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Craving healthy foods?! How sensory appeals increase appetitive motivational processing of healthy foods in adolescents

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ABSTRACT

The study examined how sensory appeal characteristics promoting fruits and vegetables capture attention, emotion, and memory formation, indicative of approach motivational processing. Grounded in biopsychological and communication science frameworks such as evolutionary theories, information-processing, LC4MP, and the dimensional emotion theory, two within-subjects experiments investigated how adolescents process pronutritional images appealing to the senses. Study 1 (N = 58, aged 12–18, 54% female) examined how sensory cues broke through the clutter of promotional media, attracting attentional selection, arousal and affect. Study 2 (N = 165, aged 12–18, 53% female) explored whether sensory appeal characteristics further directed the attention and mental resources toward processing the core healthy foods of fruits and vegetables. Eye-tracking provided an assessment of visual attentional focus and recognition memory indicated encoding efficiency. As hypothesized, core nutritious foods became noticeable, highly arousing, and memorable stimuli with adaptive significance to the organism when portrayed as enjoyable and ripe, through hedonic and palatability appeals. Sensory cues increased adolescents' attentional selection and positive emotions to the pronutritional images, but also attracted visual focus and high memory formation of the fruits and vegetables. Health communication practice should take advantage of these results and promote core healthy foods through hedonic and visual food palatability appeals.

The ubiquitous advertising for snacks and the resulting increase in unhealthy eating (Jahns, Siega-Riz, & Popkin, 2001) have been found to contribute to the worrisome obesity epidemic, especially among youth (Harris, Bargh, & Brownell, 2009). To counter the impact of unhealthy food consumption and to prevent obesity, this project focuses on promoting healthy foods. Such promotional messages are few and rely on utilitarian appeals (Coleman, 1986), which reach limited, small effects (Papies, 2016; Schor & Ford, 2007). Utilitarian cues activate mechanisms of inhibition and suppression

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of eating (Harris et al., 2009) causing subsequent binge eating, higher responsiveness, and obsessive preoccupation with food (Stice, Presnell, & Spangler, 2002). Utilitarian appeals are thus ineffective, especially for youth.

Snack food commercials use palatability and hedonic cues to appeal to adolescents, who are highly susceptible to this sensory stimulation because their excitatory mechanisms are overactive while their inhibitory neural mechanisms are slowly developing (Casey, Jones, & Hare, 2008). Pronutritional messages can be more effective if also using sensory cues. Yet, healthy food promotions neglected this potential; which is surprising because these properties deeply regulate the feeding process (Dominy, Lucas, Osorio, & Yamashita, 2001) and elicit automatic responses associated with appetite and food intake (Lee, Lee, Lee, & Song, 2013).

This study explores a new approach, grounded in psychology, communication, and food science, to promote the core healthy foods of fruits and vegetables (with energy values below 90 kcal/100 g). It does so through sensory appeal characteristics associated with the approach/appetitive motivational system (Ito, Cacioppo, & Lang, 1998; Lang, Bradley, & Cuthbert, 1990), guiding information processing and behavior to approach things that may be beneficial. We argue that there is a critical need to promote core healthy foods and to do so through appeals to the senses, thus associating the healthy foods with the appetitive motivational system. As adolescents form this association, their excitatory mechanisms become more active, triggering motivated attention (Lang, Bradley, & Cuthbert, 1997), positive affect, and cognition leading to persistent healthy eating. This research examines the effects of visual food palatability and of the hedonic enjoyment of consuming core foods in attracting attention, memory, arousal and affect. To this aim, we conduct two studies: Study 1 investigates whether visual food palatability and hedonic appeal characteristics can break through the clutter of promotional media by capturing attentional selection, arousal, and affect for the pronutritional messages. These are prerequisites for detail-processing stages when the mental resources elicited through appetitive system activation are guided to process specific healthy food elements of the pronutritional messages. Study 2 examines whether hedonic and visual palatability appeals can further direct visual attentional focus to the core healthy foods and enhance memory formation for them.

Theoretical framework

Hot hedonic mechanisms

Consumer responses are largely driven by hedonic mechanisms, which emphasize the emotional pleasure experienced or anticipated through consumption (Hirschman & Holbrook, 1982). Activating fast, automatic

responses (Cacioppo & Gardner, 1999), these mechanisms are part of the hot cognition system (Kunda, 1999) and regulate responses in situations of immediacy (Read & Van Leeuwen, 1998). When food deprivation triggers hunger modes, information processing becomes automatic and cognitive resources limited. When hungry, people use information processing that is primarily influenced by basic and swift reactions regulated by the hedonic system (Read & Van Leeuwen, 1998; Shiv & Fedorikhin, 1999).

Popular snack commercials appeal to the senses through hedonic and palatability cues: Their prevalent strategies rely on the hedonic appeals of enjoyment/fun and the palatability appeal of food attractiveness and pleasantness, especially when targeting teens (Buijzen & Valkenburg, 2002; Page & Brewster, 2007; Stitt & Kunkel, 2008). Based on these findings, hedonic and palatability cues are expected to also increase the appeal of healthy foods, in response to calls by the World Health Organization (WHO, 2005, 2006) and publications (Papies, 2016). Cognitive, evolutionary, and media psychology guide the formulation of specific hypotheses.

Processing food cues

Dimensional theories of emotion and information processing frameworks posit that attention is automatically guided by sensory-emotional stimuli, which are instantly identified as motivationally relevant (Cacioppo & Gardner, 1999; Lang et al., 1997). The overarching control system of motivation facilitates preferential access to stimuli with adaptive significance to the organism, thus sculpting the information processing systems (Lang, 2009; Lang et al., 1997; Taylor & Fragopanagos, 2005). Human responses to incoming stimuli are a function of activation in the two motivational systems: the approach and the aversive (Ito et al., 1998; Lang et al., 1990). The consummatory approach system sustains life through the motivation to approach things that may be beneficial in a relatively neutral environment. Orienting audiences toward stimuli for information intake, the appetitive system activation is associated with attentional selection of stimuli for processing (Lang et al., 1997), with a decrease in negative affect, an increase in positive affect and in arousal (Bolls, 2017; Lang et al., 1990).

High-calorie unhealthy foods were found to activate the approach motivational system (Bailey, 2016; Killgore, Young, Bogorodzki, & Yurgelun, 2003; van der Laan, De Ridder, Viergever, & Smeets, 2011). Compared to the unhealthy items, healthy foods attract less visual attention (Spielvogel, Matthes, Naderer, & Karsay, 2018), are estimated as less desirable to eat (Bailey, 2016), and fail to activate the appetitive motivational system overall (Killgore et al., 2003; Toepel, Knebel, Hudry, le Coutre, & Murray, 2009; van der Laan et al., 2011). Although previous research extensively explored the effects of unhealthy foods on appetitive system activation, the motivated processing of core healthy foods has been relatively neglected.

The dimensional theories of emotion, media psychology and information processing frameworks are applied to depictions of core healthy foods, an area of demonstrated low appetitive motivational activation. It is argued that, besides the content type of stimuli (violence, sex, healthy or unhealthy foods), the appeals through which the stimuli are depicted influence their processing. Motivationally relevant appeal characteristics, such as hedonic enjoyment of food and appetite-related palatable ripeness, can portray core foods as appetizing and subsequently elicit appetitive processing. The sensory visual appeals regulating feeding behaviors will elicit motivated attention, arousal, and affect to the pronutritional images and to the healthy foods. Theoretical frameworks are thus further extended through consideration of how motivationally relevant appeal characteristics can be used to elicit motivational attention, mental resource allocation and affective responses to fruits and vegetables.

Few publications allude to the effectiveness of the hedonic system in promoting healthy foods (Bruce et al., 2016; Hanks, Just, & Brumberg, 2016; Papies, 2016). Hanks et al. (2016) revealed that children chose to eat twice as many vegetables when they were advertised through fun, hedonic appeals: depicting healthy foods as humanized cheerful cartoon characters. Although the study was not grounded in psychology nor communication science, it can be argued that hedonic message characteristics contributed to the increased healthy eating. Promoting core nutritious foods through hedonic visual appeals is expected to lower negative affect and to increase attentional selection, positive affect, and arousal to pronutritional messages:

H1: Pronutritional messages with higher hedonic visual appeals will result in lower negative affect, greater attentional self-selection, greater positive affect, and greater arousal than those lower on hedonic visual appeals.

Evolutionary survival and food appearance

Supporting life for millions of years, the feeding process selected motivational sensory mechanisms to help its functioning (Dominy et al., 2001). These mechanisms are deeply ingrained in human systems, unlike the calorie and nutrient considerations of utilitarian diets, which are abstract constructs (Eertmans, Baeyens, & Van Den Bergh, 2001). Food intake patterns thus cannot be modeled through calories and nutrients, but they are better understood when focusing on the motivational mechanisms underlying the foraging feeding process, particularly those identifying palatable foods (Dominy et al., 2001). Food palatability conceptualizes the perceived pleasantness and attractiveness of food items reflected through their sensory properties (Kissileff, 1976, 1990; Le Magnen, 1987). Foods characteristics are primarily determined based on their appearance, as the first taste is through the eyes

(van der Laan et al., 2011). Providing crucial information from distance (Dominy et al., 2001), the importance of the visual sense in food identification cannot be overstated. This research hence focuses on the visual properties of core foods, conceptualized as visual food palatability.

Visual acuity mechanisms have evolved to locate ripe fruits in the vegetation (Dominy et al., 2001). Ripening is the physiological process that increases the perceived edibility and palatability of fruits and vegetables without changing their energy values (Barrett, Beaulieu, & Shewfelt, 2010; Nelson, Miller, Heske, & Fahey, 2000; Saltveit, 2005). People prefer ripe fruits and vegetables that are of orange and reddish saturated colors: Food and drink items with intensely saturated red-orange colors are perceived to be sweeter, more pleasant, and flavorful (Koch & Koch, 2003). Beyond enhancing the perceived flavor (Bayarri, Calvo, Costell, & Durán, 2001), color saturation indicating ripeness got foods to be appraised as "most delicious" (Lee et al., 2013, p. 513). The authors argue that the preference for saturated colored foods stems from the odds of ripe food intake (Lee et al., 2013). Based on these ingrained mechanisms, visual food palatability is identified through the color saturation of orange and reddish fruits and vegetables, revealing their ripeness (Barrett et al., 2010; Francis, 1995).

The palatability appeals indicating ripeness and pleasantness through food color saturation (Kissileff, 1976; Le Magnen, 1987) are expected to attract more attentional self-selection, arousal, positive affect, and lower negative affect. The study further enquires whether palatability and hedonic appeals interact in influencing affect, arousal and attention:

H2: Pronutritional messages with higher visual food palatability appeals will result in lower negative affect, greater attentional self-selection, greater positive affect, and greater arousal than those lower on visual food palatability appeals.

RQ1: Will visual food palatability and hedonic appeals interact in their influence on negative affect, attentional self-selection, positive affect, and arousal?

Method study 1

Design and independent variables

To test the formulated hypotheses and to answer the research question, an experiment with a 2 Hedonic Visual Appeal) × 2 (Visual Food Palatability Appeal) × 12 (Message) within-subjects factorial design was conducted. The stimuli consisted of images depicting adolescents consuming or preparing to consume common fruits and vegetables of orange and reddish colors such as oranges, apple fruits or ball

peppers, squash vegetables.[1] Both Hedonic and Palatability Appeals had two levels: Low and High. Messages in the High Hedonic category displayed people visibly experiencing pleasure as they are enjoying the healthy foods. Messages in the Low Hedonic condition contained lower to no displays of pleasure of eating (for exemplars of categories, see Figure 1). Visual Food Palatability Appeals varied through the color saturation of fruits and vegetables indicating ripeness, food attractiveness, and pleasantness (Barrett et al., 2010; Francis, 1995; Kissileff, 1976, 1990; Le Magnen, 1987) without changing the food energy values (Nelson et al., 2000; Saltveit, 2005)—one of the optimal operationalizations of Visual Food Palatability. The foods in the High Palatability category were intensely color-saturated ripe; the foods in the Low Palatability category were less color-saturated. Image assignment to the manipulation conditions was done randomly, assuring that food types are matched across conditions. The within-subjects treatment of Appeal has relatively high internal validity because subjects serve as their own control in comparisons across treatment levels, with more propitious opportunities for comparisons and causal inferences (Reeves & Geiger, 1994). The food types were diverse and matched across conditions to control for food preference. Superimposed in the lower right corner of every image, one of the depicted healthy foods was enlarged, as it is often done in print ads. It increased the visibility of the foods. The stimuli were rated prior to the experiment (see Message Selection Pilot Studies for details).

Message was a within-subjects repetition factor incorporated as a control. There were 12 different images representing each category of appeal; thus, participants were exposed to 48 images in total. Multiple messages are suggested in experimental research to reduce confounding factors within a single message (Reeves & Geiger, 1994) and to validly generalize findings to the larger media landscape (Jackson, 1992). The experimental presentation

Figure 1. Exemplars of Hedonic Visual Appeal manipulation: Left image presenting low Hedonic Appeals, right image presenting high Hedonic Appeals.

displayed the images in random order to partial out the influence of message position on the dependent variables.

Message selection pilot studies

Existing pronutritional media materials were identified and selected based on the young age of their protagonists. Because the available media were insufficient, images were created with several preconditions: First, the food items (displaying a large variety of familiar fruits and vegetables) should be central to the image topic; Second, the photos should follow a similar style: main subject(s) in spotlight, realistically portrayed in a cafeteria/lounge background—which was blurred so that the focus is entirely on subject(s). The faces of the models were framed to cover similar image surface across conditions, controlling for the primacy of face processing (Young & Bruce, 2011). The faces of the models were commonly oriented toward the healthy foods they were consuming, in realistic representations of eating situations. The biological sex of models was controlled by including relatively equal numbers of boys and girls. Context factors such as luminosity and background color were varied and matched across conditions.

Fliers distributed in schools and during open-university days for high school students recruited underage individuals to pose in images promoting healthy food. Upon receiving consent from the adolescents and their parents, approximately 300 images were created by a professional photographer. The created and the existing media pronutritional materials were viewed and rated by colleagues of the authors, all experts in the field of youth and media ($N = 7$). This initial pilot test uncovered that the existing media materials differed significantly in terms of image quality and model attractiveness from the locally created ones. To keep all conditions constant in terms of image quality and model attractiveness, all the existing media images were excluded.

A second pilot test with volunteering students ($N = 19$) was conducted on a pool of 96 stimuli images created. Based on the ratings provided, stimuli images were then selected so that they differed significantly on the display of hedonic pleasure, yet had similar ratings on all other potentially confounding factors, such as face size and prominence,[2] model attractiveness, etc. Those with the highest consistency in ratings were chosen. Efforts were also made so that the images matched in the types of fruits and vegetables displayed across the conditions. The pilot testing also verified that the selected photos have minimum distracting elements, good photographic quality, clear focus, displaying clearly the subject(s), whose faces and facial expressions are visible. Analyses of difference (ANOVAs) revealed a significant main effect of Hedonic Visual Appeals, $F(1, 17) = 3.31$, $p = .004$. There were no significant effects on the other factors: the mixed-model ANOVAs showed similar ratings with p values ranging from .48 to .96.

Dependent variables

Attentional self-selection

The experimental task offered participants the opportunity to select the images of their choice (displayed as small-medium icons) by clicking to enlarge to full-screen for better viewing. Participants were instructed that only a limited number of images could be selected, so they should choose the images they want to see the most. By clicking to enlarge to full-screen, subjects self-selected the images to attend to, without being able to go back or enlarge a formerly seen image. The website software recorded the order of the choices made, which was averaged to create the attentional self-selection: low values indicate high attentional self-selection.

The attentional self-selection was collected through a website with four webpages, each containing 12 image hyperlinks in a 4 × 3 grid. The grid image position within the webpage was randomized upon every trial to partial out the influence of image position. Each webpage consisted of all the four Appeal conditions, three message repetitions within a webpage and four message repetitions across webpages. The 12 images presented in the categories of Appeal were randomized so that any one could be displayed in any webpages, but ensuring that all four conditions were displayed in each webpage three times. In each webpage, all experimental conditions competed with each other and the task repeated until participants chose all 48 images.

Emotion: arousal and affect

Participants self-reported their arousal using the Self-Assessment Mannequin (SAM; Bradley, Greenwald, Petry, & Lang, 1992), after viewing each image. SAM is a nonverbal pictorial scale comprised of five figures with varying facial expressions of arousal (ranging from calm to excited), assessed by selecting an image or a spot between two images, which thus translates into a 9-point scale validated by prior research and especially fitted to indicate emotional responses in children. Participants also rated their negativity (ranging from neutral to negative) and positivity (ranging from neutral to positive) after viewing each image. Consistent with the SAM arousal scale, modified SAM affect scales were used, which were developed for the purposes on this experiment by adding two extra images with gradual variation in the facial expression of negativity and positivity, respectively.

Participants and procedure

The University's Ethics Committee approved the research prior to participant recruitment. Fifty-eight secondary school students (28 girls; M_{age} = 15.52, SD_{age} = 1.49, ranging from 12 to 18) participated with parental and school consent. The age-range was selected because secondary school children make

more of their food consumption choices: Adolescents, and not their parents, are thus the most appropriate target for healthy eating interventions. The participants were recruited from classes and offered opportunities to win various prizes. To prevent sensitization to the research purpose and to reduce potential socially-desirable responses, information materials invited students to participate in a study on rating positive images. The cover story was believed, as revealed in the open-ended assessments about the study topic.

Upon arrival, participants provided informed assent and were informed about the procedure. To ensure the visibility of the images as small-medium icons, all participants were seated approximately 60 cm away from a laptop computer with a 15.4″ diagonal screen displaying the welcoming page, which guided them through the experiment. After viewing all images and making all their attentional self-selections, the volunteers provided demographics. They were also asked to write in their own words what was the purpose of the study and what were their reasons for selecting the images and for their respective evaluations. At the end of the experiment, the participants were debriefed and thanked for their participation. The study reported here is part of a larger research project with another within-subjects three-level unrelated factor. Thus, the webpages with 12 images displayed all the experimental conditions of the three factors.

Data cleaning and analysis

The data were exported from the website software and formatted for analysis with SPSS Statistics 21. Repeated measures ANOVAs 2 (Hedonic Appeal) × 2 (Palatability Appeal) × 12 (Message) were performed. To correct for the violation of sphericity in repeated measures designs, the Greenhouse-Geisser epsilon procedure was applied (Vasey & Thayer, 1987). All reported post-hoc tests used a Bonferroni correction.

Results study 1

All predictions of H1 were supported (see Table 1 for details). Pronutritional messages with higher Hedonic Visual Appeals elicited significantly lower negative affect than those with lower Hedonic Appeals. Pronutritional messages with higher Hedonic Visual Appeals were significantly more likely to be selected as first choices than pronutritional messages with lower Hedonic Appeals. Similar patterns were found on the positive affect and arousal levels: Pronutritional visual messages displaying higher Hedonic Visual Appeals elicited significantly greater positive affect and arousal than those lower on hedonic appeals.

H2 was partly supported (see Table 1). Results revealed that pronutritional messages with higher Visual Food Palatability Appeals were significantly more likely to be selected as first choices than those with lower Palatability

Table 1. Analysis of variance (ANOVA) study 1.

			M (SE)	
Main effects Hedonism	$F(1,48)$	η^2	Low Hedonic Visuals	High Hedonic Visuals
Negative affect	59.26***	.34	4.08 (.18)	2.81 (.14)
Attentional self-selection	104.77***	.28	7.42 (.09)	5.58 (.09)
Positive affect	72.32***	.44	3.96 (.15)	5.53 (.21)
Arousal	36.11***	.23	2.69 (.16)	3.56 (.24)
Main effects Palatability	$F(1,48)$	η^2	Low Visual Palatability	High Visual Palatability
Negative affect	ns		3.47 (.15)	3.41 (.14)
Attentional self-selection	5.06*	.01	6.67 (.07)	6.33 (.07)
Positive affect	ns		4.71 (.17)	4.78 (.15)
Arousal	ns		3.11 (.19)	3.15 (.18)
Interaction effects	$F(1,48)$	η^2	Low Visual	High Visual
Hedonic Visuals × Visual Palatability Appeals on negative affect	5.90**	*.01*	Palatability *M (SE)*	Palatability *M (SE)*
Low Hedonic Visuals *M (SE)*			4.19 (.19)	3.95 (.17)
High Hedonic Visuals *M (SE)*			2.65 (.16)	2.76 (.17)

Note. ***$p < .001$. **$p < .01$. *$p < .05$.

Appeals. There were nonsignificant effects of Palatability Appeals on the self-reported negative affect, positive affect, and arousal.

Results also revealed that Visual Food Palatability and Hedonic Appeals interacted significantly in their influence on negative affect. As seen in Figure 2, in response to RQ1, the low Palatability low Hedonic Visual Appeals ($M = 4.19$, $SE = .19$) elicited the highest negative affect, significantly higher than the high Palatability low Hedonic Appeals ($M = 3.95$, $SE = .17$), $t(51) = 2.51$, $p = .01$, $d = .35$ and significantly higher than the high Palatability high Hedonic Appeals ($M = 2.76$, $SE = .17$), $t(51) = 7.21$, $p < .001$, $d = .90$, which did not differ significantly from the low Palatability high Hedonic Visual Appeals ($M = 2.65$, $SE = .16$), $t(51) = 1.35$, n.s.

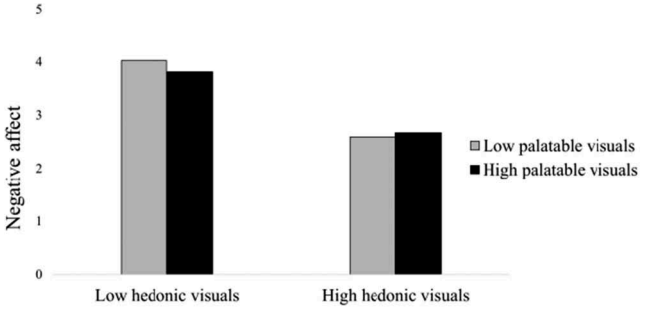

Figure 2. Negative affect elicited by pronutritional messages using Visual Palatability and Hedonic Appeals.

Discussion study 1

When the food consumption is portrayed as pleasurable, pronutritional images became noticeable, highly arousing, highly positive stimuli with adaptive significance to the organism. Visual Hedonic and Palatability cues automatically captured motivated attention to the processing of pronutritional images containing them, as predicted (Lang et al., 1997). The pronutritional images using high Hedonic Appeals also significantly influence viewers' affect and arousal, potential indicators of activation of the consummatory approach motivational system (Bolls, 2017; Ito et al., 1998; Lang et al., 1990). The findings reported in Study 1 are not only statistically significant, but also with considerably high effect sizes. They strongly demonstrated the effectiveness of Hedonic Visual Appeals.

Unlike the Hedonic Appeals, the current manipulation of Visual Food Palatability Appeals resulted in null findings on affect and arousal for the pronutritional images. These findings may have methodological explanations. The Visual Food Palatability was achieved through fine manipulations in color saturation, which might have been too subtle. Viewers may also have self-assessed their emotions to the pronutritional images based on the content of the entire image and not on the subtle color manipulation of the food elements depicted. It is reasonable that the appraisals of the pronutritional images may have also reflected more of the viewers' idiosyncratic preference for the displayed foods. This interpretation is in line with the self-reported reasons provided by participants for their responses. In their open-ended responses, participants declared that they selected and evaluated the images partly based on their preference for the depicted food types, which were kept constant across manipulation conditions. Nonetheless, although subtle, the Visual Food Palatability cues indicating ripeness, food attractiveness and pleasantness elicited appetitive attention to the pronutritional messages containing them. Visual Food Palatability will be further investigated.

The findings support the effectiveness of sensory appeals in eliciting attention and emotion to the pronutritional images. Nonetheless, these results cannot indicate whether the attention was captured by the healthy foods, among all elements displayed in images. The attentional focus on the core foods is necessary for the pronutritional information to be processed and remembered. To examine whether the sensory appeals automatically focus attention to the food items themselves, a second experiment was conducted. It explores the effects of sensory appeals on attentional focus and on memory formation for the promoted healthy foods. As the ineffectiveness of low Hedonic Visual Appeals was strongly evidenced, Study 2 only used high Hedonic Visual Appeals. Study 2 further investigates the potential of Hedonic Appeals through manipulations in nonvisual, textual form, as detailed next.

Study 2

Cold utilitarian versus hot hedonic mechanisms

Unlike hedonic approaches, utilitarian strategies (Coleman, 1986) rely on analytical information-processing for instrumental motives (Kunda, 1999). Conveying the nutrition benefits of core foods, utilitarian appeals are ubiquitous in health campaigns (Bublitz & Peracchio, 2015), yet only reach limited, small, or even contrary effects (French & Stables, 2003; Papies, 2016; Schor & Ford, 2007). Exposure to utilitarian TV pronutritional adverts lowered all food intake of participants—the unhealthy as well as the healthy food intake—and it did so significantly below the levels of those in the control group (Harris et al., 2009). Moreover, those in the pronutritional experimental group declared lower hunger levels than all participants, even below those not exposed to any food items. These findings indicate that utilitarian appeals might activate mechanisms of inhibition and suppression of eating per se, which are evidenced to cause subsequent binge eating, obsessive preoccupation with eating, and higher emotional responsiveness to foods (Stice et al., 2002). Although emphasizing health benefits and leading to higher health ratings for the depicted foods (Bailey & Muldrow, 2018), utilitarian messages seem to activate unhealthy eating processes.

Cognitive utilitarian deliberations influence little the responses made in situations of immediacy (Read & Van Leeuwen, 1998). Although the intentions for future are utilitarian, the choices made when consumption is imminent are hedonic (Read & Van Leeuwen, 1998; Shiv & Fedorikhin, 1999). Moreover, while hedonic cues activate motivational processes, utilitarian appeals have no such triggers. Based on these findings, predictions are made that utilitarian appeals will be less effective than hedonic ones.

Attentional processing under the activated approach motivational system

The activation of the approach motivational system is theorized to generate more mental resources (Lang, 2009; Lang et al., 1997), available for processing the messages in detail. The initial attentional selection, elicited toward the whole pronutritional images can be subsequently focused on specific elements of the images, capturing memory for them. This research further explores whether Hedonic and Food Palatability Appeals are effective in directing the initial attentional selection toward focusing on the promoted healthy foods.

It has been found that, while automatically eliciting mental resources to their immediate processing, the ubiquitous sex and humor appeals distract from the substantial content of messages and are thus ineffective promotional strategies (Haaland & Venkatesan, 1968; Samson, 2018). Unlike these stimuli, which are unrelated to the food items, the hedonic enjoyment of

foods and their palatable ripeness are directly related to the promoted foods. Moreover, they are motivationally relevant characteristics automatically eliciting processing. Hedonic and palatability appeals are consequently expected not to distract, but to further guide mental resources through the detail processing stages to focus on the healthy foods.

Yet, all message elements compete for the limited attentional focus of viewers (Lang, 2009). Therefore, any textual appeal is expected to elicit lower levels of attentional focus to the foods, compared to the no text condition. Study 2 also inquires whether Visual Food Palatability and Hedonic Textual Appeals interact on the visual attentional focus to the foods:

H3: Pronutritional messages with higher hedonic textual appeals will result in (a) higher visual attentional focus to the depicted foods than those lower on hedonic textual appeals but in (b) lower visual attentional focus to the depicted foods than those in the *no text* condition.

H4: Pronutritional messages with higher visual food palatability appeals will result in higher visual attentional focus to the depicted foods than those lower on palatability appeals.

RQ2: Will hedonic textual and visual food palatability appeals interact in their influence on the visual attentional focus to the depicted foods?

Memory formation under the activated approach motivational system

For the promotional messages to be effective, viewers should not only focus their attention to them, but process and remember them. Memory for the healthy foods is thus investigated next. Encoding is the first component of message information processing, which is theorized by the Limited Capacity Model of Motivated Mediated Message Processing (LC4MP; Lang, 2009). The LC4MP describes information processing as a group of three subprocesses: encoding, storage, and retrieval. Encoding consists of the process of orienting the audience toward the message for information intake, of selecting the stimuli for information-processing and initial memory formation through the allocation of mental resources. Additional resources are allocated to this subprocess as a consequence of activation in the appetitive motivational system.

This early subprocess of encoding is arguably critical for processing media messages, which occurs at this level predominantly: Viewers do not consume the visually rich media images actively to store them into their working memory, nor to intentionally integrate them into the networked organization of stored mental information. Audiences are thus able to effectively encode the mediated images they've been exposed to. To test the effectiveness of

sensory appeals, encoding levels are examined. It is argued that hedonic and palatability appeals enhance encoding of the portrayed foods. Again, because additional elements available for processing compete for the limited encoding capacity of viewers (Lang, 2009), any textual appeal is expected to elicit lower encoding compared to the no text condition. Study 2 also enquires whether Hedonic Textual and Visual Food Palatability Appeals interact in their influence on the encoding of foods:

H5: Pronutritional messages with higher hedonic textual appeals will result in (a) higher encoding of the depicted foods than those lower on hedonic textual appeals but in (b) lower encoding of the depicted foods than the *no text* condition.

H6: Pronutritional messages with higher visual food palatability appeals will result in higher encoding of the depicted foods than those lower on visual food palatability appeals.

RQ3: Will hedonic textual and visual food palatability appeals interact in their influence on the encoding of the depicted foods?

Method study 2

A 3 (Hedonic Textual Appeal) × 2 (Visual Food Palatability Appeal) × 4 (Message) within-subjects factorial design was conducted. Hedonic Textual Appeal had three levels: High, Utilitarian/low, and No Text. Messages in the High Hedonic Appeal category conveyed the enjoyment and pleasure of eating the fruits and vegetables through phrases such as: "Finger-licking goodness!" while messages in the Utilitarian/low Hedonic category emphasized the nutritional value of core foods through statements such as: "All necessary vitamins!" The word number in the Hedonic Textual Appeals was balanced across the two conditions to control for processing effort and time. The factor tested variance between the High versus Utilitarian/low Hedonic Appeals, as well as explored the differences between Textual Appeals versus the No Text condition. The message factor had four levels, displaying a total of 24 images. The Visual Food Palatability Appeals, the stimuli messages and the data analysis were identical to those in Study 1.

Dependent variables

Visual attentional focus

An eye-tracker assessed participants' visual attentional focus to the stimuli, which were displayed at a resolution of 1024 × 786 pixels × 16 million colors

on a True Color monitor. Eye movements and fixations were recorded by a Tobii T60 tablemounted eye-tracker placed approximately 60 cm away from the participant's head in a controlled environment laboratory with no natural or incandescent (gloeilampen) light (Tobii Technology User Manual). Eye positions were sampled at 60 Hz. Viewing was binocular, although only the position of the right eye was used, as it is common in eye-tracking research. In line with methodological recommendations, the visual attentional focus to particular areas of interest were computed and analyzed as the viewer's total fixation time divided by the area of the elements of interest, called fixation time per unit area (FTA; Bylinskii, Borkin, Kim, Pfister, & Oliva, 2015).

Encoding

Encoding was operationalized via visual recognition (Baars & Gage, 2007; Lang, 2009). Participants were asked to identify snapshots of particular food items as shown (1) or not shown (0) in the experiment. The items were presented on screen for 100 ms. and separated by a black screen. Participants then had 3 s to respond *yes* or *no* with assigned keyboard keys. Even if no answer was given in this time, the next item was shown. This speeded yes/no recognition test is in line with previous studies (Samson, 2018). The total of 48 items: 24 target snapshots of foods and 24 corresponding foils of were presented in random order. To create the corresponding foils, photos were used with similar but different foods.

Participants and procedure

Study 1 collected data from 58 participants, a sample size that was appropriate for capturing the large effect size associated with appetitive system activation. Study 2 focuses on analyses of medium effect size and thus targeted a larger sample. Power analysis for the main and interaction effects ANOVAs with a medium effect size (*f* of .2), a desired statistical power level of .8 and an α level of .05, calculated through G-Power v.3 (www.psycho.uni-duesseldorf.de/aap/projects/gpower) indicated a minimum sample size of 160.

One hundred and sixty-five adolescents (87 girls; M_{age} = 13.76, SD_{age} = 1.77, aged 12 to 18) visiting the Science Museum were recruited through announcements to participate in this research through the Science Live program. The information materials invited minors to participate in a study about positive advertising; This was realistic because 20 masking images—resembling the experimental stimuli without presenting any food items, but displaying other positive activities (e.g., painting, traveling)—were added to the 24 experimental images. The cover story prevented sensitization to the research purpose and reduced potential social desirable responses. It was effective, given that no participants were aware of the research purpose or manipulations.

After parents provided informed consent, the participants were introduced to the Science Live controlled environment laboratory and equipment, which was calibrated. The calibration consisted of participants fixating on five markers on the display screen area until the average error in gaze position was below 0.5°. After the Tobii system was successfully calibrated to each individual eye gaze, the experimental session began with a practice session, which familiarized participants with the procedure and controlled for primacy effects. The 24 experimental stimuli and the 20 masking messages were then presented in three set orders, required by the data collection instrument, which was preferred due to the superior data quality and reliability it provided. The orders were organized to initiate stimuli presentation with a masking message, followed by a randomly chosen experimental message, and continuing a roughly similar alternating sequence. Participants were randomly assigned to a presentation sequence, which was programmed and controlled directly through Tobii Studio. Because it uses a unified integrated system for stimulus presentation, data acquisition and eye-tracker calibration, the built-in Tobii Studio instrumentation ensures superior data quality and reliability, yet, requiring set presentation orders. There were no significant effects of presentation orders on the dependent variables. Each message was followed by a short questionnaire assessing SAM, which also served to prevent carry-over effects between conditions (Reeves & Geiger, 1994). Testing lasted approximately 25 min. At the end of the experimental session, the participants were thanked and debriefed.

Results study 2

All predictions of H3 were supported (see Table 2 for details). The healthy foods displayed in the pronutritional visual messages using higher Hedonic Textual Appeals (M = .123, SE = .004) elicited (a) significantly greater fixation time per unit area than those using Utilitarian, low Hedonic Textual Appeals (M = .085, SE = .002), $t(164) = 10.39$, $p < .001$, $d = .81$; and (b) significantly lower FTA than those displayed in images without Textual Appeals (M = .152, SE = .005), $t(164) = 6.63$, $p < .001$, $d = .52$. H4 was also supported (see Table 2 for details). The FTA to the healthy foods with higher Visual Food Palatability was significantly greater than to those with lower Visual Food Palatability. In response to RQ2, results revealed that Hedonic Textual and Visual Food Palatability Appeals interacted significantly on the FTA for foods. As seen in Figure 3(a), the levels of FTA to the foods elicited when using Utilitarian, low Hedonic Text were not statistically different between the low (M = .082, SE = .003) and high Palatability conditions (M = .087, SE = .003), $t(164) = 1.24$, n.s. They were also not statistically different from the FTA to the foods in the high Hedonic low Palatability condition (M = .082, SE = .003), $t < 1$. However, the healthy foods promoted through No Text high Palatability Appeals attracted the highest FTA levels (M = .171,

Table 2. Analysis of variance (ANOVA) study 2.

			M (SE)		
Main effects Hedonism	*F*(2,163)	η^2	Low Hedonic Text	High Hedonic Text	No Text
FTA for foods	132.50***	.22	.085 (.002)	.123 (.004)	.152 (.005)
Food Recognition	3.14*	.01	.30 (.02)	.32 (.02)	.33 (.02)
Main effects Palatability	*F*(1,164)	η^2	Low Visual Palatability		High Visual Palatability
FTA for foods	169.63***	.12	.099 (.003)		.141 (.004)
Food recognition	23.34***	.03	.29 (.02)		.34 (.02)
Interaction effects Hedonic Text × Visual Palatability Appeals on FTA for foods	*F*(2,163) 54.87***	η^2 *.07*	Low Visual Palatability *M (SE)*		High Visual Palatability *M (SE)*
Low Hedonic/Utilitarian Text *M (SE)*			.082 (.003)		.087 (.003)
High Hedonic Text *M (SE)*			.082 (.003)		.163 (.005)
No Text *M (SE)*			.133 (.005)		.171 (.006)
Hedonic Text × Visual Palatability Appeals on food recognition	*F*(2,163) 4.24**	η^2 *.01*	Low Visual Palatability *M (SE)*		High Vsual Palatability *M (SE)*
Low Hedonic/Utilitarian Text *M (SE)*			.26 (.03)		.34 (.03)
High Hedonic Text *M (SE)*			.29 (.03)		.36 (.03)
No Text *M (SE)*			.33 (.03)		.33 (.03)

Note. FTA = fixation time per unit area. ***$p < .001$. **$p < .01$. *$p < .05$.

SE = .006), double than those from the other conditions, but not statistically different to those promoted through high Hedonic high Palatability Appeals (*M* = .164, *SE* = .005), *t*(164) = 1.09, n.s. (see Table 2 for details).

H5 was partially supported (see Table 2 for details). (a) Healthy foods displayed in the pronutritional visual messages using Utilitarian, low Hedonic Textual Appeals (*M* = .30, *SE* = .02) were significantly less likely to be recognized than those with higher Hedonic Textual Appeals (*M* = .32, *SE* = .02), *t*(164) = 2.46, *p* = .01, *d* = .19, (b) whose recognition was not statistically different from those displayed in images using No Textual Appeals (*M* = .33, SE = .02), *t* < 1. H6 was fully supported (see Table 2 for details). Recognition of the healthy foods displaying higher Visual Food Palatability Appeals was significantly greater than of those displaying lower Palatability Appeals. In response to RQ3, results revealed that Hedonic Textual and Visual Food Palatability Appeals interacted significantly on the recognition of the depicted foods (see Table 2 for details). As seen in Figure 3 (b), participants were most likely to recognize the healthy food items promoted through high Hedonic high Palatability Appeals (*M* = .36, *SE* = .03)—these recognition levels were significantly higher compared to those recorded in the No Text conditions (*M* = .33, *SE* = .03), *t*(164) = 1.91, *p* = .05, *d* = .15, significantly higher compared to those in the high Hedonic low Palatability condition (*M* = .29, *SE* = .03), *t*(164) = 3.62, *p* < .001, *d* = .28, and significantly higher compared to those in the low Hedonic low Palatability condition (*M* = .26, *SE* = .03), *t*(164) = 5.28, *p* < .001, *d* = .41.

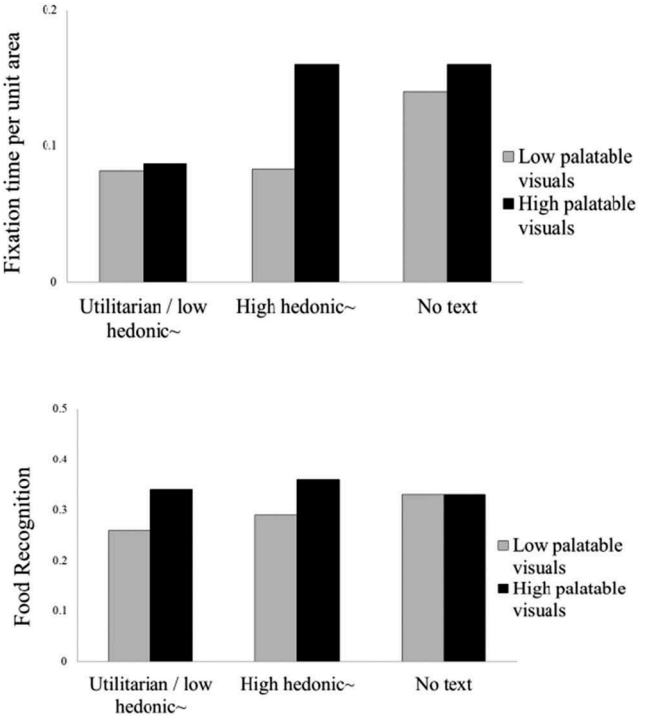

Figure 3. (a) Visual attentional focus for foods, (b) Encoding of foods elicited by pronutritional messages using Visual Palatability and Hedonic Textual Appeals.

Discussion study 2

Study 2 built on the results of Study 1—which evidenced that sensory appeals capture attentional selection, positive affect and arousal to the pronutritional images. Study 2 further examined whether sensory appeals can direct the elicited attention and mental resources to the healthy food cues promoted. Grounded in the dimensional theory of emotion, information processing frameworks and the feeding aspects of evolutionary theory, the study predicted that healthy foods would attract greater visual attentional focus and cognitive resources when portrayed through high visual palatability cues indicating ripeness, food attractiveness, and pleasantness. Similar predictions were made that depicting healthy foods as tasty and enjoyable through high hedonic textual appeals would direct visual attentional focus to the food items and attract memory formation for them. Yet, additional elements such as texts are expected to generate lower levels of visual attentional focus to the foods and lower memory formation compared to images depicting no text. As predicted, high hedonic and palatability appeals directed more visual attentional focus to the healthy foods and increased memory formation for them, indicative of approach motivational processing. Moreover, the results of the main effects analyses revealed the advantages of no-text, visual

pronutritional messages, which resulted in better processing of the core foods.

Remarkably, the interaction effects show that portraying healthy foods as both ripe and tasty is the most effective appeal, even when additional text elements compete for the limited mental capacity of viewers. Multisensory cues appealing both to the hedonic taste and the visual palatability were more potent in attracting memory formation for the fruits and vegetables. The healthy foods depicted through the multisensory high hedonic high palatability condition were statistically more memorable than all other conditions, including the ones not depicting any text, where less elements competed for processing with the foods. The high hedonic high palatability condition was also potent in attracting visual attentional focus to the fruits and vegetables, as the fixation time per unit area of participants was higher than in all other conditions, yet not statistically different from the no text condition.

These results reveal several points: (a) Whether it is still debatable which is the most successful strategy to promote healthy food, the least effective were unequivocally the utilitarian, low hedonic appeals. These were least successful in directing visual attentional focus and mental resources to the healthy foods—demonstrating that pronutritional messages stating that fruits and vegetables are healthy are not only superfluous, but less memorable and, thus, less likely to lead to attitude or behavior change. (b) The visual food palatability seems to be more potent than hedonic textual appeals in attracting memory formation for the promoted foods—as evidence by the effect sizes of the statistical analyses. (c) An advantage for visual, no-text pronutritional messages emerges from our findings. In line with the Chinese proverb that "one picture is worth 10,000 words," these results indicate that extra elements such as textual appeals distract from the promoted healthy foods. (d) On the other hand, multisensory cues reflecting the hedonic pleasure experienced as a consequence of consuming the foods combined with the direct visual appeal of palatable ripeness enhanced visual attention and mental resource allocation to the foods, even when competing with extra message elements for processing. In summary, sensory appeals can increase the effectiveness of pronutritional messages by making the fruits and vegetables more noticeable and memorable, which are all prerequisite processes in making healthy choices and forming healthy attitudes.

General discussion

This article offers promising recommendations about effective ways to promote core healthy foods to adolescents. Shaped by survival mechanisms for millions of years (Dominy et al., 2001), the feeding system informed the design of effective pronutritional media using sensory appeals. Specifically, the psychobiological frameworks guided predictions about the potential of the palatable ripeness of fruits and vegetables and their hedonic enjoyment to

promote the core nutritious foods, an area of demonstrated low appetitive motivational activation (Killgore et al., 2003; Toepel et al., 2009; van der Laan et al., 2011). The results provide empirical evidence that sensory appeal characteristics can elicit attention, emotion, and mental resource allocation to the pronutritional messages (Study 1) and specifically, to the core healthy foods promoted (Study 2). The implications of the results rely not only on their statistical significance, but also on the magnitude of their effect sizes and their predicted direction—which leads to an increase in the desired eating behaviors with key public health impacts.

Depicting healthy foods as enjoyable and ripe through hedonic and palatability cues, sensory appeal characteristics elicited motivated attention, memory, and emotions. Specifically, the capacity of enjoyable healthy foods to draw attention, emotions, and initial processing of the pronutritional images was strongly supported. Hedonic appeals also guided mental resources toward the core foods in the pronutritional images. The food palatability appeal characteristics, portraying ripe fruit and vegetables, successfully attracted attentional selection to the pronutritional messages and directed the elicited attention to focus on the healthy foods, making them more memorable. Being a food-specific appeal characteristic, the palatable ripeness of fruits and vegetables seems to be an enticing attentional pull to the promoted core foods. Moreover, the findings indicate that the palatability appeal characteristics are the most potent factors in increasing the memorability of healthy foods, arguably because they are food-specific appeals. Health campaigns should take advantage of these results and promote core healthy foods through appeals to the senses—an auspicious solution to the concerns about the obesity epidemic which has been growing at alarming rates.

The research also has important theoretical implications, contributing to the literature on health communication. First of all, support is provided in the context of pronutritional images for the dimensional theory of emotion (Ito et al., 1998; Lang et al., 1990), for the motivational information processing framework (Lang, 2009) and for the feeding aspects of evolutionary theory (Dominy et al., 2001). Second, this article reveals the fruitfulness of applying psychobiological theories in health communication research, especially among youth; It also suggests the potential of mechanisms underlying the effects and processing of pronutritional visual messages. Last but not least, this study points to the potential of focusing on motivationally relevant appeal characteristics. Beneficial health-related outcomes have been reached, not through utilitarian approaches preaching children to do what is good for them. In fact, utilitarian messages have been shown to be the least effective, less appealing than the high hedonic and than the no-text conditions. Instead, the desired health-related outcomes are achieved by focusing on motivations and by showing youngsters *healthy food porn* images. This study adds multidisciplinary perspectives and contributes to the field of media

health psychology by integrating scholarship from media psychology, communication, cognitive and food science within the context of mediated health messages.

This study investigated adolescents' attention, memory, affect, and arousal, which are necessary preconditions for behavioral change. The theoretical and methodological merits of this study are accompanied by some limitations. For more valid inferences regarding the effectiveness of sensory appeals in promoting healthy food consumption, future research should explore attitudes toward healthy eating and actual food intake. Second, limitations related to the laboratory nature of the study should also be acknowledged. The responses provided by the participants in the lab might not have accurately reflected their real world reactions. The novel circumstance of a laboratory setting might have prompted the participants to experience higher levels of arousal and attention, with more cognitive resources focused on media processing (Lang, 2009). Third, the facial emotions expressed by the models in the pronutritional images might have primed the viewers to just mimic them in the SAM ratings, without necessarily having their emotions altered. Although this is one of the primary and automatic mechanisms underlying collective emotional contagion in adults and the very development of emotions in infants, the nature of the hedonic manipulation itself might have shaped only the self-assessed emotions of participants. This possibility, and the limitations of emotional appraisals weaken the firmness of the conclusions for arousal and affect, and should be triangulated in future studies by incorporating psychophysiological indices of appetitive system activation. Fourth, the participants gave their opinions on a series of images about *positive advertising*, most of which were about healthy eating. The pronutritional images may have a different impact when incorporated within media programs. The study did not include any programming to frame the images, which were shown in a rather artificial context. Field research is thus called for in the future, conducted in a more natural media environment. The choice of a controlled lab experiment ensures a higher degree of internal validity, yet at the expense of the study's ecological validity. This research primarily pursued psychological realism (Aronson, Wilson, & Brewer, 1998), ensuring that the relevant psychological mechanisms were activated and measured, while also ensuring that the participants were not sensitized to the research goal, but instead diverted through the successful cover story.

In summary, the research reported here makes several theoretical and methodological contributions, while also providing beneficial guidelines for health communication practice. This work is new and important in four respects: (a) This article advances a new theoretically grounded approach aimed at increasing the appetitive motivational processing of core healthy food cues, which have been found to be associated with lower activation of the appetitive motivational system; (b) in response to calls from the WHO

(2005, 2006) and researchers (Papies, 2016), the current empirical findings document how sensory hedonic and palatability cues can increase the appeal of core healthy foods; (c) specifically, the article provides promising recommendations regarding how fruits and vegetables can be made noticeable, highly arousing, and memorable, when promoted through appeals to the senses, based on primary feeding mechanisms; and (d) the methodological advancement introduces ripeness as a novel manipulation of visual food palatability—reliably varying the perceived pleasantness and attractiveness of fruits and vegetables, without changing their energy values, and feasibly operationalized through color saturation. The results indicate that controlling and manipulating the palatable ripeness of core foods expressed through color saturation might bring important methodological aspects in mediated health psychology research.

Grounded in theoretical frameworks at the intersection of psychology and communication science, this study reveals that incorporating *healthy food porn* in pronutritional intervention messages can increase the information processing of core foods, indicative of the appetitive system activation. Although not among the primary motivationally relevant motivators, fruits and vegetables became more appealing, noticeable, highly arousing, and memorable when portrayed as ripe and enjoyable. Sensory appeal characteristics can thus be effective approaches in media communications, such as public health campaigns or PSAs, as well as in informal communications by parents, educators, and social institutions.

Notes

1. Commonly referred to as vegetables, these actually are the fruit parts of plants in the botanical sense.
2. The face size/prominence was controlled experimentally; the number of faces depicted was controlled statistically. It did not statistically influence the results reported in this study when included as a covariate.

Disclosure statement

No potential conflict of interest was reported by the authors.

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