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Corresponding author
Antje Hebestreit

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Emotion-driven impulsiveness and snack food consumption of European adolescents: results from the I.Family study

Running Title: Emotion-driven impulsiveness and snacks of European adolescents

Juul M. J. Coumans[1], Unna N. Danner[2], Timm Intemann[3], Annelies De Decker[4], Charalambos Hadjigeorgiou[5], Monica Hunsberger[6], Luis A. Moreno[7], Paola Russo[8], Sarolta Stomfai[9], Toomas Veidebaum[10], Roger A. H. Adan[1] and Antje Hebestreit[3], on behalf of the I.Family Consortium

[1]Brain Centre Rudolf Magnus, Department of Translational Neuroscience, University Medical Center Utrecht, The Netherlands
[2]Altrecht Eating Disorders Rintveld, Zeist, The Netherlands
[3]Leibniz-Institute for Prevention Research and Epidemiology – BIPS, Bremen, Germany
[4]Department of Public Health, Faculty of Medicine and Health Sciences, Ghent University, Ghent, Belgium
[5]Research and Education Institute of Child Health, Strovolos, Cyprus.
[6]Department of Public Health and Community Medicine, University of Gothenburg, Gothenburg, Sweden.
[7]Growth, Exercise, NUtrition and Development (GENUD) research group, Universidad de Zaragoza, Instituto Agroalimentario de Aragón (IA2), Instituto de Investigación Sanitaria de Aragón (IIS Aragón) and Centro de Investigación Biomédica en Red de Fisiopatología de la Nutrición y la Obesidad (CIBEROBN), Zaragoza, Spain.
[8]Institute of Food Sciences, National Research Council, Avellino, Italy.
[9]Department of Pediatrics, Medical Faculty, University of Pécs, Pécs, Hungary
[10]Department of Chronic Diseases, National Institute for Health Development, Tallinn, Estonia.

Corresponding author:
Antje Hebestreit
Leibniz Institute for Prevention Research and Epidemiology - BIPS, Achterstrasse 30, 28359 Bremen, Germany
Phone: +49 (0)421 218 56 849
Fax: +49 421 218 56 821
E-mail: hebestr@leibniz-bips.de

Abstract

We aimed to investigate the association between emotion-driven impulsiveness and snack food consumption in 1,039 European adolescents aged 12 to 18 years. During the cross-sectional examination in 2013/2014, complete information was collected on: emotion-driven impulsiveness (using the negative urgency subscale from the Urgency, Premeditation, Perseverance, Sensation seeking, and Positive urgency (UPPS-P) Impulsive Behaviour Scale) and snacking behaviour operationalised as 1) consumption frequency of daily snacks, 2) consumption frequency of energy-dense snacks (both measured using Food Frequency Questionnaire) and 3) usual energy intake of food consumed per snacking occasion in calories. The latter was measured using online self-administered 24-hour dietary recalls and was estimated based on the National Cancer Institute (NCI) Method. Anthropometric variables were measured and BMI z-score (zBMI) calculated. Age, sex, highest education level of the family and country of residence were assessed using a questionnaire. Mixed-effect regression analyses were separately conducted for each snacking behaviour outcome with emotion-driven impulsiveness as the exposure. After controlling for zBMI, age, sex, country and socioeconomic status, emotion-driven impulsiveness was positively associated with daily consumption frequency of snacks ($\beta = 0.07$, 95% Confidence Interval (CI) [0.02, 0.12]) and consumption frequency of energy-dense snacks ($\beta = 0.25$, 95% CI [0.19, 0.31]), but not with usual energy intake of food per snacking ($\beta = 2.52$, 95% CI [-0.55, 5.59]). Adolescents with a stronger emotion-driven impulsiveness tendency reported a higher snacking frequency and specifically more energy-dense snacks, whereas the energy intake of snack food seemed less important. These findings have implications for obesity prevention and treatment as they indicate the importance of targeting emotion-driven impulsiveness as a strategy to avoid excessive snacking.

Keywords: Snacking frequency; energy-dense snacks; negative urgency; body mass index; children, Europe.

Introduction

Obesity has reached epidemic proportions globally, making it one of the greatest public health concerns (World Health Organization, 2016). A main driver for weight gain is an energy intake that exceeds energy expenditure. One of the suggested problems with energy intake is that people eat highly palatable and energy-dense foods between meals, also referred to as snacks, which may contribute significantly to the daily energy intake (de Graaf, 2006; Larson, Miller, Watts, Story, & Neumark-Sztainer, 2016; Myhre, Løken, Wandel, & Andersen, 2015; Ovaskainen, Tapanainen, & Pakkala, 2010). Since snacks are widely available in the current food environment, this provides many temptations for the individual and encourages people to eat unhealthily (Booth, Pinkston, & Poston, 2005; Hill & Peters, 1998; Wang et al., 2004). However, not everyone is equally prone to give in to these food temptations. Individual differences in impulsivity seem to play an important role in giving in to temptations (Hofmann, Friese, & Strack, 2009; Hofmann, Gschwendner, Friese, Wiers, & Schmitt, 2008). One of the most common circumstances under which impulses tend to predominate is when people experience negative affect (i.e. negative emotions such as anger, guilt, disgust, and sadness (Watson & Clark, 1984)). Some people are more prone to act impulsively in the context of negative affect than others; a trait referred to as emotion-driven impulsiveness in this study (Chester et al., 2016; Cyders & Smith, 2008; Heatherton & Wagner, 2011). Subsequent (impulsive) behaviour is intended to lessen the intensity of the negative emotional state (Larsen, 2000), a situation that may specifically apply when confronted with food temptations.

Evidence for the relationship between food intake and emotion-driven impulsiveness stems from several studies. Previous research showed that a higher weight status is associated with more emotion-driven impulsiveness in adolescents (Delgado-Rico, Río-Valle, González-Jiménez, Campoy, & Verdejo-García, 2012; Whiteside & Lynam, 2001). Further research has shown that food has stronger rewarding properties for adolescents with overweight than for non-overweight adolescents, and that when the overweight adolescents also suffer from emotion-driven impulsiveness, it may be even more difficult to resist high caloric snacks (Nederkoorn, Braet, Van Eijs, Tanghe, & Jansen, 2006; Temple, Legierski, Giacomelli, Salvy, & Epstein, 2008). It seems likely that individuals who are more emotion-driven impulsive more frequently have difficulties with adequate regulation of emotions and may engage in ill-considered and maladaptive coping strategies to manage these intense feelings (Cyders & Smith, 2008). It is theorised that the consumption of snack foods or any food with high fat and sugar content outside the main meals may be done to temper these emotional states due to the rewarding properties of palatable food (Singh, 2014). Further evidence for this idea comes from studies on the concept of emotional eating, i.e. eating when feeling emotional. One study found that adults scoring high on emotional eating reported a higher consumption of sweet and savoury foods, but not fruits and vegetables (Konttinen, Männistö, Sarlio-Lähteenkorva, Silventoinen, & Haukkala, 2010). Comparably, other studies also found that emotional eaters were more likely to consume sweet and/or fat foods under emotional stress (Oliver, Wardle, & Gibson, 2000; Wallis & Hetherington, 2004). Those individuals who tend to overeat (eating more calories than required to keep the energy balance) in response to negative emotions may have an increased risk of becoming obese. Thus, for some people snacking behaviour is an emotion regulation strategy that can be considered as maladaptive.

However, research studying the effect of emotion-driven impulsiveness and eating behaviour in otherwise healthy individuals is rather scarce and has mainly focused on weight instead of eating behaviour (Delgado-Rico et al., 2012). The idea is that people who are more driven by their emotional impulses have a higher risk for developing excess body weight because they consume (energy-dense) foods more frequently. Yet, to our knowledge, no studies have examined whether emotion-driven impulsiveness affects weight because of its direct effects on snacking behaviour. Furthermore, most of the studies were conducted under laboratory conditions, thereby lacking ecological validity (Gibbons, Finlayson, Dalton, Caudwell, & Blundell, 2014). An important additional factor is that so far studies have mainly been conducted in adult populations using small samples. Adolescents are however especially at risk for engaging in snacking behaviour because they have an increased responsiveness to reward and they also have limited self-regulation skills because of their developmental stage, i.e. due to immature (pre)frontal brain areas (Spear, 2000). When adolescents also have difficulties adequately regulating their emotions (i.e. being more emotion-driven impulsive), they may be more likely to be at risk to give in to food temptations and more frequently consume energy-dense foods than their peers who have no difficulties regulating their emotions, or only do so to a lesser extent.

Therefore, the aim of this study was to investigate the association of emotion-driven impulsiveness with snacking behaviour in adolescents. Snacking behaviour is operationalised in three ways: 1) frequency of daily consumption of snack foods, 2) frequency of daily consumption of energy dense snacks (e.g., cookies and chocolate) and 3) the total energy intake of food in calories consumed per snacking occasion (SO), which is defined as the moments in which any food is consumed outside the main meals (i.e. breakfast, lunch and dinner). Given that is known that weight status is related to snacking behaviour, the analyses were adjusted for BMI z-score (zBMI) to control for this potentially confounding variable. It was expected that adolescents who are more emotion-driven impulsive have a higher consumption frequency of daily snacks and in particular of energy-dense snacks.

Methods

Study population

Data for this study were obtained from 2,770 adolescents (from 2,516 families) who participated in the I.Family study in 2013/2014 (Ahrens et al., 2016). The I.Family study examined children and parents from Belgium, Cyprus, Estonia, Hungary, Germany, Italy, Spain and Sweden to find associations between eating habits and lifestyle factors leading to overweight/obesity. In the present study we included adolescents from 12 to 18 years of age of whom demographic information, anthropometric and emotion-driven impulsiveness data were available and who completed the food frequency questionnaire. From this sample, 1,039 adolescents provided complete and plausible 24-hour dietary recalls (also referred to as the subsample). This study was conducted according to the guidelines laid down in the Declaration of Helsinki in 1964. Approvals by the Ethics Committee were obtained from the local authorities in each participating centre. All adolescents and their parents provided written consent for participation in the study.

Measurements

Questionnaires. Adolescents reported their date of birth and sex. Parents reported their highest educational level according to the International Standard Classification of Education (ISCED) that was used as a proxy indicator for socioeconomic status (UNESCO, 2011). Additionally, adolescents completed the negative urgency subscale from the Urgency, Premeditation, Perseverance, Sensation seeking, and Positive urgency (UPPS-P) questionnaire to assess emotion-driven impulsiveness or the disposition to engage in rash action when experiencing extreme negative affect (Cyders & Smith, 2007; Whiteside & Lynam, 2001). The participant had to rate 12 items on a four-point Likert scale ranging from "1" (agree strongly) to "4" (disagree strongly). One example statement is "when I feel bad, I will often do things I later regret in order to make myself feel better now". The original scale of all items was inversely coded to ensure that all items ran in the same direction, except for item 11 that was already in the correct direction. Thus, a higher score is indicative of more emotion-driven impulsiveness or being more impulsive in the context of negative affect. The validity and reliability of this questionnaire have already been demonstrated (Anestis, Selby, & Joiner, 2007; Claes, Vandereycken, & Vertommen, 2005; Whiteside & Lynam, 2001). The internal consistency of the scale in the present study was good (Cronbach's α = 0.87).

Children's Eating Habit Questionnaire - Food Frequency Questionnaire (FFQ). The FFQ consists of 43 items regarding food consumption frequency (Huybrechts et al., 2011). For the present study we only included the items about snack foods. Adolescents had to rate the typical frequency of snack(s) in the morning, afternoon, and evening during the month prior to the examination on a 5-point Likert scale: "1" (never), "2" (on fewer occasions than once a week), "3" (1-2 times a week), "4" (3-6 times a week), or "5" (daily). Morning snack is here defined as the eating occasion at mid-morning, between breakfast and lunch, afternoon snack as the eating occasion occurring between lunch and dinner, and evening snack as the eating occasion occurring after dinner. These ratings were converted into snacking frequency per week. Snacking frequency per day was determined by summing up the recoded frequency and divided by 7.

Furthermore, adolescents reported the consumption frequency of a particular snack food in a typical week in the last month on a 7-point Likert scale: "1" (never/less than once a week', "2" (1–3 times a week', "3" (4–6 times a week'), "4" (1 time per day), "5" (2 times per day), "6" (3 times per day) or "7" (4 or more times per day). Six types of energy-dense snacks were assessed, namely salty snacks, savoury pastries, chocolate, candy (non-chocolate), cake/pudding/cookies and ice cream. For example, one item to determine the consumption frequency of chocolate products was: "Snacks like chocolate, candy bars (Mars, Lion, Kit Kat, local examples, etc.).” The consumption frequency of energy-dense snacks per day was determined by summing up the recoded frequencies for energy-dense snacks and divided by the numbers of days in a week. Participants were excluded when they reported consuming more than 5.79 snacks each day (n = 93; defined as the number of energy-dense snack occasions of more than two standard deviations from the group mean).

Dietary information and dietary analysis. Dietary intake of the previous 24 hours was assessed using a web-based 24-hour dietary recall (24HDR) assessment program, called the “Self-Administered Children, Adolescents and Adult Nutrition Assessment” (Hebestreit et al., 2017). The software was based on the ‘Self-Administered Children and Infant Nutrition Assessment’ (SACINA), which is considered to be a well-validated method to assess dietary intake (Börnhorst et al., 2014; Hebestreit et al., 2014). SACANA has been validated, and there are results supporting the validity of SACANA as a self-reporting instrument for assessing intakes in children (publications in progress).

Participants were asked to recall their diet and to enter the type and amount (g) of all drinks and foods consumed during the previous day, starting with the first intake after waking up in the morning. They further had to enter the time for every meal occasion during the day (breakfast, lunch, dinner or snack), and for every meal had to select all food items they had eaten at that specific occasion. For each item, the participant filled in the amount of food consumed. There were two ways in which the participant could enter the amount of food (in grams) consumed for a particular food item. For easy countable items, such as the numbers of candy bars, the standard serving size was used and the participant was simply requested to enter the number of food items consumed. For food items that are normally eaten in varying portion sizes and are therefore more difficult to estimate, the online assessment additionally provides standardized photographs depicting different serving sizes (the amount of gram was visible on the photos) or participants could modify the standard serving size with two command buttons. The participant then had to recall what he/she had actually consumed, then compare it with the photos with different serving sizes and then had to choose the amount of food he/she consumed (Hebestreit, Wolters, Jilani, Eiben, & Pala, 2018). This, for example, was the case with M&Ms. The amount of food was then converted to kilocalories by the SACANA program. All nutrients and energy values were expressed per 100g edible portion. Participants were asked to complete multiple 24HDRs. At least three 24HDRs had to be completed within a time period of four weeks as far as possible, including two weekdays and one weekend day (non-consecutive days). After six and 12 months, the participants were again asked to complete another triplet (three 24HDR) in each case with the same timing guidelines as the first three 24HDRs. In the present study, the availability of repeated 24HDR varied among individuals (from one to four; 0.1% of the recalls were excluded). All available recall days were used and up to eight SOs per participant were used to calculate the usual energy intake in kcal of foods per SO. Missing or implausible intake values of single food items in the 24HDR that could not be corrected were imputed by country, food group and age-specific median intakes (this was the case for 0.14% of all food items). If more than four values were missing or implausible per recall day, the whole day was excluded from the analysis. Subsequently, it was determined whether a recall day was considered as under-reported, plausibly reported or over reported energy intake by calculating the individual ratio of the energy intake and the basal metabolic rate (EI/BMR) and comparing this ratio with the age- and sex-specific EI/BMR for children using Goldberg cut-offs as described elsewhere (Black, 2000; Börnhorst et al., 2012; Schofield, 1985; Torun, 2005). In total, we excluded 429 adolescents classified as misreporters from the analysis: among these, 98.6% were under-reporters, and 1.4% were over-reporters.

After the exclusion of under- and over reports, the usual energy intake per SO was estimated by the so-called National Cancer Institute (NCI) method based on the reported energy intake per SO (Kipnis et al., 2009). This method allows the inclusion of covariates such as age, accounts for different intakes during the weekend vs. workdays, and corrects for the variance inflation caused by daily variation in diet. Thus, usual energy intake per SO were estimated for male and female adolescents separately.

Anthropometrics. Body weight was measured using a portable electronic scale (TANITA BC 418 MA) in fasting status and height was measured using a stadiometer (SECA 225/ SECA 213). Both measurements were performed in light clothing. Body mass index (BMI) was calculated as body weight in kilograms divided by height in square meters. To account for differences in BMI by age and sex, z-scores of BMI (zBMI) were calculated according to Cole and Lobstein (2012). Weight groups (thin/normal and overweight/obese) of adolescents were categorised using age- and sex-specific cut-off values based on the extended IOTF criteria (Cole & Lobstein, 2012).

Statistical analysis

Spearman's rank correlation coefficients of emotion-driven impulsiveness with consumption frequency of daily snacks, the consumption frequency of energy-dense snacks and the usual energy intake per SO in calories were calculated. To investigate the association between emotion-driven impulsiveness and snacking behaviour, we conducted a mixed effect regression analysis separately for each of the three operationalisations of snacking behaviour as the main outcome and the emotion-driven impulsiveness as exposure. For all analyses, the potentially confounding variables sex, age, socioeconomic status and country were included for the basic models. Moreover, a random effect for family membership was used in all models to account for dependencies between siblings. In the fully adjusted model, the exposure zBMI was additionally included to investigate whether the association between emotion-driven impulsiveness and the main outcomes changed. When a significant association was found between emotion-driven impulsiveness and one of the operationalisations of snacking behaviour, an interaction term of emotion-driven impulsiveness and zBMI was added to the fully adjusted model, to investigate whether zBMI moderated this association. Using a likelihood ratio test, it was examined whether adding zBMI to the starting model or adding the interaction term zBMI × emotion-driven impulsiveness to the fully adjusted model led to a better model fit (i.e., a lower AIC value). Parameters were estimated using the maximum likelihood method. The statistical analyses were performed with the statistical software R (version 3.1.0; (R Core Development Team, 2013)) using the lme4 package (Bates, Mächler, Bolker, & Walker, 2014). Statistical significance was set at $p \leq 0.05$.

Results

Descriptive statistics

Table 1 and 2 present the characteristics of the full sample and the subsample stratified by frequency of (energy-dense) snacks. The full sample comprised 1,312 boys (47%) and 1,458 girls (53%) aged between 12 and 17.9 years (mean 13.6 years). The majority of adolescents came from medium and high socioeconomic families (43% and 52% respectively). The highest proportion of the adolescents was from Cyprus (26%) and the lowest from Belgium (2%). The majority (66%) of the adolescents had a zBMI placing them in the normal-weight range, 7% were underweight, 19% were overweight and 8% were obese.

The subsample consisted of 1,039 adolescents (565 girls and 474 boys) aged between 12.0 and 17.8 years (mean 13.50) who also completed and provided plausible 24HDRs. The majority of these adolescents also came from a medium and highly educated family (respectively 42% and 54%). Slightly more than a quarter of this sample originated from Italy (26%) and the smallest proportion was again from Belgium (4%). The majority (70%) of the adolescents had a zBMI placing them in the normal-weight range, 9% were underweight, 16% were overweight and 5% were obese.

The consumption frequency of daily snacks

There was a small positive correlation between emotion-driven impulsiveness and the daily consumption frequency of snacks, $\rho_s = 0.07$, $p < 0.001$. We did not observe any association between emotion-driven impulsiveness and the daily consumption frequency of snacks in the basic model ($\beta = 0.05$, 95% CI [-0.003, 0.10], $p = 0.064$), but a significant positive association between emotion-driven impulsiveness and the consumption frequency of daily snacks was found in the fully adjusted model, which was additionally adjusted for zBMI ($\beta = 0.07$, 95% CI [0.02, 0.12], $p = 0.004$; see Table 3).

The consumption frequency of energy-dense snacks

A small positive correlation was found between emotion-driven impulsiveness and the consumption frequency of energy-dense snacks, $\rho_s = 0.14$, $p < 0.001$. Furthermore, a positive association between emotion-driven impulsiveness and the consumption frequency of energy-dense snacks was observed in both the basic model ($\beta = 0.22$, 95% CI [0.16, 0.28], $p < 0.001$) as well as the fully adjusted model, which was controlled for zBMI ($\beta = 0.25$, 95% CI [0.19, 0.31], $p < 0.001$; see Table 3).

In addition, there was a small positive correlation between the calories consumed per SO and the consumption frequency of energy-dense snacks, $\rho_s = 0.07$ ($p = 0.02$), while no significant correlation was found between the calories consumed per SO and the consumption frequency of energy-dense snacks, $\rho_s = 0.01$ ($p = 0.72$).

We further investigated whether the association between emotion-driven impulsiveness and the consumption frequency of daily snacks and the consumption frequency of energy-dense snacks was moderated via zBMI. Adding the interaction term of emotion-driven impulsiveness and zBMI however did not significantly improve the model for both the daily consumption frequency of snacks and the consumption frequency of energy-dense snacks (see Supplemental Table 1 and Supplemental Table 2).

Energy intake of food per snack occasion

In a subsample of the adolescents who completed the SACANA ($n = 1{,}039$), it was investigated whether emotion-driven impulsiveness is associated with the usual energy intake of food consumed per SO. There was no significant correlation between emotion-driven impulsiveness and the usual energy intake of food consumed per SO (in kcal), $\rho_s = -0.04$, $p = 0.18$. There was also no significant association between emotion-driven impulsiveness and the usual energy intake of food consumed per SO, neither in the basic nor in the fully adjusted model ($\beta = 2.52$, 95% CI [-0.55, 5.59], $p = 0.11$; see Table 4).

Discussion

In this population-based study of European adolescents, the association between emotion-driven impulsiveness and snacking behaviour was investigated. The results showed that more emotion-driven impulsiveness was associated with a higher consumption frequency of daily snacks, in particular the consumption frequency of energy-dense snacks. However, no significant association between emotion-driven impulsiveness and the energy intake of food consumed in calories per SO was found. This suggests that adolescents who have a tendency to act more emotion-driven impulsive are inclined to eat more snacks a day, and in particular energy-dense snacks, but do not necessarily consume more calories during each snacking occasion.

We observed that adolescents who were more emotion-driven impulsive reported a higher consumption frequency of daily snacks after controlling for weight. Adolescents who scored highest on emotion-driven impulsiveness consumed on average 0.21 snacks more per day compared to adolescents who scored lowest on emotion-driven impulsiveness. Given that in our sample the mean number of kcal consumed during a SO is 293.6 kcal, it was estimated that adolescents scoring highest on emotion-driven impulsiveness may consume about 62 kcal more on a daily basis (0.21×293.6) compared to those scoring lowest on emotion-driven impulsiveness. This may lead to a weight increase of 2.5 kg (62 kcal x 365 days / 9000 kcal) on a yearly basis. Contrary to our expectations, this finding was independent of weight status of adolescents, suggesting that emotion-driven impulsiveness has similar effects on food consumption frequency in adolescents with normal weight and excessive weight. This is in agreement with earlier findings from Oliver et al. (2000), who also found that emotional eating is related to the consumption frequency of sweet and non-sweet food, but that this relationship did not vary according to BMI and waist circumference level. These results are also in line with studies focusing on extreme patterns of eating behaviour, namely binge eating (Fischer, Smith, & Cyders, 2008), which does not necessarily result in excessive weight as is evident in people who suffer from bulimia nervosa. In several studies, emotion-driven impulsiveness was reported to be associated with the number of binge eating episodes, as assessed in mainly female first-year college students (Anestis et al., 2007; Davis-Becker, Peterson, & Fischer, 2014; Davis & Fischer, 2013; Fischer, Peterson, & McCarthy, 2013). The current results however suggest that adolescents who are inclined to act impulsively in the context of negative affect, independent of their weight, might also be more prone to snack more often.

There are several explanations why the association between emotion-driven impulsiveness and the consumption frequency of (energy-dense) snacks is independent of weight. Firstly, the consumption frequency of (energy-dense) snacks of heavier adolescents, due to their weight, might be more restricted by parental influence than that of their lean peers (Keller, Pietrobelli, Johnson, & Faith, 2006; Tiggemann & Lowes, 2002). Secondly, adolescents with a lower weight may compensate their snacking behaviour more than adolescents with a higher weight by lowering their remaining energy intake and increasing physical activity (Kerver, Yang, Obayashi, Bianchi, & Song, 2006; Maffeis et al., 2008; Trost, Kerr, Ward, & Pate, 2001). Lastly, a higher frequency of (energy-dense) snacks may not have an equal effect on body weight for every adolescent due to individual differences in the biological predisposition and metabolic processes (Cruz & Goran, 2004; Trost et al., 2001; Weiss et al., 2004). Future research should take the role of these potentially confounding factors into account.

This study showed that more emotion-driven impulsive adolescents were in particular more inclined to consume energy-dense snacks more frequently. Adolescents who score highest on emotion-driven impulsiveness reported to consume on average 0.75 energy-dense snacks more per day compared to adolescents who score lowest on emotion-driven impulsiveness. This result is consistent with the scarce literature that is available that shows that emotional eating is related to a higher frequency of sweet and savoury foods, especially under stress (Konttinen et al., 2010; Oliver et al., 2000; Wallis & Hetherington, 2004). One possible reason for this is that food can elevate mood, with energy-dense foods having a stronger effect compared to nutrient-dense foods (Chua, Touyz, & Hill, 2004; Macht & Dettmer, 2006; Macht & Mueller, 2007). In particular, foods that contain sugars and fat are potential rewards and stimulate eating even in the absence of hunger (Lenoir, Serre, Cantin, & Ahmed, 2007). It is theorised that negative urgency is related to an increase in attention to and the salience of rewarding cues in the environment, and these types of food represent such rewarding cues. Excessive activation of the rewarding brain networks may be coupled with fatigue of the inhibitory brain regions because of their increased attention to rewarding environmental cues resulting in less effective modulation of these cues via top–down circuitry (Smith & Cyders, 2016). The frontal brain areas (related to executive functions) are not yet matured in adolescents, making them more prone to respond to reward (Somerville, Jones, & Casey, 2010). When adolescents are also more (emotion-driven) impulsive, they may, therefore, be especially vulnerable to the temptations of tasty high caloric food and to future weight gain.

We did not observe an association between high emotion-driven impulsiveness and higher energy intake of food consumed per snacking occasion in adolescents. This is in contrast with previous findings showing that impulsive individuals may have difficulties inhibiting their snacking behaviour once started (Nederkoorn, Guerrieri, Havermans, Roefs, & Jansen, 2009; Nederkoorn, Smulders, Havermans, Roefs, & Jansen, 2006). Although impulsivity has often been linked to inhibition, there are conceptual differences between these two constructs. Impulsivity is namely related to the initiation of behaviour, while inhibition is related to the termination of behaviour. Our results showed that adolescents who were more emotion-driven impulsive ate a snack more frequently but they did not eat more energy per snacking occasion compared to adolescents who are less emotion-driven impulsive. The limited research that is available presents mixed findings. While some studies found that negative emotional states influence (self-perceived) overeating, particularly in obese adults (Bekker, van de Meerendonk, & Mollerus, 2004; Chua et al., 2004; Udo et al., 2013), another study did not any positive association between emotion-driven impulsiveness and increased calorie intake (Emery, King, & Levine, 2014). This latter finding is in line with our results. The discrepancy in results between earlier studies and our study might be explained by differences in research methods (e.g. DEBQ for emotional eating, experimental design with mood induction or a sham taste perception task) and the sample used (adults versus adolescents).

Although this study included a large sample of adolescents in free-living conditions from eight different European countries, some limitations should be acknowledged. A cross-sectional design was used to examine the association between emotion-driven impulsiveness and snacking behaviour, making it impossible to draw causal inferences. Future studies should, therefore, use longitudinal designs and experimental approaches suitable for large-scale studies to test more directly whether emotions influence impulsive snacking behaviour in free-living subjects. Furthermore, this study used mainly self-reports that have many advantages, such as the easy implementation in large samples, but they also suffer from disadvantages, such as memory loss regarding dietary recall and vulnerability of social desirability bias, which could lead to underreporting of snacking behaviour (Nijs, Muris, Euser, & Franken, 2010; Willett, 2001). Additionally, this study did not investigate the association between emotion-driven impulsiveness and the consumption of sugar-sweetened beverages (SSB). These SSBs are characterised by high sugar content but do not provide the same feeling of satiety compared to solid (snack) foods (Malik, Schulze, & Hu, 2006). As this would go beyond the focus of the present study, we plan to explore to what extent emotion-driven impulsiveness is related to the consumption of SSBs and how this may contribute to the obesity epidemic in future studies.

To conclude, this study shows that emotion-driven impulsiveness is related to the type of snack food (sweet and fat) and not to the energy intake of food consumed per snacking occasion. This effect is independent of age, sex, socio-economic status and even BMI.

Temporary deficits in self-control, such as inefficient response inhibition and emotion regulation strategies are posited to play a role in the relationship between emotion-driven impulsiveness and snacking behaviour. Therefore, future studies should take the role of self-control and emotion regulation into account. Nevertheless, emotion-driven impulsiveness seems to be of importance for the prevention and treatment of obesity.

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Conflict of Interest

JC wrote the manuscript; TI was involved in the preparation of the dietary data; JC and TI performed the data analysis; UD and RA had the idea for the study; JC, UD, RA, AH have primary responsibility for final content. All authors were responsible for critical revisions and final approval of the manuscript. This manuscript represents original work that has not been published previously and is currently not considered by another journal. None of the authors declared a personal or financial conflict of interest.

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Table 1
Characteristics of sex, socioeconomic status, country and BMI status in the study population.

		Full sample (N = 2,770)		**Subsample** (n = 1,039)	
		N	%	*n*	%
Sex	Girls	1,458	52.6	565	54.4
	Boys	1,312	47.4	474	45.6
Socioeconomic status[a]	Low education	142	5.1	52	5.0
	Medium education	1,201	43.4	431	41.5
	High education	1,427	51.5	556	53.5
Country	Belgium	65	2.3	38	3.7
	Cyprus	707	25.5	92	8.9
	Estonia	414	14.9	230	22.1
	Germany	228	8.2	121	11.6
	Hungary	399	14.4	107	10.3
	Italy	492	17.8	266	25.6
	Spain	135	4.9	74	7.1
	Sweden	330	11.9	111	10.7
BMI status[b]	Underweight	200	7.2	90	8.7
	Normal	1,817	65.6	729	70.2
	Overweight	531	19.2	170	16.4
	Obese	222	8.0	50	4.8

[a] International Standard Classification of Education Maximum (ISCED); maximum of both parents.
[b] According to Cole and Lobstein (2012)

Table 2
Characteristics of age, zBMI, emotion-driven impulsiveness and the operationalisations of snacking behaviour of the study population.

	Full sample (N = 2,770)		**Subsample** (n = 1,039)	
	Mean (*SD*)	Range (min; max)	Mean (*SD*)	Range (min; max)
Age (years)	13.6 (1.1)	12.0; 17.9	13.5 (0.9)	12.0; 17.8
BMI z-score[a]	0.6 (1.1)	-2.7; 3.5	0.4 (1.1)	-2.3; 3.0
Emotion-driven impulsiveness	2.1 (0.6)	1.0; 4.0	2.1 (0.6)	1.0; 3.9
Frequency of daily snacks	1.4 (0.8)	0; 3	1.5 (0.8)	0; 3
Frequency of energy-dense snacks	1.4 (1.1)	0; 5.7	1.4 (1.0)	0; 5.7
Usual energy intake of food consumed per snacking occasion (kcal)			293.6 (39.4)	182.5; 473.3

[a] According to Cole and Lobstein (2012)

Table 3
Results from the mixed effect model analysis with the consumption frequency of daily snacks (left) and the consumption frequency of energy-dense snacks (right) as outcomes with exposure emotion-driven impulsiveness accounting for family (random effect), age, sex, socioeconomic status (ISCED) and country

	Consumption frequency of daily snacks (N = 2,770)						**Consumption frequency of energy-dense snacks (N = 2,770)**					
	Model 1: basic model			Model 2: fully adjusted model			Model 1: basic model			Model 2: fully adjusted model		
	β	CI	*p*	β	CI	*p*	β	CI	*p*	β	CI	*p*
Fixed Parts												
Intercept	1.40	0.99 – 1.80	**<.001**	1.49	1.10 – 1.89	**<.001**	1.41	0.90 – 1.92	**<.001**	1.52	1.02 – 2.03	**<.001**
EDI	0.05	-0.003 – 0.10	.064	0.07	0.02 – 0.12	**.004**	0.22	0.16 – 0.28	**<.001**	0.25	0.19 – 0.31	**<.001**
Age	-0.002	-0.03 – 0.03	.905	-0.001	-0.03 – 0.03	.946	-0.02	-0.06 – 0.01	.193	-0.02	-0.06 – 0.01	.212
Sex[a]	-0.06	-0.12 – -0.004	**.037**	-0.08	-0.14 – -0.03	**.005**	-0.12	-0.20 – -0.04	**.003**	-0.14	-0.22 – -0.07	**<.001**
ISCED (high)[b]	0.02	-0.04 – 0.09	.469	-0.003	-0.07 – 0.06	.931	-0.14	-0.23 – -0.06	**.001**	-0.17	-0.26 – -0.09	**<.001**
ISCED (low)[b]	0.04	-0.11 – 0.18	.597	0.09	-0.05 – 0.23	.228	0.04	-0.15 – 0.23	.664	0.10	-0.08 – 0.29	.284
Belgium[c]	-0.06	-0.27 – 0.16	.614	-0.20	-0.41 – 0.02	.071	-0.09	-0.37 – 0.19	.532	-0.26	-0.54 – 0.01	.063
Cyprus[c]	0.24	0.14 – 0.34	**<.001**	0.20	0.10 – 0.30	**<.001**	-0.04	-0.17 – 0.09	.519	-0.10	-0.22 – 0.03	.144
Estonia[c]	-0.26	-0.37 – -0.15	**<.001**	-0.33	-0.45 – -0.22	**<.001**	0.04	-0.10 – 0.19	.575	-0.05	-0.19 – 0.10	.504
Germany[c]	-0.05	-0.19 – 0.08	.451	-0.15	-0.28 – -0.02	**.027**	-0.50	-0.68 – -0.33	**<.001**	-0.62	-0.80 – -0.45	**<.001**
Hungary[c]	-0.13	-0.24 – -0.02	**.021**	-0.21	-0.32 – -0.10	**<.001**	0.25	0.10 – 0.39	**<.001**	0.15	0.01 – 0.29	**.041**
Spain[c]	0.15	-0.01 – 0.30	.069	0.06	-0.10 – 0.21	.478	-0.03	-0.24 – 0.17	.738	-0.15	-0.35 – 0.06	.156
Sweden[c]	-0.24	-0.36 – -0.12	**<.001**	-0.32	-0.44 – -0.20	**<.001**	0.11	-0.04 – 0.26	.163	0.01	-0.14 – 0.16	.928
zBMI				-0.14	-0.17 – -0.11	**<.001**				-0.17	-0.20 – -0.13	**<.001**
Random Parts												
σ^2		0.587			0.582			0.815			0.787	
$\tau_{00,\text{ family\_id}}$		0.060			0.045			0.247			0.245	
$N_{\text{family\_id}}$		2516			2516			2516			2516	
$ICC_{\text{family\_id}}$		0.093			0.071			0.233			0.238	
R^2 / Ω_0^2		.315 / .223			.250 / .211			.672 / .438			.644 / .461	
AIC		6682.919			6598.811			8041.760			7964.486	

AIC, Akaike Information Criterion; β, unstandardized regression coefficient; CI, 95% confidence interval; EDI, emotion-driven impulsiveness; ICC, percentage of explained variance from the family; ISCED, International Standard Classification of Education; R^2, the proportion of the explained variance in the random effect of the full model compared to the null (unconditional) model; σ^2, residual variance; τ_{00}, variance of family residuals.
[a] Boys as the reference category
[b] Intermediate education level as the reference category
[c] Italy as the reference category

Table 4
Results from the mixed effect model analysis with outcome the usual energy intake per SO (in kcal) and exposure emotion-driven impulsiveness accounting for family (random effect), age, sex, socioeconomic status (ISCED) and country

	Usual energy intake per SO (in kcal; *n* = 1,039)					
	Model 1: basic model			Model 2: fully adjusted model		
	β	CI	*p*	β	CI	*p*
Fixed parts						
Intercept	125.11	97.40 – 152.82	**<.001**	125.99	98.42 – 153.55	**<.001**
EDI	1.88	-1.18 – 4.94	.229	2.52	-0.55 – 5.59	.107
Age	13.06	11.02 – 15.09	**<.001**	13.11	11.09 – 15.14	**<.001**
Sex[a]	-42.76	-46.37 – -39.15	**<.001**	-42.95	-46.53 – -39.36	**<.001**
ISCED (high)[b]	-3.23	-7.22 – 0.77	.114	-3.84	-7.83 – 0.14	.059
ISCED (low)[b]	1.52	-7.14 – 10.17	.731	2.54	-6.08 – 11.16	.564
Belgium[c]	3.18	-7.23 – 13.60	.549	0.22	-10.26 – 10.71	.967
Cyprus[c]	7.95	0.63 – 15.26	**.033**	7.43	0.15 – 14.70	**.046**
Estonia[c]	27.62	21.88 – 33.37	**<.001**	25.93	20.13 – 31.72	**<.001**
Germany[c]	28.33	21.50 – 35.17	**<.001**	26.51	19.64 – 33.38	**<.001**
Hungary[c]	10.57	3.70 – 17.44	**.003**	8.76	1.85 – 15.67	**.013**
Spain[c]	11.63	3.80 – 19.45	**.004**	10.29	2.47 – 18.11	**.010**
Sweden[c]	9.61	2.85 – 16.37	**.005**	7.75	0.95 – 14.55	**.026**
zBMI				-3.19	-5.00 – -1.38	**<.001**
Random parts						
σ^2		726.402			720.759	
$\tau_{00, \text{family\_id}}$		130.740			126.628	
$N_{\text{family\_id}}$		996			996	
$ICC_{\text{family\_id}}$		0.153			0.149	
R^2 / Ω_0^2		.612 / .602			.613 / .603	

AIC, Akaike Information Criterion; β, unstandardized regression coefficient; CI, 95% confidence interval; EDI, emotion-driven impulsiveness; ICC, percentage of explained variance from the family; ISCED, International Standard Classification of Education; R^2, the proportion of the explained variance in the random effect of the full model compared to the null (unconditional) model; σ^2, residual variance; τ_{00}, variance of family residuals.
[a] Boys as the reference category
[b] Intermediate education level as the reference category
[c] Italy as the reference category