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When hunger does (or doesn't) increase unhealthy and healthy food consumption through food wanting: The distinctive role of impulsive approach tendencies toward healthy food

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ABSTRACT

Objective: Hunger indirectly triggers unhealthy high-calorie food consumption through its positive effect on the incentive value (or "wanting") for food. Yet, not everyone consumes unhealthy food in excess, suggesting that some individuals react differently when they are exposed to unhealthy high-calorie food, even when they are hungry. The purpose of the present study was to investigate whether individual differences in impulsive approach tendencies toward food may explain how, and for whom, hunger will influence unhealthy food consumption through its effect on food wanting. A complementary goal was to explore whether these individual differences also influence healthy food consumption.
Methods: Students (N = 70) completed a questionnaire measuring their hunger and food wanting. Then, they performed a manikin task designed to evaluate their impulsive approach tendencies toward unhealthy food (IAUF) and healthy food (IAHF). The main outcomes variables were the amount of sweets (i.e., unhealthy food) and raisins (i.e., healthy food) consumed during a product-testing task.
Results: A moderated mediation analysis revealed that the indirect effect of hunger on unhealthy consumption through food wanting was moderated by IAHF. Specifically, hunger positively predicted sweets consumption through wanting for food among individuals with a low or moderate, but not high IAHF. The moderated mediation pattern was, however, not confirmed for IAUF. Finally, results revealed a direct and positive effect of IAHF on raisins consumption.
Conclusion: These findings showed that IAHF play a protective role by preventing hunger to indirectly increase unhealthy food consumption through wanting for food. It confirms the importance of considering how individuals may differ in their impulsive approach tendencies toward food to better understand why some individuals will increase their unhealthy food intake when they are hungry, whereas other will not.

1. Introduction

The increased prevalence of overweight and obese individuals is a worldwide health concern (Finucane et al., 2011; Wang, McPherson, & Marsh, 2011). While multiple factors play a role, one crucial factor is the overconsumption of unhealthy and high-calorie food. For instance, it has been found that obese people demonstrate a preference for unhealthy food (CDC, 2013; Marks, 2015; Schrauwen & Westerterp, 2000; Skinner, Bounds, Carruth, Morris, & Ziegler, 2004) and eat more of these unhealthy energy dense food than lean people (Cutting, Fisher, Grimm-Thomas, & Birch, 1999; Ebbeling et al., 2004; Johnson & Birch, 1994). This overconsumption of unhealthy food is primarily caused by the obesogenic environment in which the opportunities to consume calorie-rich food are ubiquitous (e.g., Watson, Wiers, Hommel, Ridderinkhof, & de Wit, 2016). At the same time, despite living in this same obesogenic environment, some individuals are more successful at regulating their weight. Understanding the factors contributing or limiting the consumption of unhealthy food is thus

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important for health protection.

Food, and especially unhealthy and appetizing food items are considered as rewarding stimuli as they activate brain structures involved in attributing incentive value to environmental stimuli (DelParigi et al., 2007; Passamonti et al., 2009; Schur et al., 2009). As such, the effect of food rewards on consumption occurs because of the incentive (motivational) salience triggered by these food cues (Lawrence, Hinton, Parkinson, & Lawrence, 2012). Incentive salience, which is defined as the motivation to invest effort to obtain a reward (i.e., "wanting"), has been found to increase the attractiveness, the seeking, and the likelihood of consumption of a reward (Berridge, 2009; Berridge, Ho, Richard, & DiFeliceantonio, 2010). In addition, the incentive value of a reward is directly amplified by relevant physiological states, such as hunger (Zhang, Berridge, Tindell, Smith, & Aldridge, 2009). For instance, hunger motivates food seeking behavior and food intake (Raynor & Epstein, 2003), it motivates food purchase in a virtual supermarket (Nederkoorn, Guerrieri, Havermans, Roefs, & Jansen, 2009), and it increases the likelihood of choosing unhealthy energy dense food (Read & Van Leeuwen, 1998; Tuorila, Kramer, & Engell, 2001). Hence, these findings suggest that hunger directly magnifies the incentive value or "wanting" for food, which in turn elicits food consumption, especially of unhealthy food.

Nevertheless, not everyone consumes unhealthy food in excess or becomes overweight and obese, suggesting that individuals may react differently when they are exposed to unhealthy food, even when they are hungry. Accordingly, the indirect effect of hunger on food consumption through the increase in "wanting" for food should be conditional to certain individual differences. Recently, an increasing amount of research has suggested that individual differences in fast, automatic, and impulsive reactions toward food may determine an individual's risk of obesity and eating disorders (e.g., Berridge et al., 2010; Passamonti et al., 2009). These impulsive reactions are emotionally driven and based on automatic associative processes that the person has acquired through learning experience. For example, through the repeated positive (or negative) affective experiences toward unhealthy food (e.g., chocolate), an associative cluster may be formed that links the positive (or negative) affect during the behavioral execution and the behavioral schema that has led to the affect (i.e., eating chocolate). Once the automatic affective association is established, a mere perceptual input, such as seeing a chocolate cake in a bakery, can automatically trigger affective evaluation that will in turn, lead to an impulsive approach (or avoidance) tendency toward the chocolate cake (Hofmann, Friese, & Wiers, 2008; Strack & Deutsch, 2004). Such impulsive tendencies should not be confused with the "trait of impulsivity" (Friese & Hofmann, 2009; Hofmann, Friese, & Strack, 2009), namely a chronic and general tendency to act on impulses in a wide range of various situations. For instance, individuals with high rather than low trait impulsivity favor immediate rewards (e.g., eating unhealthy food) while discounting more valuable delayed rewards (e.g., the benefits of eating healthy food), and act spontaneously and without thinking (Eysenck & Eysenck, 1977; Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001). By contrast, "impulses" refer to specific processes that lead to a fast and primitive hedonic reaction toward a tempting stimulus, predisposing individuals to perform a particular desired action (e.g., grab a piece of chocolate) (Friese & Hofmann, 2009; Hofmann, Friese, et al., 2008).

Previous studies showed that overeaters (Brignell, Griffiths, Bradley, & Mogg, 2009; Hou et al., 2011), food cravers (Brockmeyer, Hahn, Reetz, Schmidt, & Friederich, 2015), as well as overweight and obese individuals (Havermans, Giesen, Houben, & Jansen, 2011; Kemps & Tiggemann, 2015; Mogg et al., 2012; Nijs, Muris, Euser, & Franken, 2010) demonstrated an impulsive tendency toward unhealthy high-calorie food cues. By contrast, patients with anorexia nervosa (i.e., individuals with a strong ability to limit food intake) did not demonstrated such impulsive tendency toward food (Paslakis et al., 2016; Veenstra & de Jong, 2011), and on the contrary showed an impulsive attraction toward low-calorie food (Neimeijer, de Jong, & Roefs, 2015). In addition, studies have also shown that impulsive tendencies toward food can prospectively predict changes in body mass index over a 1-year period (Calitri, Pothos, Tapper, Brunstrom, & Rogers, 2010; Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010), as well as a variety of eating behaviors, such as the self-reported snack food consumption (Conner, Perugini, O'Gorman, Ayres, & Prestwich, 2007), the likelihood to choose unhealthy food presented as a reward for participation in an experiment (Conner et al., 2007; Study 2; Friese, Hofmann, & Wanke, 2008; Study 1; Hollands, Prestwich, & Marteau, 2011), the purchasing of unhealthy food (Prestwich, Hurling, & Baker, 2011), and the amount of unhealthy energy dense food consumption during a product-testing task (Friese et al., 2008; Study 2; Hofmann, Gschwendner, Friese, Wiers, & Schmitt, 2008; Study 2; Nijs et al., 2010; Schumacher, Kemps, & Tiggemann, 2016). Taken together, the aforementioned studies provide compelling evidence that impulsive tendencies toward food are involved in the regulation of eating behaviors, by either prompting (i.e., impulsive predisposition toward unhealthy food) or limiting (i.e., impulsive predisposition toward healthy food) unhealthy food consumption. Accordingly, individual differences in these impulsive tendencies acquired through individual's learning history may therefore represent a key variable to better understand and predict which individuals are more or less susceptible to overconsume appetizing but unhealthy high-calorie food.

It should be noted, that the literature presented above suggests that impulsive tendencies are relatively stable and acquired through individual' learning experiences. However, it has been pointed out that impulsive processes are also affected by internal triggering conditions such as thirst or hunger (Aarts, Dijksterhuis, & Vries, 2001; Seibt, Häfner, & Deutsch, 2007; Strack & Deutsch, 2004). For instance, thirsty participants had a higher perceptual readiness to drinking-related stimuli (Aarts et al., 2001), and hungry participants demonstrated a stronger impulsive approach reaction toward food-related stimuli (Seibt et al., 2007). In others words, these results suggest that impulsive tendencies possess both a stable component (based on learning experiences) and a dynamic component (depending on situational internal states). In the current study, we focused more on impulsive approach (or avoidance) tendencies as representing relatively stable factor susceptible to explain individual differences in eating patterns, though we acknowledge that these processes are also likely to change in accordance with individuals' internal needs.

1.1. The present study

The purpose of the present study was to investigate whether individual differences in impulsive approach tendencies toward food may explain how, and for whom, hunger will indirectly influence unhealthy food (i.e., sweets) consumption through its effect on food wanting. Using a manikin task (e.g., Mogg, Bradley, Field, & De Houwer, 2003), a well-validated measure of impulsive approach-avoidance tendencies (Krieglmeyer & Deutsch, 2010), we assessed both impulsive approach tendencies toward unhealthy food (IAUF) and toward healthy food (IAHF). Manikin task is based on the measurement of response time latencies in computerized tasks and is particularly well-suited to capture impulsive or automatic affective reactions toward specific stimuli. It is designed to tap into the associative structure that produces hedonic or behavioral components of an impulse, thus providing indices of the

associations that automatically trigger behaviors. IAUF and IAHF are thought to automatically predispose individual to physically approach (or avoid) certain food depending on their incentive value and could therefore be considered as an automatic behavioral measure of "wanting" for food (Paslakis et al., 2016). Such measures may therefore be particularly useful to assess relatively stable individual differences in automatic "wanting" for food and for the understanding of how these differences may affect subsequent eating behaviors.

Here, we tested the assumption that the indirect effect of hunger on unhealthy food consumption through wanting for food should depend on individual differences in IAUF and/or IAHF. We expected a *moderated mediation pattern* in which the indirect effect of hunger on unhealthy food consumption through wanting for food is conditional on IAUF and IAHF. Specifically, we hypothesized that the mediating effect of wanting for food should be significant for individuals with impulsive systems predisposing to unhealthy food consumption (i.e., low IAHF and/or high IAUF). By contrast, this mediating effect of wanting for food should be non-significant for individuals with impulsive systems predisposing to healthy food consumption (i.e., high IAHF and/or low IAUF).

A complementary goal of the current study was to explore whether individual differences in impulsive approach tendencies toward food may also influence healthy food (i.e., raisins) consumption. More precisely, we propose that the mediating effect of wanting for food should be significant for individuals with impulsive systems toward healthy food consumption (i.e., high IAHF and/or low IAUF), but non-significant for individuals with impulsive systems toward unhealthy food consumption (i.e., low IAHF and/or high IAUF).

The design of our study has several strengths that add value to the existing research on impulsive tendencies and eating behaviors. First, we take into account both impulsive approach tendencies toward healthy food and toward unhealthy food. Such an approach enables us to examine the distinctive predictive validity of these two impulsive approach tendencies. Second, we examine both unhealthy and healthy food consumption for the purpose of examining whether impulsive approach tendencies have differential effects on healthy and unhealthy food consumption. Third, we use a relatively sophisticated statistical method to examine the expected sequential relationships between hunger, wanting for food, and food consumption. Fourth, we include many control variables to support the additional predictive validity of impulsive approach tendencies.

2. Methods

2.1. Participants

Participants were 70 students (62 females and 8 males; M_{age} = 19.3yr, SD = 1.9yr; M_{BMI} = 21.9kg/m2, SD = 3.6kg/m2) who received course credits for their participation. They were enrolled in several different undergraduate programs at the University of Ottawa. The study was advertised in the local participant pool online portal. To participate, students logged in, screened available studies and respective background information, and signed up. The current study was made available for students from February to May 2013. To be included in the study, participants had to be free of any allergies that would prohibit the tasting of unknown food. Participants with diabetes, a history of alcohol, or drug use were also excluded from the study. The study was approved by the University of Ottawa Institutional Review Board for the Health Sciences. In agreement with the Canadian Tri-Council Policy Statement (TCPS): Ethical Conduct for Research Involving Humans, all participants were given written informed consent prior to participation, and received a written debriefing at the end of the session.

2.2. Procedure

Participants came to the laboratory and were tested individually. A research assistant blind to the hypotheses explained that the study focused on food brands and asked the participant to sign an informed consent form. Participants were seated in front of a computer in a cubicle to complete a questionnaire measuring their hunger, food wanting, explicit attitudes toward healthy and unhealthy food, usual eating behaviors, as well as their age, height, and weight. Then, participants completed an approach-avoidance task measuring their impulsive approach tendencies toward healthy and unhealthy food. Directly after this task, participants were asked to complete a food test. Specifically, in this product-testing phase, participants were asked to taste two samples of a healthy food product (i.e. raisins) and two samples of unhealthy food product (i.e., jellybean). The order of presentation of the type of food was counterbalanced across participants. For each type of food, participants were told that one sample was a brand product whereas the other was not. Participants were informed that they were free to eat as much or as little they wanted. When they were ready to evaluate the product, participants had to rate how they liked each product on a 7-point rating scale ranging from 1 (not at all) to 7 (extremely) and then had to guess which of the sample was the brand product. This cover story was done in order to avoid that the participant understand that we measured the amount of food consumed during the tasting task. Moreover, awareness of the purpose of the experiment was tested in a funneled interview containing general questions ("What do you think this study is about?") and specific questions ("Do you think that during the product-testing phase the researchers are interested by something else that your ability to detect the brand product? If so, what can interest the researchers?). Five participants reported suspicion about the possibility that the researchers wanted to measure the amount of food consumed during the food test.

2.3. Measures

2.3.1. Hunger rating

Assessed using a 7-point rating scale anchored by 1 = "not at all hungry" and 7 = "extremely hungry" (Forwood, Ahern, Hollands, Ng, & Marteau, 2015).

2.3.2. Rating of general wanting for food

Assessed using a 7-point rating scale anchored by 1 = "not at all have an urge to eat" and 7 = "very big urge to eat" (adapted from Loxton, Dawe, & Cahill, 2011).

2.3.3. Rating of liking for the healthy and unhealthy food used during the tasting task

The ratings of the two types of food were assessed using a 7-point rating scale asking how much the participant liked each of the four sample of food tested during the food test anchored by 1 = "not at all" and 7 = "extremely" (adapted from Garbinsky, Morewedge, & Shiv, 2014).

2.3.4. Explicit attitudes toward healthy and unhealthy eating

The explicit attitudes toward healthy eating were assessed using a 7-point rating response anchored by 1 = "useful" and 7 = "useless" for the first item and 1 = "beneficial" and 7 = "harmful" for the second item, following the stem "For you, eating fruits and vegetables is something …" for explicit attitudes toward healthy food, and following the stem "For you, eating fatty

and sugary foods is something …" for explicit attitudes toward unhealthy food. For each type of food, the two items were combined into a single score (adapted from Lawton, Conner, & McEachan, 2009).

2.3.5. Usual healthy and unhealthy eating behaviors

Healthy eating behaviors were assessed using the healthy eating habits scale (Pelletier, Dion, Slovinec-D'Angelo, & Reid, 2004). This scale comprises of two subscales of four items each. One subscale refers to "healthy food" (e.g., "I eat vegetables, fruits, and grain products"), whereas the other subscale refers to "food that should be eaten with moderation (e.g, "I eat foods such as chips, chocolate, and candies"). Participants were asked to indicate using a 5−point rating scale ranging from 1 (not at all) to 5 (all of the time) the frequency with which they consume each type of food.

2.3.6. Impulsive approach tendencies

To assess participants' spontaneous approach tendencies toward healthy food (IAHF) and unhealthy food (IAUF), we used a manikin task (Krieglmeyer & Deutsch, 2010). Participants were asked to move a schematic image of a human figure upward or downward by pressing three times with their middle finger the "8" or "2" keys on a numeric keypad as fast and as accurately as possible. Each trial started with a fixation cross in the middle of the screen. Participants had to press the "5" key and keep it pressed until they began to move the manikin. The manikin could appear in either the upper or the lower half of the screen with equal probability. After 750 ms (ms) following the appearance of the manikin, an image of healthy or unhealthy food was presented at the center of the screen. All images were downloaded from publicly available websites. Depending on the condition, participants were asked to move the manikin as quickly and as accurately as possible "toward" healthy food image and "away" from unhealthy food image, or vice versa. If an incorrect response was made, error feedback appeared on the screen. Five hundred ms after the third key press, the screen was cleared for 1000 ms before the start of the next trial. Reaction time (RT) between the appearance of the image and the first key press was used in the analyses. Participants completed two blocks of trials, each consisting of 12 practice trials and 48 test trials (i.e., each of the 12 images appeared twice in the upper and twice in the lower half of the screen). In one block, participants were instructed to approach healthy food images and to avoid unhealthy food images, and in the other block, they were instructed to do the opposite. The order of the blocks was counterbalanced across participants. Before analyzing the data we excluded incorrect responses (5.57%) as well as responses below 200 ms (<0.01%) and above 1500 ms (2.55%) as recommended by Krieglmeyer and Deutsch (2010). Participants' impulsive approach tendencies toward healthy and unhealthy food were calculated by subtracting the median approach RT from the median avoidance RT toward healthy and unhealthy food images, respectively. A positive score indicates an impulsive approach rather than avoidance tendency.

2.3.7. Consumption of sweets and raisins

The amount of consumption of the two types of food was assessed by the mean amount of sweets and raisins consumed (grams) during the product-testing task. Specifically, the amount of each product consumed was calculated from the difference in bowl weight (for the two samples) from before to after the product-testing task (See Hofmann, Gschwendner, et al., 2008, for similar procedure).

2.4. Data analysis

First, we used bivariate correlations between IAHF and IAUF and hunger to examine whether impulsive approach tendencies represent relatively independent constructs of the state of hunger. Then, data were analyzed using moderated mediation models using the function *sem* from the R language *lavaan* package, version 0.5−18 (Rosseel, 2012). We conducted two separated moderated mediation analyses: Model 1 tests whether the indirect effect of hunger (i.e., the independent variable) on unhealthy food consumption (i.e., the dependent variable) through the wanting for food (i.e., mediator variable) was conditional on impulsive approach tendencies (i.e., the moderators); Model 2 examines healthy food consumption, instead of unhealthy, as dependent variable. In each model, two *indexes of moderated moderation* (i.e., one for each impulsive approach tendency) were calculated to examine the significance of this moderated mediation model. Specifically, following Hayes' recommendations (2015), these indexes of moderated moderation were obtained by multiplying the effect of the independent variable on the mediator by the interactive effect of the mediator and of the moderator on the dependent variables. Hence, the index of moderated mediation is the product of the effect of hunger on wanting for food and the interaction effect of wanting for food and IAUF (or IAHF) on unhealthy (i.e., sweets; Model 1) and healthy (i.e., raisins; Model 2) food consumption. In addition, the models controlled for covariates that may influence food consumption, including raisins and sweets linking, body mass index (BMI), positive and negative eating behaviors, and explicit attitudes toward healthy and unhealthy food. In addition, healthy (i.e., raisins) and unhealthy (i.e., sweets) food consumption were included as covariates in the model 1 and model 2, respectively. The inclusion of the other type of food consumption allowed us to control for participants individual differences in their tendencies to consume food (irrespective of their healthy or unhealthy value) during the tasting task. The dependent variables represent therefore participants' bias toward unhealthy rather than healthy food consumption in Model 1, and toward healthy rather than unhealthy food consumption in Model 2. The statistical assumption associated with the moderated mediation analyses were examined. Plots of the residuals against the predicted scores of the dependent variables showed no major signs of heteroscedasticity. Residuals were normally distributed and centered around zero. The predictors and covariates were checked for multicollinearity (using variance inflation factors) which was not found. Examination of the Cook's distance for all cases showed that no case exerted undue influence on the parameters. Thus, the statistical assumptions associated with the moderated mediation analyses were met. Finally, we performed four sensitivity analyses for both unhealthy (i.e., sweets) and healthy (i.e., raisins) food consumption: the first excluded the five participants who reported suspicion about the possibility that the researchers wanted to measure the amount of food consumed during the food test; the second included the explicit attitudes toward healthy and unhealthy eating, BMI, and consumption of raisins (sweets) as covariates only; the third included the consumption of raisins (sweets) as covariate only; and the fourth excluded all the covariates.

3. Results

3.1. Preliminary analyses

Means, standard deviations, and observed range of the scales are presented in Table 1. Bivariate correlations revealed that both IAHF and IAUF were not significantly related to hunger ($r = -0.102$, $p = 0.401$; $r = -0.064$, $p = 0.601$, respectively), suggesting that these two impulsive approach tendencies are relatively independent of hunger state.

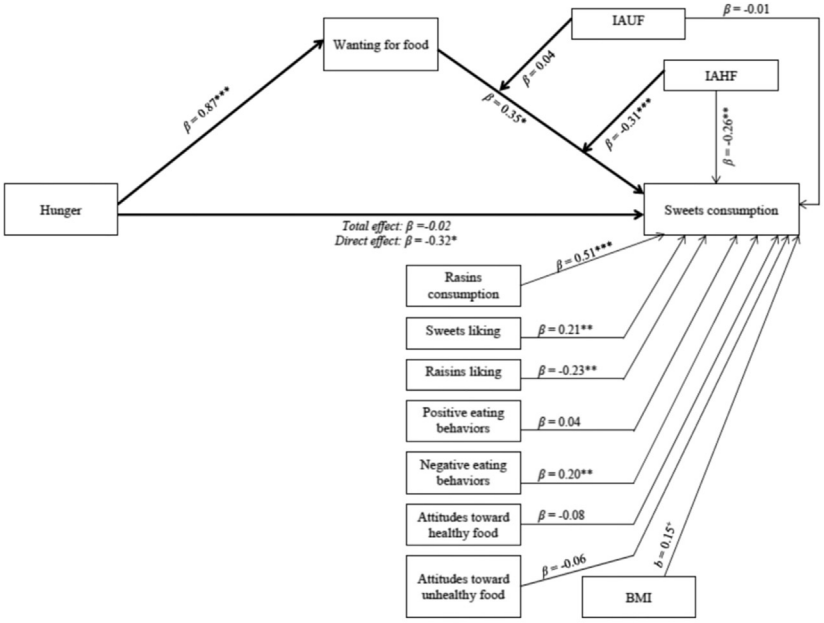
Table 1
Descriptive statistics of the variables.

Variables name	Mean	SD	Observed range
Dependent Variables			
Sweets consumption (in grams)	12.7	8.92	0.6–40.5
Raisins consumption (in grams)	8.46	7.90	0.3–31.2
Independent Variables			
Hunger (range 1–7)	3.00	1.80	1–6
Wanting for food (range 1–7)	2.81	1.72	1–6
IAHF (median in ms)	112.75	118.04	−186–348
IAUF (median in ms)	−1.75	101.57	−223–262
Covariates			
sweet liking (range 1–7)	4.35	1.40	1–7
Raisins liking (range 1–7)	4.47	1.28	1–7
Positive eating behaviors (range 1–5)	3.81	0.74	1.5–6
Negative eating behaviors (range 1–5)	2.50	0.71	1.2–4.2
Body mass index (Kg/m^2)	21.89	3.61	15–37
Attitudes toward healthy food (range 1–7)	6.56	0.68	3–7
Attitudes toward unhealthy food (range 1–7)	2.55	1.03	1–4.5

3.2. Moderated mediation analyses

3.2.1. Unhealthy food (i.e., sweets) consumption

Results revealed that the index of the moderated mediation was significant for IAHF ($b = -0.012$, SE = 0.004, $\beta = -0.31$, $p < 0.001$), but not for IAUF ($p = 0.635$) (see Fig. 1 and Table 2). Specifically, the conditional indirect effect of hunger through wanting for food on sweets consumption was statistically significant among participants with a low (i.e., at mean -1SD, conditional indirect effect = 4.29, SE = 2.143, $\beta = 0.88$, $p = 0.045$) or moderate (i.e., at mean, conditional indirect effect = 1.50, SE = 0.666, $\beta = 0.31$, $p = 0.025$), but not with high (i.e., at mean +1SD, conditional indirect effect = −1.30, SE = 1.162, $\beta = -0.27$, $p = 0.262$) IAHF. Furthermore, we calculated the simple effect of wanting for food (i.e., the mediator) on sweets consumption at the mean and at one standard deviation above and below the IAHF mean. As expected, simple effects showed that wanting for food was positively associated with sweets consumption for participants with a low ($b = 3.61$, SE = 0.789, $\beta = 0.67$, $p < 0.001$) or moderate ($b = 1.79$, SE = 0.789, $\beta = 0.35$, $p = 0.023$) IAHF. By contrast, wanting for food was not significantly associated with sweets consumption for participants with a high IAHF ($b = -0.02$, SE = 0.789, $\beta = -0.004$, $p = 0.978$) (see Fig. 2). In addition, sweets liking ($b = 1.34$, SE = 0.509, $\beta = 0.21$, $p = 0.009$), raisins consumption ($b = 0.58$, SE = 0.091, $\beta = 0.51$, $p < 0.001$), and usual negative eating behaviors ($b = 2.53$, SE = 1.087, $\beta = 0.20$, $p = 0.020$) were positively associated with sweets consumption, whereas raisins liking was negatively associated with sweets consumption ($b = -1.63$, SE = 0.637,



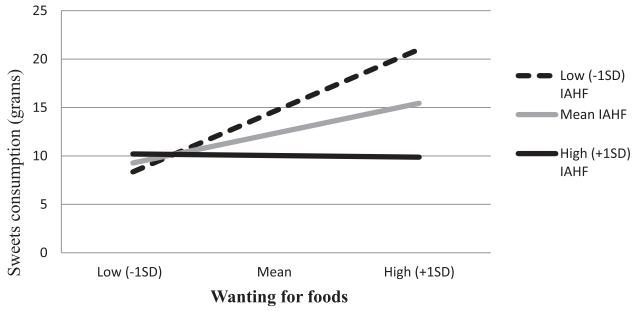
Notes. BMI = body mass index; IAHF = impulsive approach tendencies toward healthy food; IAUF = impulsive approach tendencies toward unhealthy food; + $p < .10$; * $p < .05$, ** $p < .01$; *** $p < .001$.

Fig. 1. Impulsive approach tendencies toward healthy food moderate the indirect effect of hunger on sweets consumption through wanting for food.
Notes. BMI = body mass index; IAHF = impulsive approach tendencies toward healthy food; IAUF = impulsive approach tendencies toward unhealthy food; + $p < 0.10$; *$p < 0.05$, **$p < 0.01$; ***$p < 0.001$.

Table 2
Summary of the results of the moderated mediation analyses testing whether the indirect effect of hunger on sweet consumption (Model 1) and raisins consumption (Model 2) through wanting for food is conditional on impulsive approach tendencies toward healthy and unhealthy food.

	Wanting for food (M)				Sweets consumption (Y) (Model 1)				Raisins consumption (Y) (Model 2)			
	b	*(SE)*	*β*	*p*	*b*	*(SE)*	*β*	*p*	*b*	*(SE)*	*β*	*p*
Hunger	0.85	0.056	0.87	<0.001	−1.58	0.774	−0.32	0.041	1.22	0.806	0.27	0.132
Wanting for food					1.79	0.789	0.35	0.023	−1.14	0.822	−0.25	0.166
IAHF					−0.02	0.007	−0.26	0.006	0.02	0.008	0.23	0.048
IAUF					−0.01	0.009	−0.01	0.925	−0.01	0.009	−0.07	0.533
Wanting for food X IAHF					−0.02	0.005	−0.31	<0.001	0.01	0.005	0.16	0.161
Wanting for food X IAUF					0.01	0.004	0.04	0.635	0.01	0.004	0.09	0.396
Raisins (sweets) consumption					0.58	0.091	0.51	<0.001	0.63	0.097	0.70	<0.001
Sweets liking					1.34	0.509	0.21	0.009	−0.86	0.547	−0.15	0.116
Raisins liking					−1.63	0.637	−0.23	0.010	2.24	0.643	0.36	<0.001
Positive eating behaviors					0.45	1.14	0.04	0.692	−0.65	1.188	−0.06	0.584
Negative eating behaviors					2.53	1.09	0.20	0.020	−1.21	1.167	−0.11	0.300
Attitudes toward healthy food					−1.00	1.32	−0.08	0.448	0.89	1.378	0.08	0.518
Attitudes toward unhealthy food					−0.54	0.742	−0.06	0.463	0.85	0.770	0.11	0.272
BMI					0.38	0.221	0.15	0.088	−0.19	0.235	−0.08	0.425
	$R^2 = 0.789$				$R^2 = 0.518$				$R^2 = 0.332$			
					b	*(SE)*	*β*	*p*	*b*	*(SE)*	*β*	*p*
Index of moderated mediation for IAHF					−0.012	0.004	−0.31	<0.001	0.006	0.004	0.14	0.163
Index of moderated mediation for IAUF					0.002	0.004	0.04	0.635	0.003	0.004	0.08	0.396

Notes. BMI = body mass index; IAHF = impulsive approach tendencies toward healthy food; IAUF = impulsive approach tendencies toward unhealthy food.



Notes. IAHF = impulsive approach tendencies toward healthy food.

Fig. 2. Effect of wanting for food on sweets consumption during (grams) a tasting task depending on the level of impulsive approach tendencies toward healthy food.
Notes. IAHF = impulsive approach tendencies toward healthy food.

$\beta = -0.23$, $p = 0.010$). All other effects were non-significant. In this model, the variables under consideration explain 75.96% of the variance in wanting for food and 51.8% of the variance in sweets consumption.

The results of the sensitivity analyses were consistent with those observed for the main analyses. Specifically, in all sensitivity analyses, the index of moderated mediation for IAHF remained significant and simple tests effect still revealed a significant and positive effect of wanting for food on sweets consumption for participants with a low or moderate, but not high IAHF.

3.2.2. Healthy food (i.e., raisins) consumption

Results revealed that the two indexes of moderated mediation were non-significant (*ps* = 0.163 and 0.396, for IAHF and IAUF, respectively). However, a direct and positive effect of IAHF on raisins consumption emerged ($b = 0.02$, SE = 0.008, $\beta = 0.23$, $p = 0.048$). In addition, sweets consumption ($b = 0.63$, SE = 0.097, $\beta = 0.70$, $p < 0.001$) and raisins liking ($b = 2.24$, SE = 0.643, $\beta = 0.36$, $p < 0.001$) were positively associated with raisins consumption. All other effects were non-significant. In this model, the variables under consideration explain 33.2% of the variance in raisins consumption (see Table 2).

The results of the sensitivity analysis that excluded participants who reported suspicion about the purpose of the experiment were consistent with those of the main analyses. However, in the three sensitivity analyses that excluded the covariates, the direct and positive effect of IAHF on raisins consumption became non-significant (*ps* > 0.14).

4. Discussion

The present study investigated whether individual differences in impulsive approach tendencies toward food is helpful in understanding how, and for whom, hunger will indirectly influence unhealthy food consumption through its effect on food wanting. We therefore argued a *moderated mediation pattern* in which the mediating effect of wanting for food is expected to be significant for individuals with impulsive systems predisposing to unhealthy food consumption (i.e., low IAHF and/or high IAUF), but not significant for individuals with impulsive systems predisposing to healthy food consumption (i.e., high IAHF and/or low IAUF).

The moderated mediation pattern was clearly supported for IAHF. The mediating effect of wanting for food between hunger and sweets consumption was weakened when IAHF was higher. Specifically, for participants with a low or moderate IAHF, the increase of wanting for food significantly predicted an increase in sweets consumption. By contrast, for participants with a high level of IAHF, wanting for food was not significantly related to sweets consumption (see Fig. 2). It is as if high IAHF blocked any deleterious effects of wanting for unhealthy food while in a hungry state. In other words, wanting for food is not always associated with an increase in unhealthy food intake, but is conditional on individual differences in impulsive approach tendencies toward healthy food. These results therefore suggest that IAHF play a significant role by moderating the deleterious effect of wanting for food on unhealthy food consumption. Furthermore, it is worth noting that when both hunger and wanting for food were included as predictors, a significant and negative direct effect of hunger on unhealthy food consumption emerged. This suppressive effect occurred because wanting for food explained an important part of variance in hunger (i.e., 78.9%). In other words, once the shared variance between hunger and wanting for food is taken into account, the residual effect of hunger on unhealthy food consumption becomes negative.

In sum, these results suggest that wanting for food, not hunger, may be responsible for the consumption of unhealthy food.

The pattern was, however, different for the IAUF. Indeed, unlike IAHF, IAUF had neither a direct effect nor an interactive effect with wanting for food on sweets consumption. This finding differs from the results observed in previous research showing that automatic affective reaction toward food may prospectively predict eating behavior (e.g., Hollands et al., 2011; Schumacher et al., 2016), but it was consistent with other research that failed to demonstrate such relationship (e.g., Ayres, Conner, Prestwich, & Smith, 2012; see Roefs et al., 2011; for an overview). Among the different factors likely to explain these inconsistencies, it has been postulated that certain situational, dispositional, or behavioral moderators can strongly influence the predictive validity of impulsive tendencies on behavior (Hofmann, Friese, et al., 2008). For instance, previous studies revealed that the predictive validity of impulsive tendencies on eating behaviors is moderated by situational cognitive resources (e.g., Friese et al., 2008), individual differences in working memory (e.g., Hofmann, Gschwendner, et al., 2008), and the habitual level of the behavior (e.g., Conner et al., 2007). Understanding the boundary conditions of the predictive validity of impulsive tendencies on eating behaviors is crucial from both theoretical and applied perspectives.

With regard to the complementary goal of this study, results revealed that in addition to its influence on unhealthy food consumption, IAHF had also an impact on healthy food consumption. Specifically, even if the patterns of moderated mediation were not confirmed, results revealed that IAHF had a direct and positive effect on healthy food (i.e., raisins) consumption. This finding is in line with previous research showing that impulsive tendencies can not only predict health detrimental behaviors, such as alcohol use (Wiers, Eberl, Rinck, Becker, & Lindenmeyer, 2011), but also health protective behaviors such as physical activity (Cheval, Sarrazin, Isoard-Gautheur, Radel, & Friese, 2015). However, results of the sensitivity analyses revealed that the influence of IAHF on healthy food consumption was not as strong and robust than its influence on unhealthy food consumption. Accordingly, this finding should be interpreted with cautious and needs further replication.

Overall, the present study is in line with previous research showing the importance of impulsive tendencies in the regulation of the normal and pathological eating behaviors (e.g., Berridge et al., 2010; Passamonti et al., 2009). Interestingly, the current study featured not only impulsive approach tendencies toward unhealthy food, but also toward healthy food, an impulsive tendency that can promote healthy eating behaviors. The inclusion of both impulsive approach tendencies promoting and impeding healthy eating broadens the perspective compared with the majority of previous research that often considers only one impulsive tendency at a time (e.g., Conner et al., 2007; Nederkoorn et al., 2010) or computes a single score representing the implicit attitudes toward healthy food relative to unhealthy food (e.g., Friese et al., 2008; Hollands et al., 2011), but rarely examines the distinctive predictive validity of the two impulsive tendencies (e.g., Calitri et al., 2010). In the present study, the pattern of results observed for the impulsive approach tendencies toward healthy and unhealthy food were clearly different. Consequently, it seems that taking into account these two impulsive approach tendencies may provide a more accurate prediction of eating behaviors. Finally, results also revealed no significant associations between these impulsive approach tendencies and hunger. This finding provide support for the idea that approach tendencies are relatively stable and independent of hunger state.

A practical implication of these findings is that a comprehensive consideration of the impulsive tendencies involved in eating behaviors should be taken in consideration when developing interventions promoting healthy eating behaviors. For instance, interventions designed to alter existing or create new associations such as evaluative conditioning or the retraining of impulsive approach tendencies (Hofmann, Friese, et al., 2008; see Marteau, Hollands, & Fletcher, 2012; for overviews) have proven to be useful in a variety of health-related behaviors, such as smoking (e.g., Wittekind, Feist, Schneider, Moritz, & Fritzsche, 2015), excessive alcohol consumption (e.g., Wiers et al., 2011), and physical activity (Cheval, Sarrazin, Pelletier, & Friese, 2016). In the context of eating behaviors, even if the evidence are mixed (e.g., Becker, Jostmann, Wiers, & Holland, 2015; Dickson, Kavanagh, & MacLeod, 2016), some studies suggest that these interventions could be effective in influencing food choices and food consumption (e.g., Hollands & Marteau, 2015; Hollands et al., 2011; Schumacher et al., 2016). Based on the present results, interventions may be particularly useful if they focus on strengthening the impulsive approach toward healthy food, given that this impulsive approach tendency was found to play a protective role by inhibiting the deleterious effect of wanting for food on unhealthy food consumption and to directly promote healthy food consumption.

In drug addiction, previous research showed that sensitization to a particular drug often increases the sensitization to other substances (Robinson & Berridge, 1993). This phenomenon of cross-sensitization has been demonstrated not only between different drugs (Pontieri, Monnazzi, Scontrini, Buttarelli, & Patacchioli, 2001), but also with non-drug related stimuli, such as stress (Prasad, Ulibarri, & Sorg, 1998), sexual behaviors (Fiorino & Phillips, 1999), and eating behaviors (Avena & Hoebel, 2003; Avena, Rada, & Hoebel, 2008; Le Merrer & Stephens, 2006). Therefore, the neural processes underlying these various classes of behaviors may share some common mechanisms. Accordingly, one may expect that impulsive response to healthy and unhealthy foods may not only impact healthy eating behaviors but also drinking behaviors as well. This hypothesis should be investigated in future research.

Overall, the present study had several strengths. It included: (a) dependent variables (i.e., unhealthy and healthy food consumption) that possess good external validity; (b) a well-validated measure of impulsive approach-avoidance tendencies; (c) an examination of distinctive approach tendencies toward healthy food and toward unhealthy food; (d) the use of a relatively sophisticated statistical method particularly suited to examine the expected sequential relationships between hunger, wanting for food, and food consumption, and (e) the inclusion of many control variables, that supported the additional predictive validity of impulsive approach tendencies. However, it had also some limitations. First, the present findings stem from the assessment of impulsive approach tendencies that were already existing. Future studies should investigate whether experimental procedure designed to modify impulsive approach tendencies toward food may significantly help individual to limit their unhealthy food intake when they are hungry. Second, our study included young and healthy participants. It may be particularly important to test in future research how the current pattern of results can vary depending on the sample characteristics, such as overweight and obese individuals, overeaters, or patients with anorexia nervosa or other eating disorders. Third, even if the dependent variable used has a good external validity, the present study was carried out under laboratory conditions. Measuring eating behaviors in natural setting outside the laboratory remains an important challenge.

In conclusion, the present results show that impulsive approach tendencies toward healthy food play a protective role by preventing hunger to indirectly increase unhealthy food consumption through wanting for food. This study therefore confirms the importance of considering how individuals may differ in their impulsive tendencies toward food to better understand why some individuals

will increase their unhealthy food intake when they are hungry, whereas other will not. In addition, impulsive approach tendencies toward healthy food had also a direct and positive effect on healthy food consumption, stressing that this impulsive tendency may be useful not only to reduce unhealthy food intake but also to promote healthy food consumption. Finally, a practical implication of the present findings is that interventions designed to promote healthy eating behaviors could benefit from using techniques designed to directly target impulsive tendencies, in addition to usual techniques targeting reflective precursors of eating behaviors, such as explicit attitudes. Such interventions aiming to influence both the reflective and impulsive determinant of eating behaviors appear to hold a great promise in improving public health.

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