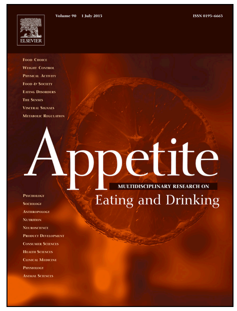

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Interactive effects of impulsivity and dietary restraint over snack intake in children

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RUNNING HEAD: IMPULSIVITY AND DIETARY RESTRAINT

Abstract

Impulsivity and dietary restraint have been found to interact to affect dietary intake in adults. Few studies have explored this effect in children. The current study therefore aimed to investigate the interactive effects of behavioural impulsivity and dietary restraint on intake. Fifty 7-11-year-olds participated in this laboratory-based study. Impulsivity was assessed through behavioural tasks measuring a number of impulsivity facets. Children self-reported dietary restraint. Children visited the lab and had access to a range of snack foods; intake was recorded. Hunger at arrival was assessed. A series of 2 x 2 between-subjects ANCOVAs indicated that motor impulsivity and dietary restraint interacted to affect intake. Reward sensitivity, delay of gratification and inhibitory control did not interact with dietary restraint. Post-hoc analyses indicated that children high in motor impulsivity and restraint ate significantly more snacks than restrained children low in motor impulsivity. Furthermore, children low in motor impulsivity but high in dietary restraint were better at inhibiting their intake than children low in impulsivity and dietary restraint. The results indicate that high levels of impulsivity or dietary restraint in isolation do not affect children's dietary intake but that their combination may lead to overeating in food rich environments.

Key words: Impulsivity, Inhibitory Control, Dietary Restraint, Eating Behavior

Interactive effects of motor impulsivity and dietary restraint over snack intake in children

Research has shown that impulsivity plays an important role in eating behaviour and weight regulation. Impulsivity is a multifaceted construct considered to be a stable personality trait, that develops over the life-span and can be affected by situational demands [1, 2]. Impulsivity has been defined as a tendency to react fast, without planning or foresight, to a range of internal and external stimuli [3]. Behavioural impulsivity can be expressed in a variety of ways such as reward sensitivity, the ability to delay gratification, response speed, inhibitory control, motor impulsivity and reflectivity, with previous research linking all of these impulsivity facets with eating behaviour and weight. Higher impulsivity levels are thought to make it more difficult to resist palatable, immediately available foods, which tend to be higher in sugar, salt and fat compared to healthier foods. Furthermore, healthier foods often require more effortful preparation, and sometimes it is necessary to delay access to less healthy foods to achieve long-term healthy eating or weight loss goals [4, 5]. Thus, the different facets of impulsivity may be implicated in eating behaviours in different ways.

Each of the facets of impulsivity can be measured through behavioural tasks [5, 6]. Impulsivity can also be assessed through questionnaires but it may be difficult for children, especially those high in impulsivity, to accurately report their impulsivity levels. Furthermore, to accurately measure the different facets of impulsivity, it may be particularly useful to utilise behavioural measures of impulsivity with younger populations [4]. A number of impulsivity facets such as reward sensitivity and the ability to delay gratification have been found to be elevated in overweight compared to healthy weight individuals [e.g. 5, 7] and inhibitory control and reward sensitivity in early childhood have been found to be predictive of later weight and obesity risk [8]. Motor impulsivity and an ability to slow down responses have received limited attention but may also impact on children's eating behaviour [9]. Research has also indicated that impulsivity, especially the facet of inhibitory control, is linked with dietary restraint and that high levels of impulsivity in combination with high levels of dietary restraint may be particularly detrimental to eating behaviour in adults [e.g. 4, 10]. Hence, impulsivity may be particularly relevant to dieting success and failure. High levels of dietary restraint combined with poor inhibitory control may be linked with disinhibited eating tendencies and dieting failure [5, 9]. Jansen et al. [4] e.g. examined the interactive effect of impulsivity and dietary restraint in a sample of female, healthy weight, college students. Females were grouped as high or low in dietary restraint on the basis of validated cut-off scores, and they were classed as high or low in impulsivity on the basis of a median-split of their performance on the Stop-Signal Task. The authors found that restrained females only over-ate if they were also impulsive. Furthermore, Van Koningsbruggen et al. [5] found that restrained eaters with lower levels of self-reported trait impulsivity were more likely to be successful dieters. In unrestrained eaters, impulsivity had no impact on dieting success. The authors suggest that lower levels of impulsivity may aid restrained eaters to form associative links between tempting foods and thoughts of dieting, leading them to engage in more successful dietary restraint in the long-term [12, 13]. Meule et al. [10] explored the impact of dietary restraint and food/non-food cues on behavioural disinhibition measured by a Go-No/Go task. Participants were classed as high or low in dietary restraint using a median split of their score on the restraint scale. Interestingly, these authors noted that restrained eaters made fewer commission errors irrespective of cue type, while having greater response latencies when confronted with food cues only. These results suggest that restrained eaters may be less impulsive but may be biased towards attending to food cues.

Overall, research has indicated that impulsivity and dietary restraint impact on eating behaviour and weight in children and adults. Additionally, both factors have been found to interact with each other, affecting eating behaviour in adults. To date research has not addressed whether similar interactive effects of impulsivity and dietary restraint on eating behaviour can be observed in a non-clinical sample of children, nor has it examined which aspects of impulsivity might be most important in predicting children's eating behaviour. Unpicking which impulsivity facets play a significant role in the context of disinhibited eating and dieting failure will allow the development of targeted interventions to improve intake regulation in food environments that could lead to excess intake in children and adults.

Aims and hypotheses

This study aimed to explore the interactive effects of impulsivity and dietary restraint on eating behaviour in 7-11-year-olds. To unpick which impulsivity facets are particularly relevant to eating behaviour in children the effects of four different impulsivity facets (reward sensitivity, ability to delay gratification, ability to inhibit prepotent responses to non-food stimuli, and motor impulsivity) were explored in this context. Based on previous research it was hypothesized that impulsivity and dietary restraint would interact; children with high compared to low levels of impulsivity and dietary restraint would consume more calories from a snack than children low in impulsivity or dietary restraint, or both factors.

Method

Participants

Fifty 7-11-year-olds and their parents participated and were recruited through the Infant and Child Laboratory (ICL) database, from schools in and around Birmingham (UK) and through an advert in a parent magazine (*Families*) delivered in and around Birmingham. Exclusion criteria included the presence of known food allergies, of disorders affecting eating, current or recent major illness or diagnosed intellectual disabilities and diagnosed impulsivity-related or anxiety disorders. Overall, 77 parents were contacted of whom 50 agreed to participate (65% response rate). The sample's demographic characteristics can be seen in Table 1.

Measures

Demographic information. Mothers provided information on their child's age and gender, their own age, ethnicity, their annual household income and level of education. Mothers and children were measured and weighed by a trained researcher at the laboratory, wearing light indoor clothing, without shoes. Where fathers attended (n=2) mothers were contacted and their self-reported height and weight were recorded. Maternal BMIs and child BMI z-scores, adjusting for age and gender, were calculated.

Restrained eating. The Dutch Eating Behaviour Questionnaire-Child version (DEBQ-C) [14] was used to assess self-reported restrained eating behaviour in children. The seven items are written in question form, using a 3-point Likert scale ranging from 1 (*No*) to 3 (*Yes*). The scale is validated for use with children from 7 years. Cronbach's alpha for the Restrained Eating subscale was .77, indicating good internal consistency.

Hunger. Child hunger was measured using the Teddy Picture Rating Scale [15]. The scale consists of five black and white cartoon bear silhouettes with labels describing varying levels of hunger ranging from 1 (*very hungry*) to 5 (*not hungry at all/very full*).

Impulsivity. Behavioural impulsivity facets were measured through four behavioural tasks. Reward sensitivity was measured using the Door Opening task [16, 17]*.* Children could open up to 100 sequentially presented doors, through a key-press. Behind each door either a happy face, associated with winning a point or a sad face, associated with losing a point, was displayed. After each block of ten doors the probability of finding a happy face reduced by 10%. The number of doors opened dependent variable (DV) was recorded as an indicator of reward sensitivity, with more impulsive children opening more doors.

The ability to delay gratification was measured using the Delay Discounting task [18]*.* Over four practice and 32 experimental trials children selected either an immediate small reward (one plastic counter) or a larger delayed reward (two plastic counters) through a key press. Counters could be exchanged for stickers (more counters equalled more stickers) at the end of the session. The number of trials in which a larger delayed reward was selected was recorded (DV) and a greater number of delays were indicative of a greater ability to delay gratification and lower levels of impulsivity.

The ability to inhibit prepotent responses to non-food stimuli was measured using the Go/No-Go task (GNG task) [19]**.** Children were asked to respond to one of two stimuli with a key press (sun) while inhibiting the response to the other stimulus (flower). The task consisted of 12 practice trials and 100 experimental trials. The ratio between targets and non-targets was 3:1. Errors of commission and Go trial reaction time (RT) were recorded, with more errors (poorer inhibitory control) and faster RT (i.e. numerically lower, faster response speed) reflecting higher levels of impulsivity.

Motor impulsivity was measured by the Circle Drawing task (CDT) [17, 20]**.** Children traced the outline of a large circle (ø=50.8cm), drawn onto a wooden square, with their index finger, once without instruction and while being told to trace as slowly as possible. The tracing time during the inhibition condition was recorded. Slower tracing (i.e. larger values) indicated lower motor impulsivity.

The order in which behavioural tasks were administered was counterbalanced.

Snack composition and preparation. Children had access to six different sweet and savoury snack foods that varied in fat and sugar content during a 10-minute snack session. The foods consisted of 130g chocolate chip cookies (496kcal/100g), 300g Haribo Gold Bears (348kcal/100g), 70g salted crisps (536kcal/100g), 90g salted pretzels (378kcal/100g), 280g green grapes

(69kcal/100g) and 200g carrot sticks (35kcal/100g). Overall calorie intake was calculated. Water was available throughout the snack session.

Procedure

Parents and children visited the ICL. At arrival children completed a hunger rating, which was followed by the completion of a range of questionnaires and impulsivity tasks. Parents completed demographic questionnaires in an adjacent room and were able to see their child through a one-way mirror at all times. After completing the questionnaires and impulsivity tasks children had access to a range of snack foods over a 10-minute period, during which the researcher left the room. Children also had access to reading and colouring materials during the snack session. After ten minutes the researcher re-entered the room, removed the foods and recorded intake. Following the snack session children chose a toy and stickers as a thank you for participation. Parents were reimbursed (£5) for their travel expenses and debriefed at the end of the visit. The Ethical Review Committee of the University of Birmingham approved this study (ERN 12-0465P).

Statistical analysis

SPSS version 20 statistical software was used to analyse the data. The criterion alpha for significance was .05. Histograms were inspected and indicated that the majority of data, except for hunger ratings, were normally distributed. Data from four children was excluded on all analyses involving the CDT, as their performance was anomalous (slow tracing time more than three SD above the mean). Initially, descriptive statistics for impulsivity were calculated and potential gender differences explored using independent samples *t*-tests. The impact of potential covariates on intake, dietary restraint and impulsivity was assessed. Additionally, the impact of hunger on intake was assessed through Spearman's rank correlations. Next, a series of 2 (Impulsivity: high vs. low) X 2 (Dietary restraint: high vs. low) between-subjects ANOVAs, controlling for significant covariates, were carried out to examine whether impulsivity and dietary restraint interacted to affect calorie intake. Children were grouped as high or low in restraint and impulsivity using median splits of DEBQ-C and impulsivity task performance scores; this approach has been successfully used by other researchers exploring interactive effects in these measures [4, 7, 10]. Post-hoc analyses were carried out to follow-up significant interactive effects. In response to a reviewer's query we also conducted regression analyses of these data, using dietary restraint and impulsivity measures as continuous variables, and their interaction terms, to predict calorie intake. These analyses can be seen in Supplementary Table I.

Results

Demographic characteristics

Table 1 shows the demographic characteristics of the overall sample. Analyses indicated that there were no gender differences in child age ($t(48)=-.14$, $p=.89$), weight ($t(41.78)=-1.53$, $p=.13$) or performance on the impulsivity tasks (See Supplementary Table II). Table 2 shows an overview of task performance on the behavioural impulsivity tasks and Median scores used to provide median-splits for the subsequent analyses. Performance on the individual impulsivity tasks was comparable to other studies exploring links between impulsivity and eating behaviour in non-clinical samples of children. DEBQ-C Restraint scores ranged from 1 to 3 (*M*=1.89; *SD*=.48; *MDN*=1.86), which is comparable to restraint scores in 7-12-year-olds previously reported (M=1.59, SD=.5) [13]. Information on the breakdown of the number of children scoring high/low on impulsivity tasks overall and broken down by dietary restraint (high/low) can be seen in Supplementary Table III.

Table 1

Demographic characteristics of the sample (N=50)

Variables	Parent Characteristics	Child Characteristics
Gender	48 female, 2 male	28 female, 22 male
Age, mean (*SD*)	38.44 (5.41)	8.22 (1.05)
Age range	27 – 50	7 – 11
BMI, mean (*SD*)+	25.86 (4.7)	.35 (1.07)*
Range	18.86 – 45.79	-2.19 – 2.71
Educational level	30% Undergraduate degree (*n*=15)	
	26% A-Levels (*n*=13)	
	24% Qualified professional (*n*=12)	
	18% Postgraduate degree (*n*=9)	
	2% GCSEs (*n*=1)	
Ethnicity	82% White Caucasian (British/Irish) (*n*=41)	
	6% Asian (*n*=3)	
	6% Black (African/Caribbean) (*n*=3)	
	2% Chinese (*n*=1)	
	2% Mixed (*n*=1)	
	2% Other (*n*=1)	

+ BMIs (mean and *SD*) of mothers measured and weighed by a trained researcher in the laboratory.

* For children BMIs (mean and *SD*) are adjusted for their age and gender (BMI z-scores).

Table 2

Overview of impulsivity task performance scores and Medians for median-splits

	Mean (*SD*)	Min	Max	*MDN*
Door Opening task: Doors Opened	43.74 (32.06)	1	100	40

Delay of Gratification task: Number of Delays	9.66 (8.64)	0	32	7.5
GNG task: Go trial RT (msec)	370.69 (29.01)	295.69	423.38	375.5
GNG task: Errors of Commission	8.26 (3.12)	2	15	8
CDT: Slow Tracing Time (s)	69.19 (42.69)	4.62	187.97	59.81

Covariates

Analyses exploring the influence of confounding variables (child BMI z-scores, age, hunger) on calorie intake indicated that BMI-z scores were positively associated with intake ($r(49)=.3$, p=04). Analyses exploring differences in intake between children with high vs. low impulsivity and dietary restraint levels therefore controlled for child BMI-z score. Spearman's Rank correlations indicated that hunger and intake were not related ($r_s(49)=-.23$, $p=.12$). Additionally, associations between confounding variables and dietary restraint and each of the impulsivity measures were explored. These analyses indicated that child age was positively correlated with errors of commission ($r(47)=.31$, $p=.03$); no other associations were observed.

Interactive effects between impulsivity and dietary restraint

A series of 2 (Impulsivity: high vs. low) X 2 (Dietary Restraint: high vs. low) between-subjects ANCOVAs were carried out to explore the hypothesised interaction of impulsivity and dietary restraint affecting calorie intake; analyses controlled for child BMI z-score (Table 3). Overall, there were no significant main effects of impulsivity, measured by any of the behavioural tasks, or dietary restraint on intake. There were also no interactions between dietary restraint and three of the four measured facets of impulsivity (reward sensitivity, ability to delay gratification, ability to inhibit prepotent responses to non-food stimuli) on calorie intake. Motor impulsivity as measured by the CDT, and dietary restraint interacted to affect calorie intake ($F(1, 40)=6.14$, $p=.02$, partial $\eta^2=.13$; Figure 1).

Post-hoc analyses indicated that there was a significant difference in calorie intake for children who were high in dietary restraint and either high or low in motor impulsivity ($F(1,37)=5.04$, $p=.03$). Children high in dietary restraint and in impulsivity consumed significantly more calories from snacks (*M*=385.08, *SD*=191.81) than children high in dietary restraint and low in impulsivity (*M*=245.81, *SD*=174.88). In addition, post-hoc analyses indicated that there was a significant difference in calorie intake in children who were low in motor impulsivity but either high or low in dietary restraint ($F(1, 37)=5.23$, $p=.03$). Children who were low in motor impulsivity but high in dietary restraint ate significantly fewer calories from snacks (*M*=245.81, *SD*=174.88) than children low in impulsivity and low in dietary restraint (*M*=375.76, *SD*=194.12). Children high in impulsivity but low in dietary restraint did not differ in intake from the other children (*M*=301.18, *SD*=150.99).

Table 3

Interactive effects of impulsivity and dietary restraint affecting calorie intake

	Calorie Intake+
Door Opening task X DEBQ-C Restraint	$F(1, 28)=.01$, $p=.94$, partial $\eta^2=0$
Delay of Gratification task X DEBQ-C	$F(1, 40)=.07$, $p=.8$, partial $\eta^2=.002$

	Calorie Intake+
Restraint	
GNG task: Go trial RT X DEBQ-C Restraint	$F(1, 39)=.11$, $p=.74$, partial $\eta^2=.003$
GNG task: Errors of commission X DEBQ-C Restraint*	$F(1, 41)=1.3$, $p=.26$, partial $\eta^2=.03$
CDT Slow X DEBQ-C Restraint	$F(1, 40)=6.14$, $p=.02$, partial $\eta^2=.13$

+ Controlling for child BMI z-score

*Controlling for child age

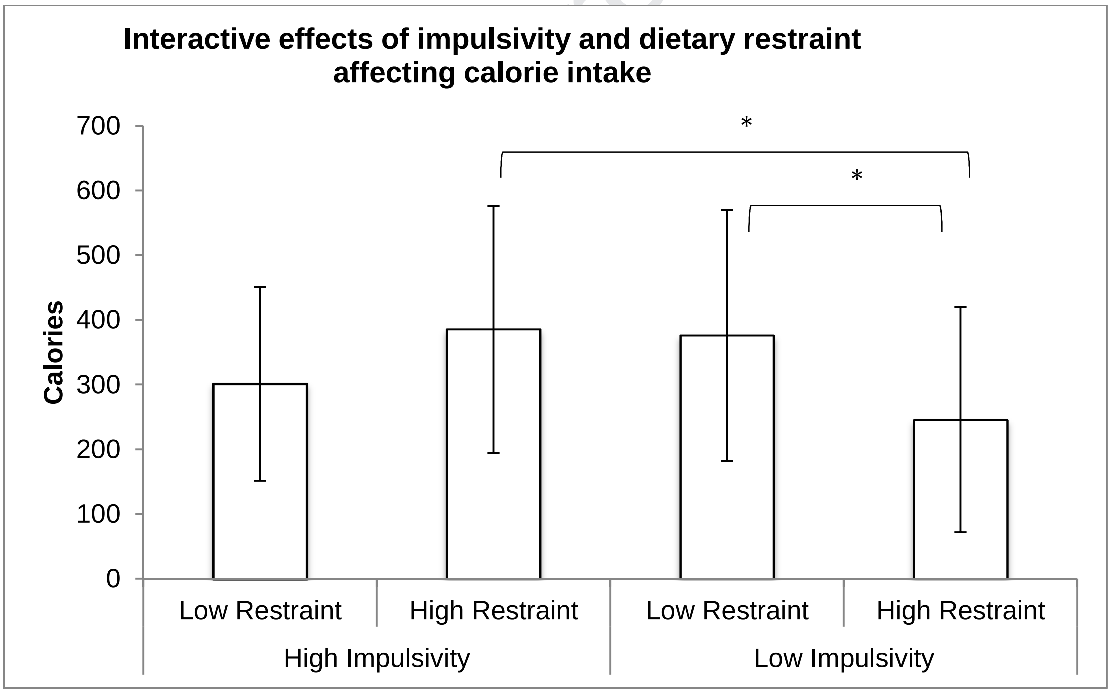

Figure 1. Interactive effects of impulsivity measured by the CDT and dietary restraint affecting calorie intake. Error bars indicate ±1SD.

* p<.05

Supplementary analyses

Regression analyses (See Supplementary Table I) demonstrated that there were no effects of restraint or impulsivity or their interaction terms, when treated as continuous variables, on intake.

Discussion

The current study aimed to assess the interactive effects of impulsivity, measured by a number of behavioural tasks capturing different impulsivity facets and dietary restraint, on eating behaviour in healthy weight 7-11-year-olds. Research in children has identified links between impulsivity and weight, poorer food choices and dieting success [21, 22]. Additionally, impulsivity (inhibitory control) has been found to interact with dietary restraint in adults [e.g. 4]. Up to now, research has not investigated the interactive effects of impulsivity and dietary restraint on eating behaviour in children. The results of the current study showed that in ANCOVA analyses using median splits, motor impulsivity and dietary restraint interacted to affect calorie intake. No other aspects of impulsivity affected intake, directly or in interaction with restraint in these analyses.

It was hypothesized that dietary restraint and impulsivity would interact, indicating that children with high scores on both factors would consume more calories than children scoring low on either or both factors. Findings from the adult literature have highlighted that combinations of impulsivity and restraint can lead to disinhibited eating in food-rich environments [4, 5, 11]. In line with this hypothesis, children high in motor impulsivity and dietary restraint consumed more calories than children low in motor impulsivity and high in restraint. Furthermore, children low in impulsivity but high in dietary restraint consumed fewer calories than children low in impulsivity and dietary restraint.

Overall, this pattern suggests that in 7-11-year-olds the combination of motor impulsivity and dietary restraint is linked with a tendency toward poorer intake control also seen in adults.

In line with research in adults, children with high levels of impulsivity and high levels of dietary restraint consumed the greatest number of calories. Research has indicated that restrained eaters are more sensitive to food cues in their environment [10, 23]. Children high in dietary restraint and motor impulsivity may thus be primed to focus on food cues, and also have a tendency to respond to food cues in their environment rapidly, without being able to successfully engage with their long-term goals around intake restriction or weight regulation [12, 13]. This combination of factors could explain why intake in these children was exacerbated. In line with our hypotheses, but in contrast to research by Jansen et al. [4], we found that children who self-reported being high in dietary restraint and low in impulsivity, consumed the smallest amount of calories, suggesting that they successfully restricted their intake of palatable snack foods. Although these children were high in dietary restraint and thus more sensitive to food cues in their environment these children successfully controlled their intake. Their comparatively low impulsivity levels may have meant that they were able to delay intake until engaging with their long-term goals around intake restriction or weight regulation [12, 23, 24]. In addition these findings suggest that self-reported dietary restraint measured by the DEBQ-C Dietary Restraint subscale may accurately reflect child behaviour. Interestingly, children high in motor impulsivity and dietary restraint were not uniquely high in intake and did not differ in intake from children with high levels of impulsivity but low in dietary restraint. Children low in dietary restraint are likely to respond to foods in their environment without a tendency to restrict their intake for weight/health reasons. These children may, however, consume fewer calories during later meals, to compensate for their intake of snacks, demonstrating greater responsiveness to internal hunger and satiety cues. This interpretation fits with research exploring the impact of parental restriction on eating in the absence of hunger in younger children, which suggests that greater parental restriction is linked with greater eating in the absence of hunger [24]. Further research evaluating the role of impulsivity and dietary restraint in both snack and mealtime intake, and the process of compensation across time, would provide valuable insights into mechanisms underlying differences in compensatory abilities in children.

The interactive effects of impulsivity and dietary restraint were only observed in the CDT, which assesses motor impulsivity. Performance on other behavioural impulsivity tasks measuring the ability to delay gratification, reward sensitivity, response speed or inhibitory control, showed no effects in combination with dietary restraint. This suggests that motor impulsivity assessed by the CDT may be particularly sensitive to the impact of dietary restraint on intake in children. Research in adult populations has highlighted associations between motor impulsivity, measured through self-report, and disinhibited eating [e.g. 26], suggesting that impulsive individuals are more likely to overeat in palatable food environments. Additionally, motor impulsivity in particular has been implicated in problematic eating behaviours observed in clinical populations, such as individuals with Binge Eating Disorder, suggesting that motor impulsivity in particular may be associated with more problematic forms of eating behaviour than other types of impulsivity [27].

In line with these findings, inhibitory control training may be useful to reduce the impact of impulsivity on eating behaviour, improving the ability of children high in dietary restraint in particular to respond to palatable snacks in a less impulsive way [28]. Furthermore, mindfulness-based approaches may improve the capacity of individuals high in impulsivity and dietary restraint to notice their eating urges without needing to respond to these. Recent research exploring the effectiveness of mindfulness on dysfunctional eating patterns in adults has provided promising evidence for these types of interventions [28].

This study has several limitations. Guided by our hypotheses, the sample was split into high and low impulsivity subsamples based on the median-split of scores on impulsivity measures. This method may not have been sensitive enough to create meaningful groups of children high and low in impulsivity. Although more rigorous methods of grouping children may have provided less arbitrary cut-offs previous research has successfully applied such statistical approaches [4, 7, 10]. The selected statistical approach reflects the hypothesis that effects of impulsivity and restraint on intake were most likely to be seen in children scoring high in both restraint and impulsivity, rather than those children scoring high on either of the measures. Furthermore, this study aimed to explore whether findings from the adult literature can be translated to a paediatric population. A comparable statistical approach to that used within the adult literature was hence selected. Nonetheless, we carried out supplementary regression analysis to examine whether effects were robust. In these supplementary analyses, impulsivity and dietary restraint did not reach statistical significance as individual predictors of intake, nor or as interaction terms. Thus, some caution is required in the interpretation of the exact facet of impulsivity that is important in predicting children's caloric intake. We were unable to group children in this sample based on clinical levels of impulsivity because none of the children participating in this study had clinically elevated impulsivity levels. Children labelled as high in impulsivity were impulsive only in comparison to the other children in the sample. Finally, completing the DEBQ-C before the snack session may have primed children to engage in dietary restraint, influencing eating behaviour subsequently [4, 29]. Nevertheless, we decided to ask participants to complete impulsivity and questionnaire measures prior to the snack session because engaging in a snack session may have conversely affected DEBQ responses if they had been completed after eating.

Overall, the results of the current study indicate that when categorising children as high or low in dietary restraint or impulsivity, these classifications per se do not predict overeating in children but that the combination of dietary restraint and poor control of motor impulses in particular is crucial for overeating in children as well as adults.

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Conflict of Interest: The authors declare that they have no conflicts of interest.

References

1. Kochanska G, Murray KT, Harlan ET (2000) Effortful control in early childhood: Continuity and change, antecedents, and implications for social development. Dev Psychol 36:220-232

2. Rothbart MK, Ahadi SA, Evans DE (2000) Temperament and personality: Origins and outcomes. J Pers Soc Psychol 78:122-135

3. Moeller FG, Barratt ES, Dougherty DM, Schmitz JM, Swann AC (2001) Psychiatric aspects of impulsivity. Am J Psychiatry 158:1783-1793

4. Jansen A, Nederkoorn C, Van Baak L, Keirse C, Guerrieri R, Havermans R (2009) High-restrained eaters only overeat when they are also impulsive. Behav Res Ther 47:105-110

5. Van Koningsbruggen GM, Stroebe W, Aarts H (2013) Successful restrained eating and trait impulsiveness. Appetite 60:81-84

6. Dougherty DM, Mathias CW, Marsh DM, Jagar AA (2005) Laboratory behavioral measures of impulsivity. Behav Res Methods 37(1), 82-90

7. Guerrieri R, Nederkoorn C, Jansen A. (2008) The interaction between impulsivity and a varied food environment: Its influence on food intake and overweight. IJO 32:708-714

8. Graziano PA, Calkins SD, Keane SP (2010) Toddler self-regulation skills predict risk for pediatric obesity. IJO 34:633-641

9. Verbeken S, Braet C, Claus L, Nederkoorn C, Oosterlaan J (2009) Childhood obesity and impulsivity: An investigation with performance-based measures. Behav Change 26:153-167

10. Meule A, Lukito S, Vögele C, Kübler A (2011). Enhanced behavioral inhibition in restrained eaters. Eat Behav 12:152-155

11. Nederkoorn C, Jansen E, Mulkens S, Jansen A (2007) Impulsivity predicts treatment outcome in obese children. Behav Res Ther 45:1071-1075

12. Fishbach A, Friedman RS, Kruglanski AW (2003) Leading us not into temptation: Momentary allurements elicit overriding goal activation. J Pers Soc Psychol 84:296-309

13. Stroebe W, Van Koningsbruggen GM, Papies EK, Aarts H (2013) Why most dieters fail but some succeed: A goal conflict model of eating behavior. Psychol Rev 120:110-138

14. Van Strien T, Oosterveld P (2008) The children's DEBQ for assessment of restrained, emotional, and external eating in 7- to 12-year-old children. Int J Eat Disord 41:72-81

15. Bennett C, Blissett J (2014) Measuring hunger and satiety in primary school children. Validation of a new picture rating scale. *Appetite 78*:40-48

16. Daugherty TK, Quay HC (1991) Response perseveration and delayed responding in childhood behavior disorders. J Child Psychol Psychiatry 32:453-461

17. Verbeken S, Braet C, Claus L, Nederkoorn C, Oosterlaan J (2009) Childhood obesity and impulsivity: An investigation with performance-based measures. Behav Change 26:153-167

18. Johnson WG, Parry W, Drabman RS (1978) The performance of obese and normal size children on a delay of gratification task. Addict Behav 3:205-208

19. Bezdjian S, Baker LA, Lozano DI, Raine A (2009) Assessing inattention and impulsivity in children during the Go/NoGo task. Br J Dev Psychol 27:365-383

20. Bachorowski J, Newman JP (1990) Impulsive motor behavior: Effects of personality and goal salience. J Pers Soc Psychol 58:512

21. Nederkoorn C, Braet C, Van Eijs Y, Tanghe A, Jansen A (2006) Why obese children cannot resist food: The role of impulsivity. Eating Behav 7:315-322

22. Thamotharan S, Lange K, Zale EL, Huffhines L, Fields S (2013) The role of impulsivity in pediatric obesity and weight status: A meta-analytic review. Clin Psychol Rev 33:253-262

23. Stroebe W (2008) Dieting, overweight, and obesity: Self-regulation in a food-rich environment. American Psychological Association, Washington

24. Johnson F, Pratt M, Wardle J (2012) Dietary restraint and self-regulation in eating behavior. IJO 36:665-674

25. Birch LL, Fisher JO, Davison KK (2003). Learning to overeat: maternal use of restrictive feeding practices promotes girls' eating in the absence of hunger. Am J Clin Nutr 78:215-220

26. Lyke JA, Spinella M (2004) Associations among aspects of impulsivity and eating factors in a nonclinical sample. Int J Eat Disord 36:229-233

27. Nasser JA, Gluck ME, Geliebter A (2004) Impulsivity and test meal intake in obese binge eating women. Appetite, 43:303-307

28. Jones A, Di Lemma LC, Robinson E, Christiansen P, Nolan S, Tudur-Smith C, Field M (2016) Inhibitory control training for appetitive behaviour change: A meta-analytic investigation of mechanisms of action and moderators of effectiveness. Appetite 97:16-28

29. Shmueli D, Prochaska JJ (2009) Resisting tempting foods and smoking behavior: Implications from a self-control theory perspective. Health Psychol 28:300-306