliberations as well as more instantaneous bodily responses (Kelly, 2011; Rozin & Fallon, 1987). Disgust research in the food area has revealed that people show disgust in relation to unfamiliar production technologies (e.g., producing cultured meat) (Siegrist & Hartmann, 2020) and especially in the context of the consumption of animal products (Kubberød, Ueland, Tronstad, & Risvik, 2002).

In the case of moving food, the violation of established food-related norms may be related to the killing of animals, which is likely to arouse people's empathy with other living creatures. In a study using food preparation and eating scenarios, Martins and Pliner (2006) found that reminders of the livingness and animalness of food products accounted for much of the variability in ratings of perceived food disgust. People are generally reluctant to eat food items that physically resemble human beings or have had a close physical relationships with them, such as pets (Rozin & Fallon, 1987). Food activist groups have used these connections to encourage changes in people's consumption habits.

For example, some activist groups have created advertisements with animals that allegedly say they want to live longer. PETA made a billboard showing an octopus that reads “I’m ME, not MEAT. See the individual. Go Vegan.” (Allen, 2022) and showed a fish with the text “My life is in your hands. Go vegan.” (Moore, 2014). Another ad shows a woman in a cage with the text: “Try to relate to who is on your plate. Go vegetarian.” (PETA, 2011). Such campaigns appeal to the moral understanding of consumers and evoke multiple negative emotions, including shame, guilt and disgust (Kranzbühler & Schifferstein, 2023).

In everyday life, people can develop empathy with their food sources by nurturing, caring for, and bringing them into their homes. This way they can care for a pig, chicken, or rabbit at home. And they could also grow vegetables or fruits in their garden. But what happens if they later want to use these animals as a food source? How does the emotional bond people develop over time affect their decision to eat them? Some animals, such as rabbits, which can be a food source as well as a pet, elicit disgust and guilt when consumers are asked to eat them (Magalhães, Costa, & de Camargo, 2022; Rousset, Deiss, Juillard, Schlich, & Droit-Volet, 2005). In particular, people who developed a strong attachment to their pet during childhood seem to develop more empathy for animals, leading to greater meat avoidance in adulthood (Rothgerber & Mican, 2014). In 2011, a school in Germany reenacted a stone age experience with fifth grade students. Over the course of a week, the children participated in various activities and were informed and prepared for the final event, which involved killing and eating a rabbit. Despite knowing this, one child fainted during the event, and several cried while they watched the rabbit being killed by the farmer (Lübke-Naberhaus, 2011). This example shows that in many cases it is difficult for people to emotionally disconnect themselves from a living being, even though they are aware that it was intended to be used as a source of food. Hence, seeing animals being killed or eaten alive activates people’s empathy and raises negative emotions such as disgust.

In response, people have developed ways to cognitively separate eating meat from its animal origin by using strategies that reduce empathy and levels of disgust when people present, prepare, and talk about meat (Benningstad & Kunst, 2020; Rothgerber, 2020). Evidence includes using an efficient and fast pace of food shopping, trying not to think about the life and death of the animals while eating (Graça, Calheiros, & Oliveira, 2014), removing parts that are characteristic for an animal such as the head and feet (Kunst & Hohle, 2016), and the use of specialized terms like pork, beef, and mutton in everyday food vocabulary (Evans & Miele, 2012; Kunst & Hohle, 2016). Therefore, food producers, chefs, and cooks may try to remove parts that remind people that a piece of meat comes from a living animal. In supermarkets, consumers can buy chicken breasts in a neatly wrapped package with no skin, feathers, paws, head, bones, or any part of the chicken carcass visible. These parts are also often removed when served on a plate. Seeing parts of an animal’s face, especially the eyes, can be experienced as confronting and disgusting in Western culture (Lemke, Boon, & Schifferstein, 2021). In a similar vein, producers and chefs could try to reduce or eliminate any spontaneous movements if they want to stimulate consumption of the food.

However, to understand the context of food provision, it is important that people become aware of the connection between animal-derived foods and their sources and get used to what foods of animal origin look like. In modern society, the prominence of ultra-processed foods has made common food encounters, such as eating meat with bones or consuming a whole fish, inconvenient or distasteful, especially for children (Wijayaratne, Reid, Westberg, Worsley, & Mavondo, 2018; York & Gossard, 2004). This development can lead to the marginalization of culinary important ingredients from households, school canteens and restaurants (Soon & Tee, 2014) and ultimately from regional cuisines. Feuer (2022) explores the potential to reframe the consumption of such "difficult" foods as a life skill to overcome nutritional problems in children. For example, the consumption of a whole fish requires not only acceptance of its flavor, but also the acquisition of mechanical skills needed to separate bones and dissect the fish (Højer, Wistoft, & Frøst, 2021). So, while eating moving food may be an exception, getting to know a whole animal body, and knowing how to prepare and consume it, requires important life skills that are relevant for a region’s cultural heritage and can contribute to a healthy nutritional status in the population.

In general, people may feel ambivalent towards eating meat: According to the ‘meat paradox’ consumers like to eat meat, but they do not wish to harm animals (e.g., Loughnan, Haslam, & Bastian, 2010). There is broad cross-cultural evidence that people experience discomfort in killing animals to obtain meat (Simoons, 1994), but people may have different ways of coping with the psychological discomfort caused by the conflict between the pleasure of eating meat and caring for animals, and such differences may be culturally rooted. Reminding participants of the animal origin of meat or the slaughter process typically results in less dissociation, more disgust, and more empathy with animals (Kunst & Palacios Haugestad, 2018), and less willingness to eat the meat (Tian, Hilton, & Becker, 2016). However, the impact of such manipulations seems to depend in part on people’s experience with the production of meat (e.g., slaughter, seeing dead animals). In several parts of the world (e.g., Western countries), people are becoming less and less involved in the production of meat, and Western consumers may only become aware of the ethical challenges of meat consumption via the media (Khara, Riedy, & Ruby, 2021). Consequently, animal suffering may be more problematic to Western participants, and they may experience stronger cognitive dissonance when eating meat. For instance, when seeing a picture of a pork roast, US participants were much more affected by the presence or absence of the head than Ecuadorian participants in their responses of disgust and empathy (Kunst & Palacios Haugestad, 2018). In an American sample, people with an East Asian background tended to feel less guilty about the slaughtering of animals than other groups (Choi & Lee, 2023). In some instances, religion may also play a role, as believers may classify some animals as holy animals, which are deemed to possess richer mental life than other animals (Manokara, Lee, Kamble, & Krumhuber, 2021). In a study focusing on the presumed mental capacities of animals, French participants were less likely to attribute specific mental states (e.g., self-control, communication, feeling pleasure or pain) to cows than Chinese participants (Study 2 in Tian et al., 2016). A third cultural difference is related to the fact that people may be familiar with different types of animal foods in different cultures. In fact, Possidónio, Piazza, Graça, and Prada (2022) show that animal resemblance has its most pronounced influence on appetite for meat products when products are unfamiliar.

Disgust is not only connected to empathy, but it is also related to fear in multiple ways (Fisher et al., 2014; Harris et al., 2019), such as the fear of becoming ill (Oaten, Stevenson, & Case, 2009). For instance, Rozin and Fallon (1987, p. 23) define disgust as "revulsion at the prospect of (oral) incorporation of an offensive object.” These offensive objects may be seen as contaminants that render the food unacceptable, even if they are only briefly in contact with an acceptable food. Contamination can be defined as "an individual’s fear of contagion with disgusting stimuli" (van Overveld, de Jong, Peters, & Schouten, 2011, p. 326) and this fear of contamination may be especially prominent for stimuli of animal origin (Harris et al., 2019; Polák et al., 2020). Moreover, in the case of moving foods, people might worry that swallowing living animals might damage their gastrointestinal tract, as these animals might bite to defend themselves or try to release themselves. Second, disgusting stimuli may be perceived as threatening because they activate people’s thoughts regarding their vulnerability to death (Cox, Goldenberg, Pyszczynski, & Weise, 2007). In this case, the moving food reminds people of their own animalness (Rozin & Fallon, 1987). Furthermore, according to Spence (2018) people’s aversion to having animate food on their plate may also be related to a primordial fear of asphyxiation. In this case, as the moving food is transferred to the mouth and enters the closed body, empathizing with the food might

activate a feeling of suffocation. However, despite their close connections, fear and disgust can also be differentiated along the dimensions of behavioral intentions, appraisal, and physiological processes (van Hooff et al., 2013; Woody & Teachman, 2000). Although avoidance characterizes both fear and disgust, it does so for different reasons: "fear-motivated avoidance protects the person from perceived danger, while disgust-motivated avoidance may be more often linked to sensation or imagery" (Woody & Teachman, 2000, p. 293). This difference also becomes evident in the way people respond to the two emotions: While fear activates a fight, flight or freeze response (Maack, Buchanan, & Young, 2015), disgust activates a tendency to avoid contact or to vomit (van Overveld, de Jong, & Peters, 2010).

Food movements and the disgust they elicit do not necessarily have only negative effects on consumer appreciation. Disgusting stimuli tend to hold people's attention (van Hooff et al., 2013). Hence, food movements can fascinate a restaurant's clientele, and this can happen even when some ingredients appear to be alive. For example, the Danish restaurant Noma served live ants as part of a dish (Markwell, 2012). Experiencing disgust in such a safe environment can have a positive effect, as it can create a certain "macabre allure" and evoke attraction to food practices and products (Korsmeyer, 2011). As such, disgust can play a role in rich user experiences (Fokkinga & Desmet, 2012) and can be an integral part of aesthetic experiences in the context of art, drama and food (Ablett, 2020; Lemke & de Boer, 2022; Menninghaus et al., 2017).

1.2. The present study

In the present study, we examine people's responses to moving foods. Previous studies on food movement as indicator of freshness have mainly focused on the different types of food movements and its effect on the evaluation of the food product. However, movement as an indicator of product aliveness is more likely to generate interest in consumers' emotional responses, including those for disgust, fear, and fascination. Therefore, in the present study we will try to assess all three parts (movement characteristics, food evaluations and emotional responses) in a single study and relate all elements to each other.

Our study will generate a more detailed understanding of movement-related qualities that can evoke an aversive response on the one hand, or an attraction-seeking response on the other. In line with the discussion above, we expect food stimuli that seem to be alive to elicit feelings of empathy, and to evoke disgust and possibly fear. For stimuli that move but do not seem alive, we expect to find mainly positive associations and emotions, such as freshness or fascination. In some exceptional cases, however, we may also find "macabre allure", predicting a combination of disgust and fascination for a single stimulus. As we do not have a concrete idea yet of what movements make a food seem alive or not, we will explore the relationship between movement characteristics and judgments of aliveness for the first time in the present study.

We would also like our study to generate insights for the design of foods and the development of interventions that help people to eat healthier and more sustainable. Possibly, our findings can help designers to develop interventions that convince consumers to avoid certain foods and promote the consumption of others. Therefore, we are also interested in how the different stimuli are evaluated on the variables we assess.

2. Method

For this empirical study, we used fourteen food-related videos showing a food item that displayed movement. Each participant evaluated a single video.

2.1. Participants

The study was completed by 710 participants who were born and lived in the US, who did not follow a vegan, vegetarian or any other diet, and were recruited through the Prolific panel. The sample consisted of 44 % women and 56 % men, of whom the majority (79 %) were Caucasian. Age ranged from 19 to 78 (mean 38.6 years). Participants received financial remuneration according to standard Prolific rates. The research proposal has been approved by the Human Research Ethics Committee of TU Delft under ID number 1332.

Sample size was mainly determined by the differences we wanted to examine between individual stimuli. Aggregate analyses included the responses of all 14 stimuli and would likely have enough observations. Stimulus differences were judged interesting as they would improve our insights in individual cases and could provide clues for future food design challenges. A previous study using similar 7-point scales found that the means on single emotion items had an average standard deviation (SD) of about 2.0, although for other types of items and multi-item measures, the SD could decrease to about 1.3 (Kranzbühler & Schifferstein, 2023). Starting out with an SD value of 2.0, $\alpha = 0.05$ and $1\text{-}\beta = 0.70$, to detect a difference of about 1 unit on the 7-point scale in a t-test with independent samples, we would need a sample of 51 participants per video (Faul, Erdfelder, Lang, & Buchner, 2007; Lakens, 2022). Therefore, we decided to recruit at least 50 participants per video. Although the value of $1\text{-}\beta$ is not very high, we considered this value acceptable given the explorative nature of the study, and the fact that we used a conservative estimate for the SD value.

2.2. Materials

In an initial step, we brainstormed about food items that showed movement. We looked for videos containing these items on the YouTube video platform, and we searched for additional videos using the search terms "disgusting food" and "moving food". We selected 27 videos showing moving food and evaluated the displayed movement, whether people ate the food, the type of food (animal, plant, other organic matter), and the expected level of disgust, ranging from low to medium to high. The perceived level of disgust for each video was determined in discussions between the authors and was based in part on the extent to which the animal was recognizable (e.g., seeing the whole animal or just a part), the animal's specific movements (e.g., erratic or smooth; many or few), as well as the type of animal (e.g., fish, insects or shrimp). Because the degree of disgust experienced is probably partly culturally determined, the study was conducted in a group with a similar (Western) background as the authors.

We selected videos that were at least 10 s long and in landscape format, and we removed videos that were difficult to apprehend, that we found too cruel, or that showed similar content. In our final selection, we used 14 different videos of various food products, including octopus (twice), shrimp, fish, fish flakes, crab, oyster, coconut worms, steak, casu martzu (cheese with maggots), pasta, pop rocks candy, tea, and a speculative design (see Appendix A). We reduced each video to 10 s in duration and removed the audio. When editing the video, we made sure that our viewers could understand that they saw food items moving during preparation and/or eating. In some cases, it involved seeing people preparing the food in a kitchen or eating the food. Otherwise, the focus in the video was on the food itself. The final video excerpts can be obtained from the authors upon request. The study materials and datasets will be made available through the TU Delft repository at https://doi.org/10.4121/21740015.

2.3. Procedure

A questionnaire has been constructed in Qualtrics. A description of most questionnaire items can be found in Table 1, together with how

Table 1
Overview of questionnaire items showing the exact wording of each item, the descriptors of the two end anchors of the response scale, and the factor loading obtained in PCA. For multi-item sum scales, the % of variance of that factor in PCA and the value of Cronbach's α is included.

Item	Left anchor	Right anchor	Factor loading
Baseline measure: "To what extent do you find consuming the following foods disgusting?"			
disgust intensity	Not disgusting at all	Extremely disgusting	
Emotional responses: "When I see the food in this video, I feel…"			
Empathy scale (33 %, α = 0.84)			
sorry for the ingredients that make up this dish	Not at all	Very much	0.762
angry at the people who prepare or eat it	Not at all	Very much	0.785
ashamed	Not at all	Very much	0.813
compassionate	Not at all	Very much	0.816
Fascination scale (24 %, α = 0.88)			
fascinated	Not at all	Very much	0.943
interested	Not at all	Very much	0.906
Disgust scale (23 %, α = 0.86)			
disgusted	Not at all	Very much	0.843
scared to eat it	Not at all	Very much	0.933
Movement characteristics: "The movements of the food in this video…"			
Synthetic items relating to the food as a whole			
look natural with the food	Not at all	Very much	
mimic those of a living creature	Not at all	Very much	
Descriptive items relating to the movement per se			
are fast	Not at all	Very much	
are subtle	Not at all	Very much	
fade out over time	Not at all	Very much	
are twitchy	Not at all	Very much	
Food evaluations: "I think this food…"			
Harmful scale (20 %,α = 0.78)			
contains a lot of harmful microbes	Strongly disagree	Strongly agree	0.782
causes me pain when I eat it	Strongly disagree	Strongly agree	0.793
makes me ill when I eat it	Strongly disagree	Strongly agree	0.787
Attractive scale (20 %, α = 0.79)			
has a pleasant texture	Strongly disagree	Strongly agree	0.795
will taste delicious	Strongly disagree	Strongly agree	0.803
is familiar to me	Strongly disagree	Strongly agree	0.748
Nutritious scale (18 %, α = 0.74)			
is healthy	Strongly disagree	Strongly agree	0.627
is fresh	Strongly disagree	Strongly agree	0.840
is natural	Strongly disagree	Strongly agree	0.776
has been processed extensively	Strongly disagree	Strongly agree	-0.619
Vegetable scale (13 %, α = 0.80)			
is plant based	Strongly disagree	Strongly agree	0.928
is of animal origin	Strongly disagree	Strongly agree	-0.794
Safety item			
is safe to eat	Strongly disagree	Strongly agree	
Aliveness item			
is still alive	Strongly disagree	Strongly agree	

they were clustered in sum scales after exploratory Principal Components Analysis (PCA). All items were rated on a 7-point scale with only end anchors named, unless indicated otherwise.

After reading instructions and providing informed consent, participants indicated whether they were vegan or vegetarian, or whether they ate meat or fish. Only the group that ate meat or fish were invited to continue with the study. They were then asked to indicate to what extent they found consuming the 12 foods in the different videos disgusting (octopus, shrimp, fish, dried fish flakes, crab, oysters, worms, beef steak, cheese, pasta, tea, candy) as a baseline measure of disgust. They could also tick a box if they did not know the product. The only product for which we could not define an equivalent here was the speculative design.

Then the participants saw one of the videos and recorded their emotional responses to the video (Table 1). Subsequently, they indicated their expected interaction in real-life with the food by choosing one of the following options: "If someone would present me with this food as it is here, without further preparation, I would not even look at it / look at it, but not touch it / touch it, but not put it in my mouth / put it in my mouth, but not swallow it / put it in my mouth and swallow it." In the case of the raw steak, the question was reworded to refer to the prepared product. After that, they rated the characteristics of the movements in the video (Table 1) and their evaluations of the food itself (Table 1). On the "strongly disagree" – "strongly agree" response scale for the food evaluations, all seven answer categories were named (strongly disagree, disagree, somewhat disagree, neither agree nor disagree, somewhat agree, agree, strongly agree). In addition, at the end of the survey, participants could write feedback about aspects of the food in the video they found disgusting, and they could add any comments about the questionnaire.

2.4. Data analysis

As our study is exploratory in nature and we measured many different aspects of the movement, the food, and the consumer experience of the products in the videos through individual items, we tried to simplify presentation by using conventional data reduction techniques, i.e., PCA with varimax rotation. In our analyses we used a pragmatic approach in which items with high loadings ($> |0.60|$) on a single factor were combined in a sum variable. Even though such items might measure constructs that could be distinguished theoretically, their responses were combined in a single scale, because they correlated highly in the context of the present study. This avoided repeated presentation of highly similar patterns for multiple items. In cases of special interest, additional analyses were performed to check for deviations between individual items.

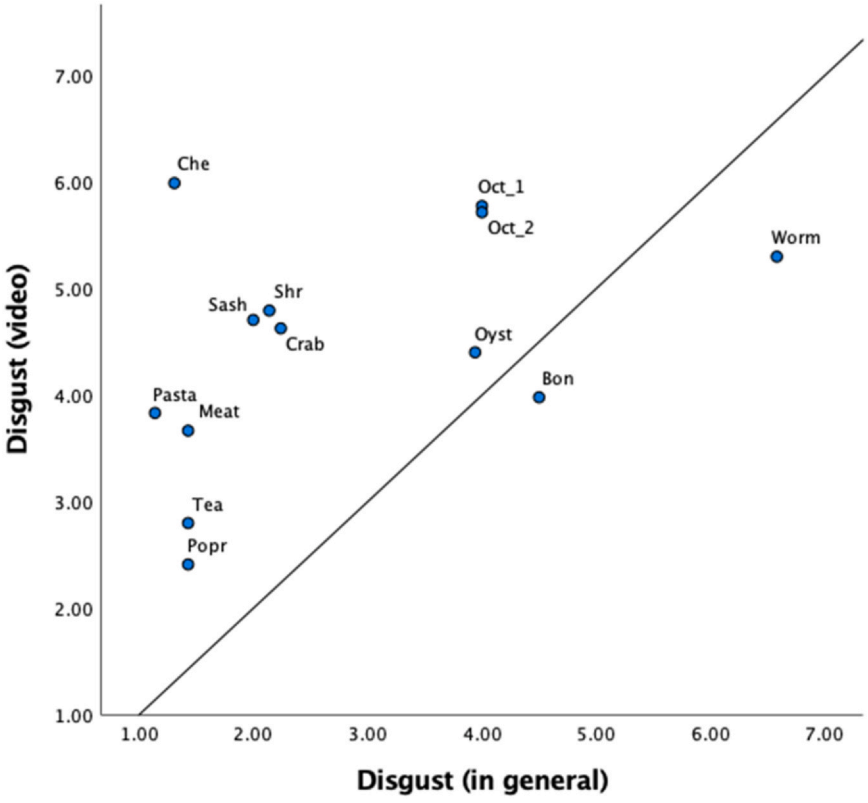

Fig. 1. Mean Disgust scores for the videos as a function of the a priori disgust ratings for the food categories in general (Abbreviations: Oct-Octopus, Sash-Sashimi Fish, Bon-Bonito fish flakes, Shr-Shrimp, Che-Cheese, Spec-Speculative dish, Meat-Beef steak, Oyst-Oyster, Popr-Pop rocks). The standard errors of the disgust means vary from 0.026 to 0.092 (in general, N = 710) and from 0.220 to 0.338 (video, N = 50–51).

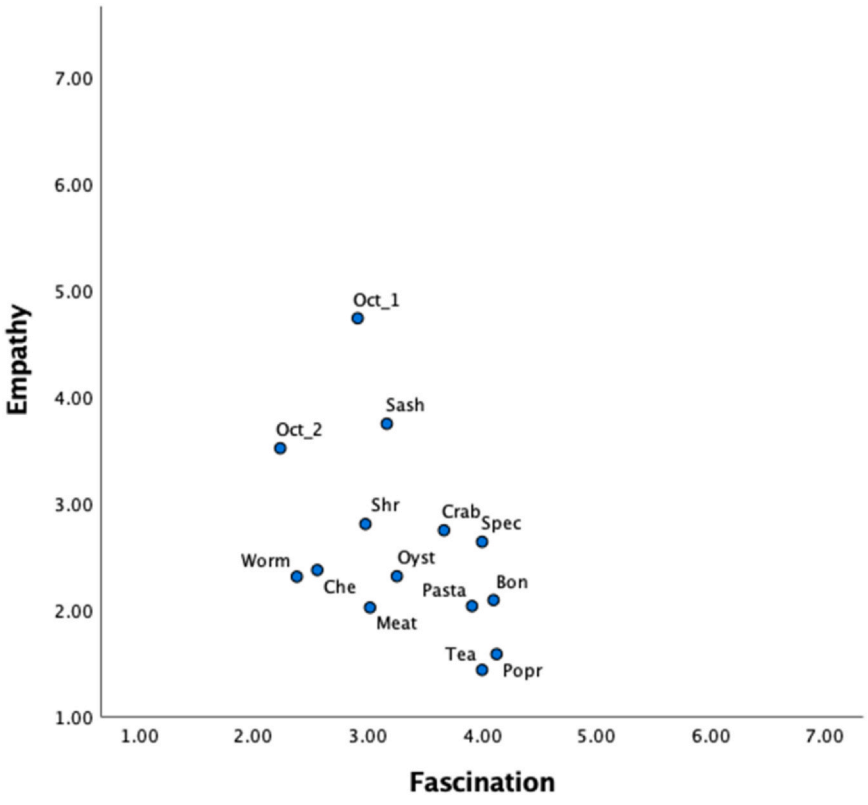

Fig. 2. Mean scores on the Empathy and Fascination scales for the 14 videos (Abbreviations: Oct-Octopus, Sash-Sashimi Fish, Bon- Bonito fish flakes, Shr-Shrimp, Che-Cheese, Spec-Speculative dish, Meat-Beef steak, Oyst-Oyster, Popr-Pop rocks). The standard errors of the means (N = 50–51) vary from 0.231 to 0.295 (fascination) and from 0.086 to 0.276 (empathy).

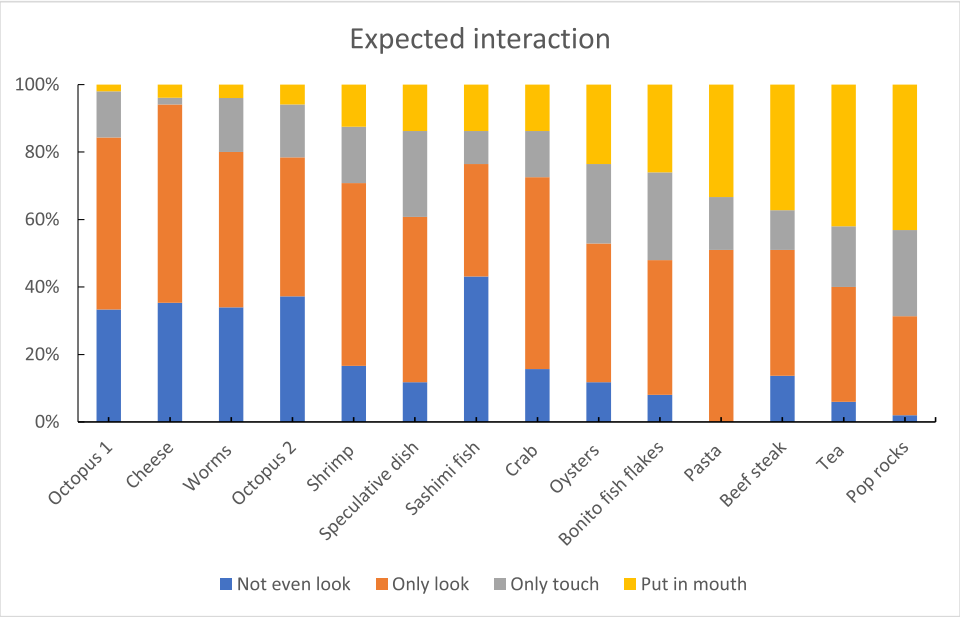

Fig. 3. Expected interaction patterns for the foods in the videos (N = 50–51 per video).

3. Results and discussion

As our study is exploratory in nature, we have mixed the reporting of the results in this section with some interpretation.

3.1. Disgust, fascination, and empathy

Before viewing the video, all participants rated the extent to which they found consuming twelve foods disgusting (Fig. 1). As expected, many regular foods rate low (e.g., meat, pasta) while more unusual foods rate high (e.g., worms). Interestingly, for products with mean ratings between 3 and 5 (e.g., octopus, oyster), we typically see a bi-modal distribution of responses, where some people experience almost no disgust while others find the product very disgusting.

We performed PCA with varimax rotation on the eight emotional responses participants gave to the videos after watching it (N = 710). This yielded 3 factors with eigenvalues greater than 1. The first factor (33 %) contained the four items measuring feelings of shame, compassion, feeling sorry, and anger directed at the people who made animals suffer. We combined the ratings on these items into an *Empathy* scale (Cronbach's $\alpha = 0.84$). The second factor (24 %) contained the two positive items of fascination and interest. These items were combined in a *Fascination* scale ($\alpha = 0.88$). The third factor (23 %) combined ratings of disgust with those of feeling scared into a *Disgust* scale ($\alpha = 0.86$). Even though we distinguished disgust and fear conceptually in the Introduction, we also know that they often co-occur and the PCA shows that they are highly correlated in the context of the current study. For ease of presentation, we have therefore combined them in a single scale. Ratings on individual items were averaged to calculate the scores on the sum scales.

Fig. 1 shows the mean Disgust ratings for the videos as a function of the disgust ratings that were given to the different foods before watching the videos. These means show that participants were most disgusted by the video of the cheese with maggots and the moving octopuses, followed by the worms and the other seafood (fish, shrimp, crab, and oysters). Next, we have the bonito flakes, pasta, and the steak, while the least disgusting are the tea and pop rocks videos. The mean Disgust rating for the speculative design video is 5.05, which is close to the worms and the shrimps.

Fig. 1 shows that the Disgust responses to the videos with the moving foods generally yielded higher responses than what the participants expected beforehand for the various product categories. This suggests that (unexpected) movement of the food or elements in the food increases the aversion to the different products. The oysters are close to the reference line, possibly because oysters are known to be always eaten alive. Only the means for the bonito flakes and the worms fall under the reference line. These are the two products with the highest initial disgust ratings. People seem to be less familiar with these foods, as is evidenced by lower N values (609 for bonito flakes and 679 for worms, compared to 710 for familiar products), indicating that some participants did not know these foods. Perhaps seeing the actual products in the videos made people realize they were not so disgusting after all.

Fig. 2 shows the mean scores for Empathy and Fascination. The graph suggests a negative correlation between these two variables, indicating that when people empathize with a suffering being, they are less likely to be fascinated by its movement. Possibly, to be fascinated, a person needs to be sure that it is not at the expense of another living creature. The pop rocks, bonito flakes, tea, speculative design, and pasta in particular rate high on Fascination. Most of these videos rate low on Disgust, except for the speculative design video, which rates high on both Fascination and Disgust. Possibly, people are fascinated by the fact that these videos show movement although they do not seem to have animal parts.

The Empathy ratings are highest for the octopuses and the sashimi fish, and they are lower for the cheese with maggots and the worms. This suggests that people mainly empathize with larger, more complex animals rather than smaller animals like insects or shrimps. The lowest Empathy ratings are found for foods that are not of animal origin (tea, pop rocks, pasta) and for the steak. The low Empathy ratings for the steak are particularly interesting because they indicate that after an animal has been slaughtered and cut up, many participants do no longer feel sorry for the animal. In this case, the animal does not feel pain anymore, which is different from the videos where whole animals can be seen moving.

We also determined whether participants were willing to look at the food, touch it, put it in their mouth, or swallow it when presented with the food. Almost no one (n = 8) chose the option "put it in my mouth, but not swallow it", of which most cases (n = 5) involved the pop rocks. To simplify presentation, these responses were combined with the "put it in my mouth and swallow it" category. Fig. 3 shows the frequencies of the various responses and suggests that participants tend to limit their

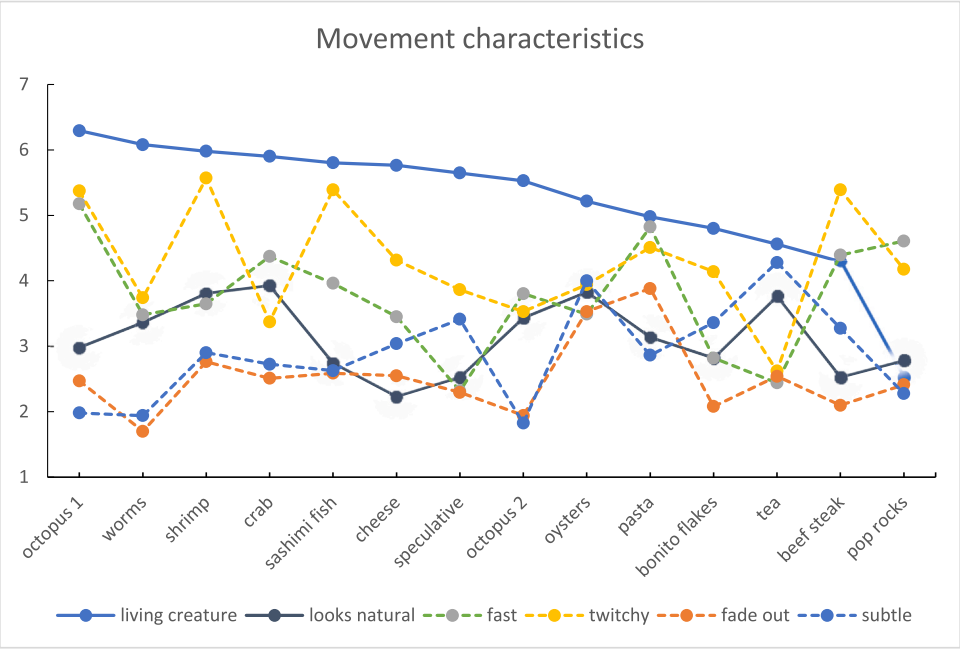

Fig. 4. Mean ratings on movement characteristics for the 14 videos. Standard errors of means (N = 50–51) vary from 0.165 to 0.297 (living creature), 0.235–0.313 (natural), 0.203–0.291 (fast), 0.216–0.323 (twitchy), 0.172–0.280 (fade out), and 0.165–0.273 (subtle).

interactions with the foods they find disgusting. However, we also see some notable deviations from this pattern: Many participants do not want to look at the sashimi fish, even though the disgust ratings are not among the highest. This may be because empathy ratings for sashimi are relatively high, suggesting that people find the preparation of this dish particularly cruel.

3.2. Movement characteristics

The mean ratings of the six movement characteristics can be found in Fig. 4. These items consist of four descriptive items trying to capture the speed and pattern of movement itself, and two synthetic items that relate to the character of the food as a whole: whether the movements mimic those of a living creature or look natural with the food. Fig. 4 is sorted by the ratings indicating that the movements mimic those of a living creature. These ratings show significant correlations with movements that are twitchy ($r = 0.40$, $p < 0.001$), fast ($r = 0.21$, $p < 0.001$), and not subtle ($r = -0.11$, $p < 0.001$). The ratings on looking natural show the highest correlations with movements that are subtle ($r = 0.31$, $p < 0.001$), not twitchy ($r = -0.21$, $p < 0.001$), and fade over time ($r = 0.16$, $p < 0.001$).

Table 2 shows the correlations between the three sum scales with emotional responses and the various movement characteristics. These results suggest that both Disgust and Empathy are high for foods that move like living creatures, with fast, twitchy, non-subtle movements. However, the level of Disgust decreases when the movement looks natural with the food, whereas this does not seem to affect the degree of Empathy felt. Fascination occurs especially with movements that are subtle and look natural to the food and diminishes when the food seems to be alive.

Table 2
Pearson correlations between the sum scales of emotional responses and movement characteristics (N = 710).

	Disgust	Fascination	Empathy
Descriptive items			
are twitchy	0.175**	0.021	0.200**
are fast	0.086*	0.060	0.186**
fade out over time	-0.059	0.071	0.012
are subtle	-0.154**	0.145**	-0.104**
Synthetic items			
mimic those of a living creature	0.444**	-0.109**	0.307**
looks natural with the food	-0.234**	0.107**	0.019

* **p < 0.01; *p < 0.05.

3.3. Product evaluations

An exploratory PCA with varimax rotation on the items that measured the evaluations of the foods in the videos yielded 4 factors with eigenvalues larger than 1, with 71.5 % variance explained. For each factor we retained the items with factor loadings over |0.60| to obtain 4 sum scales. This resulted in a *Harmful* scale ($\alpha = 0.78$) consisting of the harmful, ill and pain ratings; an *Attractive* scale ($\alpha = 0.79$) with the items delicious taste, pleasant texture and familiar; a *Nutritious* scale ($\alpha = 0.74$) with items for fresh, natural, healthy, and processed (reversed); and a *Vegetable* scale ($\alpha = 0.80$) with the items for plant-based and animal origin (reversed). Two items (safe/still alive) did not provide loadings over |0.60| on any factor and showed cross loadings over |0.30| on the first three factors. These were analyzed separately.

Fig. 5 is sorted by the ratings indicating that the food still seems to be alive. These ratings show significant positive correlations with harmful (0.52) and nutritious (0.16), while it is perceived as neither attractive (−0.44), vegetable (−0.41), nor safe (−0.37) (all $p < 0.001$).

Table 3 shows the relationship between the three sum scales with emotional responses and the six product evaluation characteristics. Almost all these correlations are statistically significant. Like the movement characteristics, we find highly comparable correlation patterns for Disgust and Empathy, with positive correlations for looking alive and harmful, and negative correlations for attractive, safe, and vegetable. In contrast, for Fascination all correlations are opposite to those found for Disgust and Empathy, with an additional positive correlation for nutritious.

3.4. Characterization of aliveness

To get a sense of what exactly makes people conclude that a food is alive, we performed regression analyses for the three items that

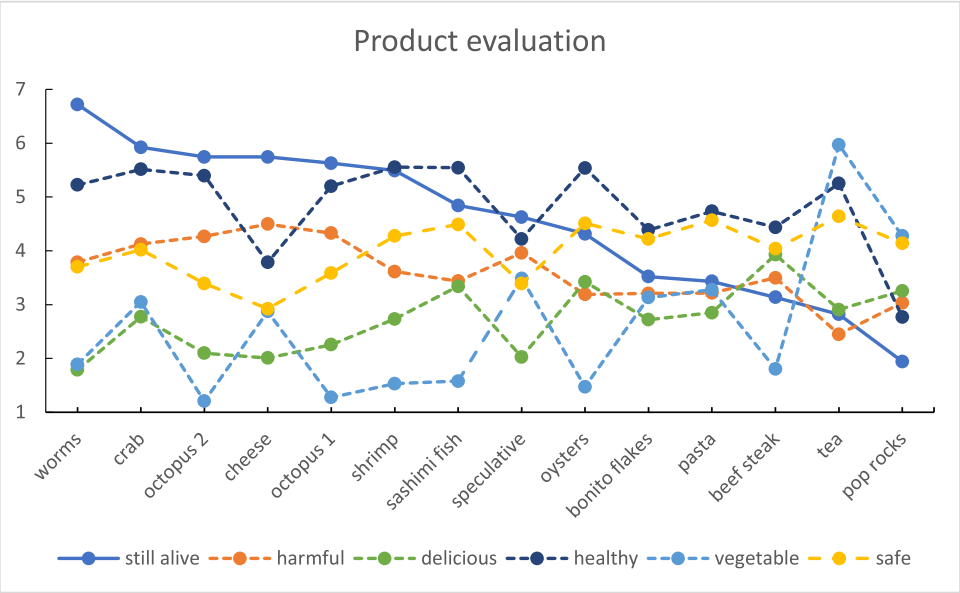

Fig. 5. Mean ratings for the evaluations of the 14 products in the videos. Standard errors of the means (N = 50–51) vary from 0.095 to 0.310 (still alive), 0.182–0.254 (harmful), 0.132–0.237 (attractive), 0.113–0.185 (nutritious), 0.056–0.245 (vegetable), and 0.205–0.299 (safe).

Table 3
Person correlation coefficients between factors with emotional responses and product evaluation aspects (N = 710).

	Disgust	Fascination	Empathy
still alive	0.573**	-0.216**	0.427**
harmful	0.598**	-0.250**	0.418**
attractive	-0.614**	0.360**	-0.220**
nutritious	-0.057	0.111**	0.059
vegetable	-0.361**	0.202**	-0.301**
safe	-0.481**	0.293**	-0.251**

* *p < 0.01.

Table 4
Standardized beta weights found in linear regressions using three items qualifying the movement of food as dependent variables and the descriptors of movement characteristics as independent variables (N = 710).

	Items describing the movement of the food		
	Movement mimics those of a living creature	*I think this food is still alive*	*Movement looks natural with the food*
fast	0.033	0.039	0.149**
twitchy	0.370**	0.127**	-0.248**
subtle	-0.052	-0.114**	0.262**
fade out	0.009	-0.086*	0.097**
R^2	0.159	0.050	0.150

* *p < 0.01; *p < 0.05.

tried to qualify the type of movement of the food (as alive or natural) as dependent variables, while using the four descriptive items assessing movement characteristics as independent variables. The 2nd and 3rd columns in Table 4 show that people are more likely to report that a product appears alive when it makes twitchy, non-subtle movements that do not fade over time. In contrast, movements tend to look natural for a food if they are subtle and maybe fast (but not twitchy) and fade over time. Since these patterns are quite opposite, we tend to conclude that the natural movements of a food item are different from those that show that the source of the food is still alive, and that people believe that prepared foods should no longer show any signs of life (Table 3).

4. General discussion

In this study, we set out to investigate the relationships between movements in foods, their role as indicators of product freshness and aliveness, and the degree to which people experience emotions like disgust and fascination. To explore these relationships, we collected videos with many different types of food items showing different types of movement, including highly processed foods and largely unprocessed foods, plant-based and animal-based foods, consisting of animal parts or whole animals, and we asked participants to rate the properties of the movements, their perceptions of the foods, and the emotional responses that were evoked.

4.1. General patterns versus responses to single stimuli

Our analysis shows that many of the product aspects that elicit disgust also trigger feelings of empathy. If we look at the relationships with the movement characteristics and the product evaluations we measured, we find quite similar correlational patterns for disgust and empathy, with opposite correlations for fascination. Overall, products that elicit empathy and disgust in our study seem alive and are considered harmful as they move twitchy, while people mainly become fascinated by foods that are perceived as attractive, safe, and nutritious, and have a vegetable origin, while their movements are subtle and look natural with the food.

However, if we look at the data and the analyses in more detail, we also find some nuanced differences that require attention. For instance, the comparison of Figs. 1 and 2 shows that disgust is particularly strong for maggots in cheese and creeping coconut worms, while participants empathize mainly with the octopus and the fish. Even though we find that disgust and empathy often co-occur, these differences suggest that people experience empathy mainly for larger animals, while they are disgusted more by insects and worms that are often considered pests in daily life.

Most of the results in our study show opposing patterns for disgust and fascination, leading us to wonder if some of the stimuli in our study could be the exception to the rule by displaying some “macabre allure” (Korsmeyer, 2011) and evoke both emotional responses. The most likely candidate in this case would be the speculative design, which has a high rating for Disgust (5.05) and one of the highest for Fascination (4.00). This assessment is further supported by an analysis of the two

items that make up the Disgust scale (Table 1). While most products show a similar ordinal relationship on the two items supporting our decision to combine the items for pragmatic purposes, the speculative design stands out with relatively high ratings for feeling scared to eat it (5.49) compared to feeling disgusted (4.61). Making an informed guess about what makes this product both disgusting and fascinating, we might suggest that the movements are slow and subtle and that the moving elements are thin and resemble insect legs; at the same time, the product is unfamiliar, which all in all gives it a weird, mystical quality and a macabre character that could be used to build suspense if used in a horror movie. Other products that rate relatively high on Disgust and Fascination are the bonito flakes (3.98 for Disgust, 4.10 for Fascination) and the shape shifting pasta (3.83 for Disgust and 3.93 for Fascination). These foods are also relatively thin, move subtly, and are unfamiliar, leaving an observer wondering where the movement comes from. The whole animal with the highest Fascination scores is the crab (4.63 for Disgust and 3.67 for Fascination). However, of these three products, only the crabs seem to have somewhat of a macabre allure as they show slightly higher ratings on feeling scared to eat (4.94) compared to feeling disgusted (4.29).

4.2. Study limitations

In our process of selecting videos, we mainly strived to have videos that would elicit different degrees of disgust in a variety of products. Our selection procedure with a focus on disgust may have introduced various types of bias that may have influenced the outcomes of our study. For instance, a relatively high number of videos involved fish and seafood. Perhaps because people are less likely to empathize with cold-blooded animals than they are with birds or mammals, some people do not mind eating moving fish or seafood, while they are less likely to appreciate dishes from warm-blooded animals that are still moving. However, it raises the question to what extent our findings can be generalized to all types of moving foods.

In addition, because we used online videos, we did not have control over many aspects that may have affected participants' responses including video quality, camera angle, the way the food was presented, the cultural context, the presence of people and the way they acted. We only standardized the videos in terms of length and sound. These aspects may have affected our outcomes and we are unsure to what extent. For instance, our pasta shape shifting video was shown at high speed, because the pace at which the pasta changes shape is very slow and gradual. However, the unnatural speed of the video may have confused our participants and made comparison with the other videos tricky, because the participants of this group are unaware of the actual speed at which transformation processes take place. There are several other ways judgments can be affected (e.g., Anderson, 1996; Peterson, Gillam, & Sedgwick, 2007). For instance, elevating the camera is likely to increase the sense of power felt by the viewer, while decreasing the distance between camera and food is likely to enhance the emotions felt. Using close ups of the animal's head or spilling body fluids can add to the degree of disgust. The presence of people and seeing their emotions is likely to increase empathy with those eating the food. Furthermore, seeing people and the consumption context is likely to activate stereotypes about gender roles, race, and culture. For instance, in the octopus 2 video the participant can see the facial expressions of the girl who puts a whole octopus in her mouth and struggles to chew and swallow the animal, while in the octopus 1 video the participant can only see the hands of someone pouring soy sauce on the octopus and does not see how the food is being eaten. Interestingly, the disgust ratings for the two foods are similar (Fig. 1), but the empathy ratings are higher for octopus 1 than for octopus 2 (Fig. 2), possibly because people empathize more with the girl than with the octopus in video 2. Many of the variables that differ between our videos could be controlled in future studies if researchers generated their own stimuli. This is likely to decrease the noise in the measurements and would make it possible to assess the nature of mechanisms more precisely.

Some of the products in the videos were presented raw, whereas others were ready-to-eat. However, as we were investigating moving and seemingly alive foods, the line between raw and prepared was extremely thin. For instance, the sashimi fish had been sliced and the shrimp had been peeled, but they were still moving just before consumption. Only with the raw steak it was clear that the product still needed to be cooked, although consuming raw beef is also not uncommon in some countries (e.g., steak tartare). Rather than distinguishing raw from prepared, the distinction between whole animal (octopus, fish, maggot) versus animal part (beef steak, fish flakes), or plant-based (pasta) and highly processed food (pop rocks) may be more noteworthy.

In our analyses, familiarity did not show up as a separate factor of influence as it was included in the attractiveness variable (Table 1). Indeed, it is quite common to find that people like to eat and are attracted to foods with which they are familiar (e.g., Tuorila, Meiselman, Bell, Cardello,& Johnson, 1994). As the sample we used consisted of people who were born in and lived in the US, we see that the sample is quite homogeneous with 79 % being Caucasian and consequently the differences in product familiarity between participants may be small. Since we conducted our study in the US, the responses may be specific to consumers in this country. In contrast, because eating moving animals is more common in other parts of the world, a large part of the videos come from Asia. Although we would expect that the mechanisms relating food movements, food perception and emotional responses are universal and similar in different cultures, it would be interesting to see how the different videos are rated on the variables. As people in Asia may be more familiar with the foods and practices in the videos, we would expect that disgust responses are lower in some Asian countries.

The multi-item measures were mainly developed for pragmatic reasons in our exploratory study and were based on the outcomes of the PCA, while in some cases they contained items that were conceptually quite distinct, such as fear and disgust, or delicious and familiar. Although the responses of the items were highly correlated with the other items in the scale, for some products the responses might deviate between items. We already saw this for the speculative design and the crabs, which rated relatively high on fear compared to their ratings on disgust. Analogously, the oysters deviated somewhat in the Attractiveness scale, with high ratings for familiarity, but lower ratings for pleasant texture. Therefore, we propose that future studies use more sophisticated measures and provide more detailed analyses of the mechanisms that can provide clarity on the exact relationships between the different variables.

In this study, we focused on the visual perception of foods. However, food is usually also touched during preparation and consumption and the tactile perception of the displayed movement might give rise to different disgust intensities, as studies indicate that tactile qualities of stickiness, wetness, oiliness, viscosity, coldness, and lumpiness can influence disgust responses (Saluja & Stevenson, 2019). In future studies it would be interesting to explore other sensory dimensions of moving and seemingly alive food products as well, including their mouthfeel and the sounds they make.

4.3. Practical implications

The wide variety of foods that we examined allowed us to identify several basic characteristics of foods that appear alive, and they are very different from what participants consider natural for a food that moves (Table 4). Most US participants are unfamiliar with eating (seemingly) live food and generally do not appreciate it, even though they appreciate food that is fresh. Nonetheless, the presentation of moving food seems to fit into a recent gastronomic trend amongst contemporary chefs to develop dishes that are likely to shock their guests (Spence & Youssef, 2022).

Would it also be possible to use aliveness in foods to support strategies that help people eat healthier or more sustainably? Some of the

videos we used make the potential suffering of animals in people's food supplies very explicit. In fact, the Internet houses multiple videos that involve the use of complete animals in dishes that we found so cruel that we considered them unsuitable for use in the study. Animal welfare concerns are one of the reasons why people are turning to vegetarian or vegan diets, which also tend to be more sustainable than omnivorous diets (Willett et al., 2019). Hence, strategies that stimulate bonding with living animals could be an interesting approach to influence food choices. In that respect, our study shows that movements of complete, more complex animals in particular evoke empathy with these animals. Movements in pieces of meat (the steak) or small animals (insects, worms) evoke much less empathy (Fig. 2).

Presenting consumers with live, moving animals could be an interesting strategy to influence the purchase and consumption of seafood, fish, birds, and small mammals, which are often sold as whole animals. For the larger animals that are sold in pieces, it seems more plausible to use other strategies to increase the connection with the living animal, for example by including (images of) the head, feet, or skin with the pieces of meat. In addition, using lifelike or real-time (moving) images of farms where animals are kept can also increase awareness of production conditions (Kranzbühler & Schifferstein, 2023). In contrast, using subtle movement to stimulate consumption could be used with plant-based foods to increase the fascination for these types of food.

However, although strategies to increase the connection to live animals are likely to be effective in inducing disgust and decreasing the appeal of animal foods in Western countries, meat producers and suppliers are unlikely to voluntarily implement such measures. Like the deterrent pictures of diseased organs that we currently see on cigarette packs, such measures will likely have to be enforced by government regulations. Hence cooperation and alignment of opinions between consumer psychologists, communication experts, food producers and legislators will be necessary to develop interventions that support people in eating healthier and more sustainable, with attention for animal welfare.

CRediT authorship contribution statement

Hendrik Schifferstein: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Visualization, Writing – original draft, Writing – review & editing, Funding acquisition. **Mailin Lemke:** Conceptualization, Methodology, Resources, Visualization, Writing – original draft, Writing – review & editing. **Gijs Huisman:** Conceptualization, Methodology, Resources, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that the study was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Acknowledgements

This experiment was based on an original idea by Bachelor students Karlijn van den Bos, Klarike Meilof, Tobias Hilberink, and Liselot Roijakkers. This research was supported by the Pride and Prejudice project by the 4TU Federation under Grant No. 4TU-UIT-346 that partly funded the personnel costs and provided the participant fees.

Appendix A. Description of the 14 videos

	Abbreviation – Food Category – Title of original video - Link to original video	Description of 10s experiment video*
1	**Oct_1** - Octopus - Dancing squid bowl dish in Hakodate https://www.youtube.com/watch?v=dxQmOR_QLfQ	You see a squid on top of a bowl of food. As soon as someone pours soy sauce over the squid, it starts moving.
2	**Tea -** Tea - Blooming tea ball flower https://www.youtube.com/watch?v=4COPalSN2Zo	You see a dried flower in a transparent cup with water. Slowly the flower starts opening and moving around a bit.
3	**Sash** - Sashimi Fish – Ikizukuri https://www.youtube.com/watch?v=SWFTT7AE490	A live fish in a net is being taken from an aquarium and a chef cuts the raw fish. When he deposits the small pieces on a half fish, you see the big part moving.
4	**Worm** - Worm - ASMR eating alive coconut worms challenge https://www.youtube.com/watch?v=Q2iRiawE4a8	Worms are crawling on a plate among parsley, pieces of pepper, and flowers. A masticating girl picks up a worm with chop sticks and bites in the worm.
5	**Bon** - Bonito fish flakes - Moving bonito flakes https://www.youtube.com/watch?v=Pt2YyGZsA6o	A dish of fried food and white sauce is covered by thin flakes that slowly move.
6	**Oct_2** - Octopus - Hateful! Challenge to eat whole live octopus! https://www.youtube.com/watch?v=C_j0deh5fLw	A girl sits behind a cutting board where several octopuses lie, in addition to a bowl of sauce. She puts the head of the octopus in her mouth and tries to masticate, while the legs of the octopus crawl outside of her mouth.
7	**Shr** - Shrimp - Shocking Japanese Food!!! LIVE https://www.youtube.com/watch?v=svb0cpqTvVQ	Shrimps lie on a plate. When the chef picks up a shrimp, you see it move. He peels the shrimp, and you see the peeled shrimp squeeze. Then he dips it in soy sauce.
8	**Che** - Cheese - Unusual Foods that Are ONLY Eaten Alive https://www.youtube.com/watch?v=O71CsR989U0 (topic starts at 7:50)	Flies walk over a cheese. Someone cuts off the top of the cheese, next to a glass of wine. You see white maggots move in the cheese. When someone moves a knife over the cheese, it sticks to the knife. Then a man puts a piece of bread with cheese in his mouth and visibly enjoys it.
9	**Spec** - Speculative dish - Living foods by Minsu Kim https://www.youtube.com/watch?v=wQWeidLRAaY	A purple, spider-like creature with eight legs, all made up of several threads, lies in a pool of reddish, fruit-like juice. The eight legs move slowly and elegantly.
10	**Pasta** - Pasta - MIT researchers create flat-pack food that takes shape in water https://www.youtube.com/watch?v=JOgJ7bB06gc Transformative appetite https://news.mit.edu/2017/researchers-engineer-shape-shifting-noodles-0525	At high speed you see a kitchen where a chef is preparing. With tweezers, a hand puts black strips of pasta in water and the strips curl up. The chef takes out the pieces of pasta with the tweezers, puts them on a plate, and adds other ingredients.
11	**Meat** - Beef steak - Raw meat twitching! https://www.youtube.com/watch?v=r6d77P6bdqU	You see a steak where many pieces are alternately twitching, as the camera zooms in.
12	**Crab** - Crab - Mukbang Raw Live Crab https://www.youtube.com/watch?v=as620Qtmf6c	You see a crab walking over a salad, when a guy puts some of the dish in his mouth. A second guy puts down his beer can, picks up some salad and the moving crab, and pops it into his mouth.
13		

	Oyst - Oyster - These Oysters are ALIVE!! https://www.youtube.co m/watch?v = GYYfhL8PKak	Three oysters lie on a plate, with a piece of lemon in the background. When someone drops a few drops of liquid (lemon juice) on the oysters one by one, they contract.
14	**Popr** - Pop rocks candy - 500 Packs of POP ROCKS! https://www.youtube.com/watch?v = WQ3l7pWxqxE	A circle of red pop rock granules lies on a turquoise plate in water and seems to sizzle a little. Then we go back in time: we see dry pop rocks on the plate when water is added, and two grains explode in succession. We see a black plate with a stack of red and blue pop rocks. Every time a drop of water falls on the stack, it results in a small local explosion.

*The 10 s videos used in the study can be obtained from the authors.

References

Ablett, S. J. (2020). *Dramatic disgust: Aesthetic theory and practice from Sophocles to Sarah Kane.* Chicago, Il: Transcript Verlag.

Allen, E. (2022). *Opinion: the world's first octopus farm in Gran Canaria would be a stain on humanity*. Retrieved from https://www.spainenglish.com/2022/01/18/world-first-octopus-farm-gran-canaria-stain-humanity/.

Amar, M., Gvili, Y., & Tal, A. (2021). Moving towards healthy: Cuing food healthiness and appeal. *Journal of Social Marketing, 11*(1), 44–63. https://doi.org/10.1108/JSOCM-03-2019-0038

Anderson, J. (1996). *The reality of illusion: An ecological approach to cognitive film theory*. Carbondale IL: SIU Press.

Basildon, P. (2015). *Chocolate pudding opens like a flower*. Retrieved from https://www.finediningloversm.com/article/chocolate-pudding-opens-flower.

Benningstad, N. C. G., & Kunst, J. R. (2020). Dissociating meat from its animal origins: A systematic literature review. *Appetite, 147*, Article 104554. https://doi.org/10.1016/j.appet.2019.104554

Choi, S. E., & Lee, K. J. (2023). Ethnic differences in attitudes, beliefs, and patterns of meat consumption among American young women meat eaters. *Nutrition Research and Practice, 17*(1), 73–90. https://doi.org/10.4162/nrp.2023.17.1.73

Cox, C. R., Goldenberg, J. L., Pyszczynski, T., & Weise, D. (2007). Disgust, creatureliness and the accessibility of death-related thoughts. *European Journal of Social Psychology, 37*(3), 494–507. https://doi.org/10.1002/ejsp.370

Deng, J., Olivier, P., & Mueller, F. F. (2023). Exploring tasty fluidics for designing food as computational artifact. *International Journal of Gastronomy and Food Science, 31*, Article 100630. https://doi.org/10.1016/j.ijgfs.2022.100630

Dunne, A., & Raby, F. (2013). *Speculative everything: Design, fiction, and social dreaming.* Cambridge, MA: MIT Press.

Ekman, P. (1999). *Basic emotions. In Handbook of cognition and emotion.* Chichester, UK: Wiley45–60.

Etherington, R. (2013). Living food by Minsu Kim. Retrieved from https://www.dezeen.com/2013/06/27/living-food-minsu-kim-synthetic-biology-royal-college-of-art/.

Evans, A. B., & Miele, M. (2012). Between food and flesh: How animals are made to matter (and not matter) within food consumption practices. *Environment and Planning D Society and Space, 30*(2), 298–314. https://doi.org/10.1068/d12810

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175–191. https://doi.org/10.3758/BF03193146

Feuer, H. N. (2022). Managing culinary adversity with food literacy: Children's encounter with whole fish and bitter greens. *International Journal of Food Design, 7*(2), 159–170. https://doi.org/10.1386/ijfd_00043_3

Fisher, M. M., Rosen, D. S., Ornstein, R. M., Mammel, K. A., Katzman, D. K., Rome, E. S., … Walsh, T. (2014). Characteristics of avoidant/restrictive food intake disorder in children and adolescents: A "New Disorder" in DSM-5. *Journal of Adolescent Health, 55*(1), 49–52. https://doi.org/10.1016/j.jadohealth.2013.11.013

Fokkinga, S., & Desmet, P. M. A. (2012). Darker shades of joy: The role of negative emotion in rich product experiences. *Design Issues, 28*(4), 42–56.

Graça, J., Calheiros, M. M., & Oliveira, A. (2014). Moral disengagement in harmful but cherished food practices? An exploration into the case of meat. *Journal of Agricultural and Environmental Ethics, 27*(5), 749–765. https://doi.org/10.1007/s10806-014-9488-9

Gvili, Y., Tal, A., Amar, M., Hallak, Y., Wansink, B., Giblin, M., & Bommelaer, C. (2015). Fresh from the tree: Implied motion improves food evaluation. *Food Quality and Preference, 46*, 160–165. https://doi.org/10.1016/j.foodqual.2015.07.015

Gvili, Y., Tal, A., Amar, M., & Wansink, B. (2017). Moving up in taste: Enhanced projected taste and freshness of moving food products. *Psychology & Marketing, 34*(7), 671–683. https://doi.org/10.1002/mar.21014

Harris, A. A., Romer, A. L., Hanna, E. K., Keeling, L. A., LaBar, K. S., Sinnott-Armstrong, W., … Zucker, N. L. (2019). The central role of disgust in disorders of food avoidance. *International Journal of Eating Disorders, 52*(5), 543–553. https://doi.org/10.1002/eat.23047

Højer, R., Wistoft, K., & Frøst, M. B. (2021). Yes I can cook a fish; effects of a five week sensory-based experiential theme course with fish on 11- to 13- year old children's food literacy and fish eating behaviour – a quasi-experimental study. *Food Quality and Preference, 92*, Article 104232. https://doi.org/10.1016/j.foodqual.2021.104232

Horton, H. (2021). *Boiling of live lobsters could be banned in UK under proposed legislation*. Retrieved from https://www.theguardian.com/world/2021/nov/19/boiling-of-live-lobsters-could-be-banned-in-uk-under-proposed-legislation.

Kelly, D. (2011). *Yuck!: The nature and moral significance of disgust.* Cambridge, MA: MIT Press.

Khara, T., Riedy, C., & Ruby, M. B. (2021). A cross cultural meat paradox: A qualitative study of Australia and India. *Appetite, 164*, Article 105227. https://doi.org/10.1016/j.appet.2021.105227

Korsmeyer, C. (2011). *Savoring disgust: The foul and the fair in aesthetics.* Oxford University Press.

Kranzbühler, A. M., & Schifferstein, H. N. J. (2023). The effect of meat-shaming on meat eaters' emotions and intentions to adapt behavior. *Food Quality and Preference, 107*, Article 104831. https://doi.org/10.1016/j.foodqual.2023.104831

Kubberød, E., Ueland, Ø., Tronstad, Å., & Risvik, E. (2002). Attitudes towards meat and meat-eating among adolescents in Norway: A qualitative study. *Appetite, 38*(1), 53–62. https://doi.org/10.1006/appe.2002.0458

Kunst, J. R., & Hohle, S. M. (2016). Meat eaters by dissociation: How we present, prepare and talk about meat increases willingness to eat meat by reducing empathy and disgust. *Appetite, 105*, 758–774. https://doi.org/10.1016/j.appet.2016.07.009

Kunst, J. R., & Palacios Haugestad, C. A. (2018). The effects of dissociation on willingness to eat meat are moderated by exposure to unprocessed meat: A cross-cultural demonstration. *Appetite, 120*, 356–366. https://doi.org/10.1016/j.appet.2017.09.016

Lakens, D. (2022). Sample size justification. *Collabra Psychology, 8*(1), 33267. https://doi.org/10.1525/collabra.33267

Lemke, M., Boon, B., & Schifferstein, H. N. J. (2021). Between attraction and aversion: How designers can use the concept of disgust to influence food consumption. *International Journal of Food Design, 6*(1), 67–102.

Lemke, M., & de Boer, B. (2022). Setting the stage: Disgust as an aesthetic food experience. *Design Issues, 38*(3), 20–33. https://doi.org/10.1162/desi_a_00689

Li, S., & Liu, P. (2022). Will "moving" food tastes better? Effect of dynamic food image in print advertising on food taste perception. *Journal of Sensory Studies, 37*(1), Article e12719. https://doi.org/10.1111/joss.12719

Loughnan, S., Haslam, N., & Bastian, B. (2010). The role of meat consumption in the denial of moral status and mind to meat animals. *Appetite, 55*(1), 156–159. https://doi.org/10.1016/j.appet.2010.05.043

Huisman, G., Bruijnes, M., & Heylen, D.K. J. (2016). A moving feast: Effects of color, shape and animation on taste associations and taste perceptions. In Proceedings of the thirteenth international conference on advances in computer entertainment technology, Osaka, Japan. Retrieved from https://doi.org/10.1145/3001773.3001776.

Lübke-Naberhaus, F. (2011). *German kids endure hare-raising experience*. Retrieved from https://www.spiegel.de/international/germany/slaughtered-at-school-german-kids-endure-hare-raising-experience-a-754363.html.

Maack, D. J., Buchanan, E., & Young, J. (2015). Development and psychometric investigation of an inventory to assess fight, flight, and freeze tendencies: The fight, flight, freeze questionnaire. *Cognitive Behaviour Therapy, 44*(2), 117–127. https://doi.org/10.1080/16506073.2014.972443

Magalhães, L. C. d C., Costa, R. B., & de Camargo, G. M. F. (2022). Consumption of rabbit meat in Brazil: Potential and limitations. *Meat Science, 191*, Article 108873. https://doi.org/10.1016/j.meatsci.2022.108873

Manokara, K., Lee, A., Kamble, S. V., & Krumhuber, E. G. (2021). Mind your meat: Religious differences in the social perception of animals. *International Journal of Psychology, 56*(3), 466–477. https://doi.org/10.1002/ijop.12717

Markwell, L. (2012). *World's best restaurant is coming to town… and it's serving ants*. Retrieved from https://www.independent.co.uk/life-style/food-and-drink/news/world-s-best-restaurant-comes-to-town-and-it-s-serving-ants-7995007.html.

Martins, Y., & Pliner, P. (2006). "Ugh! That's disgusting!": Identification of the characteristics of foods underlying rejections based on disgust. *Appetite, 46*(1), 75–85. https://doi.org/10.1016/j.appet.2005.09.001

Menninghaus, W., Wagner, V., Hanich, J., Wassiliwizky, E., Jacobsen, T., & Koelsch, S. (2017). The distancing-embracing model of the enjoyment of negative emotions in art reception. *Behavioral and Brain Sciences, 40*, Article e347. https://doi.org/10.1017/S0140525×17000309

Moore, H. (2014). *PETA's 'Tiffany Tuna' Asks San Franciscans to 'Try Vegan'*. Retrieved from https://www.peta.org/blog/tiffany-tuna-try-vegan/.

Motoki, K., & Sugiura, M. (2018). Disgust, sadness, and appraisal: Disgusted consumers dislike food more than sad ones. *Frontiers in Psychology, 9*. https://doi.org/10.3389/fpsyg.2018.00076

Mulier, L., Meersseman, E., Vermeir, I., & Slabbinck, H. (2021). Food on the move: The impact of implied motion in pictures on food perceptions through anticipated pleasure of consumption. *Foods, 10*(9), 2194. 〈https://www.mdpi.com/2304-8158/10/9/2194〉.

Oaten, M., Stevenson, R. J., & Case, T. I. (2009). Disgust as a disease-avoidance mechanism. *Psychological Bulletin, 135*(2), 303–321. https://doi.org/10.1037/a0014823

Paul Ekman Group (2022). Disgust. Retrieved from https://www.paulekman.com/universal-emotions/what-is-disgust/.

PETA (2011). *Monica Dogra's new PETA Ad*. Retrieved from https://www.petaindia.com/blog/monica-dogra-s-new-peta-ad/.

Peterson, M.A., Gillam, B., & Sedgwick, H.A. (2007). *In the mind's eye: Julian Hochberg on the perception of pictures, films, and the world*. Oxford, UK: Oxford University Press.

Polák, J., Rádlová, S., Janovcová, M., Flegr, J., Landová, E., & Frynta, D. (2020). Scary and nasty beasts: Self-reported fear and disgust of common phobic animals. *British Journal of Psychology, 111*(2), 297–321. https://doi.org/10.1111/bjop.12409

Possidónio, C., Piazza, J., Graça, J., & Prada, M. (2022). An appetite for meat? Disentangling the influence of animal resemblance and familiarity. *Appetite, 170*, Article 105875. https://doi.org/10.1016/j.appet.2021.105875

Rothgerber, H. (2020). Meat-related cognitive dissonance: A conceptual framework for understanding how meat eaters reduce negative arousal from eating animals. *Appetite, 146*, Article 104511. https://doi.org/10.1016/j.appet.2019.104511

Rothgerber, H., & Mican, F. (2014). Childhood pet ownership, attachment to pets, and subsequent meat avoidance. The mediating role of empathy toward animals. *Appetite, 79*, 11–17. https://doi.org/10.1016/j.appet.2014.03.032

Rousset, S., Deiss, V., Juillard, E., Schlich, P., & Droit-Volet, S. (2005). Emotions generated by meat and other food products in women. *British Journal of Nutrition, 94*(4), 609–619. https://doi.org/10.1079/BJN20051538

Rozin, P., & Fallon, A. E. (1987). A perspective on disgust. *Psychological Review, 94*, 23–41.

Saluja, S., & Stevenson, R. J. (2019). Perceptual and cognitive determinants of tactile disgust. *Quarterly Journal of Experimental Psychology, 72*(11), 2705–2716. https://doi.org/10.1177/1747021819862500

Siegrist, M., & Hartmann, C. (2020). Consumer acceptance of novel food technologies. *Nature Food, 1*(6), 343–350. https://doi.org/10.1038/s43016-020-0094-x

Simoons, F.J. (1994). *Eat not this flesh: food avoidances from prehistory to the present.* 2nd ed. Madison WI: University of Wisconsin Press.

Soon, J. M., & Tee, E. S. (2014). Changing trends in dietary pattern and implications to food and nutrition security in association of Southeast Asian Nations (ASEAN). *International Journal of Nutrition and Food Sciences, 3*(4), 259–269. https://doi.org/10.11648/j.ijnfs.20140304.15

Spence, C. (2018). Why are animate dishes so disturbing? *International Journal of Gastronomy and Food Science, 13*, 73–77. https://doi.org/10.1016/j.ijgfs.2018.07.001

Spence, C., & Youssef, J. (2022). On the rise of shocking food. *International Journal of Gastronomy and Food Science, 30*, Article 100615. https://doi.org/10.1016/j.ijgfs.2022.100615

Tao, Y., Lee, Y.-C., Liu, H., Zhang, X., Cui, J., Mondoa, C., … Yao, L. (2021). Morphing pasta and beyond. *Science Advances, 7*(19), Article eabf4098. https://doi.org/10.1126/sciadv.abf4098

Tian, Q., Hilton, D., & Becker, M. (2016). Confronting the meat paradox in different cultural contexts: Reactions among Chinese and French participants. *Appetite, 96*, 187–194. https://doi.org/10.1016/j.appet.2015.09.009

Toet, A., van Schaik, M. G., Kaneko, D., & van Erp, J. B. F. (2019). Do food cinemagraphs evoke stronger appetitive responses than stills? *International Journal of Food Design, 4*(1), 63–83. https://doi.org/10.1386/ijfd.4.1.63_1

Tuorila, H., Meiselman, H. L., Bell, R., Cardello, A. V., & Johnson, W. (1994). Role of sensory and cognitive information in the enhancement of certainty and liking for novel and familiar foods. *Appetite, 23*(3), 231–246. 〈http://www.sciencedirect.com/science/article/pii/S0195666384710567〉.

Van Doleweerd, E., & Bruns Alonso, M. (2023). The creation of a holistic interactive dining experience with shape-changing food materials at restaurant alchemist. *In* Proceedings of the seventeenth international conference on tangible, embedded, and embodied interaction, Warsaw, Poland. Retrieved from https://doi.org/10.1145/3569009.3572791.

van Hooff, J. C., Devue, C., Vieweg, P. E., & Theeuwes, J. (2013). Disgust- and not fear-evoking images hold our attention. *Acta Psychologica, 143*(1), 1–6. https://doi.org/10.1016/j.actpsy.2013.02.001

van Overveld, M., de Jong, P. J., & Peters, M. L. (2010). The disgust propensity and sensitivity scale – revised: Its predictive value for avoidance behavior. *Personality and Individual Differences, 49*(7), 706–711. https://doi.org/10.1016/j.paid.2010.06.008

van Overveld, M., de Jong, P. J., Peters, M. L., & Schouten, E. (2011). The disgust Scale-R: A valid and reliable index to investigate separate disgust domains? *Personality and Individual Differences, 51*(3), 325–330. https://doi.org/10.1016/j.paid.2011.03.023

van Rompay, T. J. L., Fransen, M. L., & Borgelink, B. G. D. (2014). Light as a feather: Effects of packaging imagery on sensory product impressions and brand evaluation. *Marketing Letters, 25*(4), 397–407. https://doi.org/10.1007/s11002-013-9260-3

Veeck, A. (2010). Encounters with extreme foods: Neophilic/neophobic tendencies and novel foods. *Journal of Food Products Marketing, 16*(2), 246–260. https://doi.org/10.1080/10454440903413316

Warwick, J. (2015). *The truth about Noma's live prawn dish*. Retrieved from https://www.theguardian.com/lifeandstyle/wordofmouth/2015/jan/30/noma-live-prawn-dish-japan-truth.

Wijayaratne, S. P., Reid, M., Westberg, K., Worsley, A., & Mavondo, F. (2018). Food literacy, healthy eating barriers and household diet. *European Journal of Marketing, 52*(12), 2449–2477. https://doi.org/10.1108/EJM-10-2017-0760

Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., … Murray, C. J. L. (2019). Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems. *The Lancet, 393*(10170), 447–492. https://doi.org/10.1016/S0140-6736(18)31788-4

Woo, P. C., Lau, S. K., & Yuen, K. Y. (2006). Infectious diseases emerging from Chinese wet-markets: Zoonotic origins of severe respiratory viral infections. *Current Opinion in Infectious Diseases, 19*(5), 401–407. https://doi.org/10.1097/01.qco.0000244043.08264.fc

Woody, S. R., & Teachman, B. A. (2000). Intersection of disgust and fear: Normative and pathological views. *Clinical Psychology: Science and Practice, 7*(3), 291–311. https://doi.org/10.1093/clipsy.7.3.291

Wyman, O. (2013). *Getting fresh: Lessons from the global leaders in fresh food*. Retrieved from http://www.oliverwyman.com/content/dam/oliver-wyman/europe/germany/de/insights/publications/2015/jan/OW_POV_Getting%20Fresh.pdf.

York, R., & Gossard, M. H. (2004). Cross-national meat and fish consumption: Exploring the effects of modernization and ecological context. *Ecological Economics, 48*(3), 293–302. https://doi.org/10.1016/j.ecolecon.2003.10.009

Yu, J., Droulers, O., & Lacoste-Badie, S. (2022). Why display motion on packaging? The effect of implied motion on consumer behavior. *Journal of Retailing and Consumer Services, 64*, Article 102840. https://doi.org/10.1016/j.jretconser.2021.102840

Zhong, S., Crang, M., & Zeng, G. (2020). Constructing freshness: The vitality of wet markets in urban China. *Agriculture and Human Values, 37*(1), 175–185. https://doi.org/10.1007/s10460-019-09987-2