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Impulsivity, perceived self-regulatory success in dieting, and body mass in children and adolescents: A moderated mediation model

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Impulsivity has been suggested to contribute to overeating and obesity. However, findings are inconsistent and it appears that only specific facets of impulsivity are related to eating-related variables and to body mass. In the current study, relationships between self-reported impulsivity, perceived self-regulatory success in dieting, and objectively measured body mass were examined in $N = 122$ children and adolescents. Scores on attentional and motor impulsivity interactively predicted perceived self-regulatory success in dieting, but not body mass: Higher attentional impulsivity was associated with lower perceived self-regulatory success at high levels of motor impulsivity, but not at low levels of motor impulsivity. A moderated mediation model revealed an indirect effect of attentional and motor impulsivity on body mass, which was mediated by perceived self-regulatory success in dieting. Thus, results show that only specific facets of impulsivity are relevant in eating- and weight-regulation and interact with each other in the prediction of these variables. These facets of impulsivity, however, are not directly related to higher body mass, but indirectly via lower success in eating-related self-regulation in children and adolescents.

1. Introduction

Impulsivity refers to a predisposition toward rapid, unplanned reactions to internal or external stimuli without regard to the negative consequences of these reactions (Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001). High impulsivity levels have been suggested to contribute to overeating (e.g., binge eating in individuals with eating disorders) and obesity (Guerrieri, Nederkoorn, & Jansen, 2008; Lavender & Mitchell, 2015). For example, it has been found that overweight or obese individuals react more impulsively than normal-weight participants do in behavioral tasks (e.g., go/no-go, stop signal, or delay discounting tasks) in samples of adults (Mobbs, Iglesias, Golay, & Van der Linden, 2011; Nederkoorn, Smulders, Havermans, Roefs, & Jansen, 2006; Weller, Cook, Avsar, & Cox, 2008) and children (Fields, Sabet, & Reynolds, 2013; Nederkoorn, Braet, Van Eijs, Tanghe, & Jansen, 2006; Wirt, Hundsdörfer, Schreiber, Kesztyüs, & Steinacker, 2014). Similarly, it has been found that overweight or obese individuals report higher impulsivity than normal-weight participants do using questionnaire measures in samples of adults (Mobbs, Crépin, Thiéry, Golay, & Van der Linden, 2010; Rydén et al., 2003) and children (Nederkoorn, Braet, et al., 2006). Furthermore, higher impulsivity (lower motor response inhibition in particular) prospectively predicted weight gain or lower dieting success in children (Nederkoorn, Jansen, Mulkens, & Jansen, 2007; Reinert, Po'e, & Barkin, 2013).

Findings are, however, inconsistent. For example, scores on impulsivity measures were unrelated to body mass in several studies in adults (Hendrick, Luo, Zhang, & Li, 2012; Koritzky, Yechiam, Bukay, & Milman, 2012; Loeber et al., 2012) and in children (Fields et al., 2013; Verdejo-García et al., 2010). In other studies, impulsivity was associated with body mass or weight gain, but only as a function of moderating variables such as responsiveness to food cues in adults (Houben, Nederkoorn, & Jansen, 2014; Meule & Platte, 2016; Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010) and children (Nederkoorn, Coelho, Guerrieri, Houben, & Jansen, 2012).

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These inconsistent findings may be, in part, explained by the fact that only specific facets of impulsivity are associated with body mass (Mobbs et al., 2010). For example, one of the most widely used self-report measures for the assessment of impulsivity, the *Barratt Impulsiveness Scale* (BIS; Stanford et al., 2009), comprises three subscales representing *attentional impulsivity* (i.e., inability to focus attention or concentrate), *motor impulsivity* (i.e., acting spontaneously or without thinking), and *non-planning impulsivity* (i.e., lack of future orientation or forethought; Patton, Stanford, & Barratt, 1995). Emerging evidence suggests that particularly attentional and motor impulsivity, but not non-planning impulsivity, are related to measures of overeating and to body mass (Meule & Blechert, 2016; Meule, 2013).

In addition to the finding that only specific impulsivity facets are related to eating- and weight-regulation, it has also been found that these impulsivity facets interact with each other when predicting eating behavior and body mass. Higher scores on attentional impulsivity in combination with higher scores on motor impulsivity predicted percent body fat and self-reported binge eating severity in female students (Meule & Platte, 2015). Likewise, attentional and motor impulsivity interactively predicted intake of sweet foods in the laboratory in female students (Kakoschke, Kemps, & Tiggemann, 2015). To conclude, it appears that when both attentional and motor impulsivity levels are high, unhealthy food intake or overeating as well as body mass are elevated in adults.

Another consideration when examining associations between impulsivity and obesity is how an impulsive personality translates into higher body mass. Specifically, as impulsivity is a construct that does not cover energy intake or expenditure, it is implausible that it affects fat mass directly. Higher impulsivity can only lead to higher body mass through mediating mechanisms, for example, eating behavior. For instance, Murphy, Stojek, and MacKillop (2014) found that the relationship between trait impulsivity and body mass was mediated by self-reported addiction-like eating. Importantly, this indirect effect was observed in the absence of a direct relationship between impulsivity and body mass. Thus, it is likely that being impulsive may increase the likelihood of falling prey to food temptations, which in turn results in weight gain.

In the current study, it was expected that similar findings would be found in a sample of children and adolescents with a wide range in body mass. Specifically, a self-report measure of perceived self-regulatory success in dieting was used, which has been previously found to be associated with both impulsivity and body mass (Meule, Papies, & Kübler, 2012). It was expected that particularly attentional and motor impulsivity would be associated with lower perceived self-regulatory success in dieting and with a higher body mass. Moreover, it was expected that attentional and motor impulsivity would be *interactively* associated with these measures: perceived self-regulatory success in dieting was expected to be lowest and body mass was expected to be highest at high levels of both attentional and motor impulsivity. Finally, it was tested if perceived self-regulatory success in dieting mediated the relationships of attentional and motor impulsivity with body mass and, thus, may represent a psychological proxy variable or mechanism through which behavioral control-related impulsivity facets influence body mass.

2. Methods

2.1. Participants

The study was approved by the ethical review board of the University of Salzburg and all participants (and, when appropriate, their parents) signed informed consent. Participants were recruited during routine examinations at the obesity clinic of the Paracelsus Medical University and from public schools in Salzburg (Austria). The study was advertised as a study about the neural processing of food cues (cf. procedure section below). One-hundred and twenty-two children and adolescents (51.60% female, $n = 63$) between 10 and 18 years of age ($M = 13.61$ years, $SD = 2.18$) completed all measures used in the current analyses. Age- and gender-specific mean body mass index (BMI) percentile based on German reference values (Kromeyer-Hauschild et al., 2001) was $M = 74.43$ ($SD = 32.32$) and mean standardized BMI (zBMI) was $M = 1.22$ ($SD = 1.51$). It is recommended to use the third, 10th, 90th, and 97th percentile for defining severe underweight, moderate underweight, overweight, and obesity, respectively (Kromeyer-Hauschild et al., 2001). Using these cut-off values, 1.60% were severely underweight ($n = 2$; $M_{zBMI} = -2.10$, $SD = 0.14$), 4.10% were moderately underweight ($n = 5$; $M_{zBMI} = -1.62$, $SD = 0.24$), 37.70% had normal weight ($n = 46$; $M_{zBMI} = -0.06$, $SD = 0.69$), 10.70% were overweight ($n = 13$; $M_{zBMI} = 1.52$, $SD = 0.17$), and 45.90% were obese ($n = 56$; $M_{zBMI} = 2.57$, $SD = 0.52$) in the present sample.

2.2. Measures

2.2.1. Barratt Impulsiveness Scale – short form (BIS-15)

The German version of the BIS-15 (Meule, Vögele, & Kübler, 2011; Spinella, 2007) was used as a self-report measure of trait impulsivity. This 15-item questionnaire includes three subscales, each consisting of five items, representing *attentional impulsivity* (e.g., “I am restless at lectures or talks.”), *motor impulsivity* (e.g., “I act on the spur of the moment.”), and *non-planning impulsivity* (e.g., “I plan tasks carefully.” [inverted]). Items are scored on a four-point scale with response categories ranging from *rarely/never* to *almost always/always*. Higher scores represent higher impulsivity. Validity has been demonstrated by positive relationships with other self-report impulsivity measures and with behavioral impulsivity tasks (e.g., Aichert et al., 2012; Lange & Eggert, 2015; Meule & Kübler, 2014; Meule et al., 2011). Internal consistencies were $\alpha = 0.43$ (attentional), $\alpha = 0.74$ (motor), and $\alpha = 0.73$ (non-planning) in the current study.

2.2.2. Perceived Self-Regulatory Success in Dieting Scale (PSRS)

The German version of the PSRS (Fishbach, Friedman, & Kruglanski, 2003; Meule et al., 2012) was used as a self-report measure of self-regulatory success in dieting. This three-item measure asks how successful participants are in watching their weight or losing weight and how easy it is for them to stay in shape. Items are scored on a seven-point scale anchored *not successful/not difficult* and *very successful/very difficult*. Higher scores represent higher perceived self-regulatory success in dieting. Validity has been demonstrated by negative relationships with other questionnaire measures that are associated with self-regulatory failure in eating behavior control and with BMI (Meule et al., 2012). Internal consistency was $\alpha = 0.68$ in the current study.

2.2.3. Body mass

Height was measured in centimeters with a body height meter and body weight was measured in kilogram with a digital scale in the laboratory. BMI was calculated as weight in kilogram divided by squared height in meters.

2.3. Procedure

Participants were tested individually and completed the BIS-15 and the PSRS in the laboratory. They were assisted by the experimenter during questionnaire completion in case of comprehension difficulties. The study also included EEG recording amongst other measures, results of which are described elsewhere (Hofmann, Ardelt-Gattinger, Paulmichl, Weghuber, & Blechert, 2015; Meule, Hofmann, Weghuber, Ardelt-Gattinger, & Blechert, 2015a). At the end of the testing session, body height and weight was measured. Participation was reimbursed with €20.

2.4. Data analyses

Linear regression analyses were used to examine moderation and mediation effects with PROCESS for SPSS (Hayes, 2013). Specifically, a moderated mediation model (model no. 12 in PROCESS) was tested, in which scores on all three BIS-15 subscales, their two-way interactions, and the three-way interaction of all BIS-15 subscales were used as predictor variables for both PSRS scores and BMI percentiles (Fig. 1A). Predictor variables were mean-centered before calculating the product terms. Significant interactions were followed-up with simple slopes analysis at high (+1*SD*) and low (-1*SD*) values of the moderator variable (Hayes, 2013). Exact *p*-values are reported for significant regression weights ($p < 0.05$), except when $p < 0.001$. *P*-values $\geq$ 0.05 are denoted as *ns*. Furthermore, PSRS scores were used as mediating variable between BIS-15 scores and BMI percentiles (Fig. 1A). Indirect (i.e., mediating) effects were evaluated with 95% bias-corrected confidence intervals based on 10,000 bootstrap samples. When the confidence interval does not contain zero, this means that the indirect effect can be considered statistically significant (Hayes, 2013). If the presence of such an indirect effect depends on the value of a moderating variable, this is an indication of moderated mediation. Results were similar when using the standardized BMI instead of BMI percentiles and, thus, only results with BMI percentiles are reported. Also, including sex and age as covariates did not change interpretation of results and, thus, results are presented without covariates.

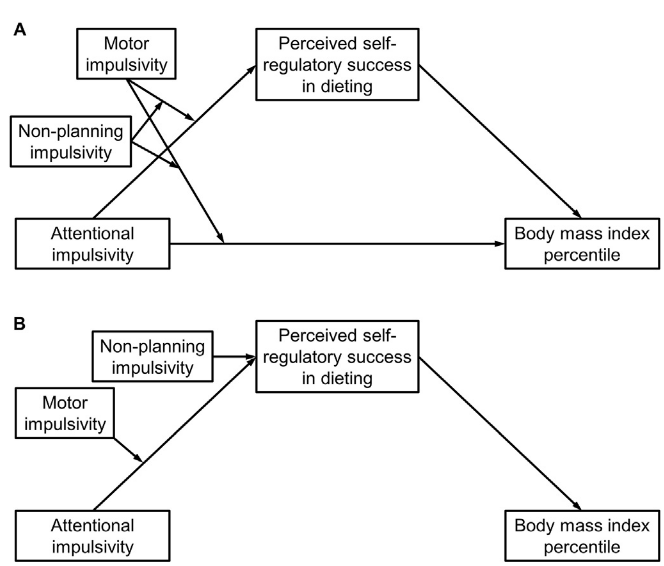

Fig. 1. (A) Conceptual moderated mediation model, in which scores on all three impulsivity subscales, their two-way interactions, and the three-way interaction were used as predictors of both perceived self-regulatory success in dieting (as mediator) and body mass. (B) Empirical moderated mediation model, where only those paths of the conceptual model that reached significance in the current study were retained (also see Table 2). Specifically, an interaction between attentional and motor impulsivity predicted perceived self-regulatory success in dieting ($b = -0.10$, $SE = 0.04$, $p = 0.02$; Fig. 2). Non-planning impulsivity negatively predicted perceived self-regulatory success in dieting ($b = -0.32$, $SE = 0.13$, $p = 0.01$). Perceived self-regulatory success in dieting, in turn, negatively predicted body mass ($b = -2.46$, $SE = 0.75$, $p = 0.001$). There was no direct effect of attentional impulsivity on body mass, but an indirect effect of attentional impulsivity on body mass, which was moderated by motor impulsivity: the effect of attentional impulsivity on body mass was mediated by perceived self-regulatory success in dieting, but only at high motor impulsivity (Table 3).

3. Results

Descriptive statistics of and correlations between study variables are depicted in Table 1. Perceived self-regulatory success in dieting was negatively correlated with body mass and with attentional and non-planning impulsivity. Attentional and motor impulsivity were positively correlated with each other.

Non-planning impulsivity negatively predicted PSRS scores (Table 2). Moreover, there was an interactive effect between attentional and motor impulsivity when predicting PSRS scores (Table 2). Examination of the nature of this interaction revealed that attentional impulsivity negatively predicted PSRS scores, but only at high levels of motor impulsivity and not at low levels of motor impulsivity, that is, PSRS scores were lowest when both attentional and motor impulsivity were high (Fig. 2). In turn, PSRS scores negatively predicted BMI percentiles (Table 2). Testing the indirect effect of BIS-15 scores on BMI percentiles via PSRS scores revealed that PSRS scores mediated the association between attentional impulsivity and body mass, but only at high levels of motor impulsivity and not at low or medium levels of motor impulsivity (Table 3).

The empirical moderated mediation model is displayed in Fig. 2B and can be summarized as follows: Although there was no direct association between attentional impulsivity and body mass, there was an indirect association between attentional impulsivity and body mass via perceived self-regulatory success in dieting. This indirect association, however, was only present at high levels of motor impulsivity. Although non-planning impulsivity was also associated with perceived self-regulatory success in dieting, it did not moderate the effect of attentional impulsivity on body mass.

4. Discussion

The current study investigated the relationships of three facets of trait impulsivity with perceived self-regulatory success in dieting and body mass in children and adolescents. It was found that higher attentional impulsivity and, contrary to expectations, non-planning impulsivity correlated with lower perceived self-regulatory success in dieting. There were no correlations between impulsivity subscales and body mass. However, an indirect effect of impulsivity on body mass was found: attentional and motor impulsivity were interactively related to perceived self-regulatory success in dieting, which was, in turn, related to body mass. Specifically, higher attentional impulsivity was associated with lower perceived self-regulatory success in dieting only when motor impulsivity was also high. This lower perceived self-regulatory success in dieting was then associated with higher body mass.

These findings partially replicate, but extend previous findings. The negative correlation between attentional impulsivity and PSRS scores is in line with several previous studies in adults (Meule, 2013; Meule et al., 2012; van Koningsbruggen, Stroebe, & Aarts, 2013), which indicates that attentional impulsivity appears to be a personality trait associated with reduced eating-related self-regulation. Unexpectedly, non-planning impulsivity was negatively correlated with PSRS scores as well. While it has been suggested that non-planning impulsivity may only play a minor role in eating- and weight-regulation (Meule, 2013), it has indeed been found to be negatively correlated with the PSRS in at least one study (van Koningsbruggen et al., 2013). Similarly, non-planning impulsivity was associated with striatal brain activations during high-calorie versus low-calorie food choices (van der Laan, Barendse,

Table 1
Descriptive statistics of and correlations between study variables.

$N = 122$	M	SD	1.	2.	3.	4.	5.
1. Body mass index percentile	74.43	32.32	–	−0.32*	0.08	0.11	0.01
2. Perceived Self-Regulatory Success in Dieting	12.91	4.11		–	−0.23*	−0.16	−0.20*
3. Attentional impulsivity	10.26	2.71			–	0.51*	0.11
4. Motor impulsivity	12.23	3.42				–	0.05
5. Non-planning impulsivity	10.03	3.33					–

*$p < 0.05$.

Table 2
Results from linear regression analyses with impulsivity scores predicting perceived self-regulatory success in dieting and body mass.

$N = 122$	Perceived self-regulatory success in dieting			Body mass index percentile		
	b	SE	p	b	SE	p
Perceived self-regulatory success in dieting	–	–	–	−2.46	0.75	0.001
Attentional impulsivity	−0.25	0.15	*ns*	−0.38	1.22	*ns*
Motor impulsivity	−0.06	0.12	*ns*	0.73	0.95	*ns*
Non-planning impulsivity	−0.32	0.13	0.01	−0.64	1.04	*ns*
Attentional × motor impulsivity	−0.10	0.04	0.02	0.41	0.34	*ns*
Attentional × non-planning impulsivity	0.01	0.05	*ns*	−0.64	0.36	*ns*
Motor × non-planning impulsivity	−0.06	0.04	*ns*	−0.003	0.28	*ns*
Attentional × motor × non-planning impulsivity	0.01	0.01	*ns*	0.02	0.10	*ns*

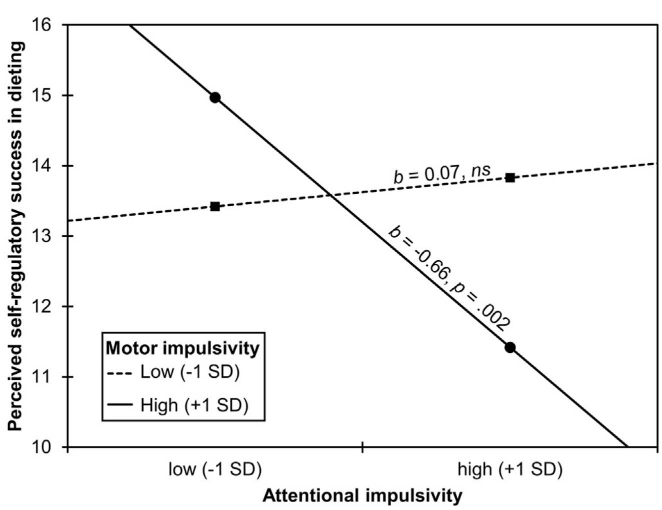

Fig. 2. Simple slopes probing the interaction between attentional and motor impulsivity when predicting perceived self-regulatory success in dieting. Scores on attentional impulsivity negatively predicted perceived self-regulatory success in dieting at high scores on motor impulsivity (+1 *SD*), but not at low scores on motor impulsivity (−1 *SD*).

high-calorie food cues, which ultimately increases the likelihood of being unsuccessful in regulating high-calorie food intake.

The interactive effect between attentional and motor impulsivity when predicting PSRS scores is in line with previous findings in female students, which showed that higher attentional impulsivity in combination with high motor impulsivity predicted higher binge eating frequency (Meule & Platte, 2015) and higher intake of sweet foods in the laboratory (Kakoschke et al., 2015). Contrary to a previous study (Meule & Platte, 2015), however, this interactive effect could not be found when predicting body mass. While this discrepancy may be related to age differences between the two studies, it was found in the current study that there was an indirect effect of the interaction between attentional and motor impulsivity on body mass, which was mediated by perceived self-regulatory success in dieting. This is reasonable as impulsivity has been suggested as a personality trait that potentially increases the risk for engaging in various maladaptive behaviors (e.g., substance use, binge eating, gambling), but is usually manifested in only one or few of these behaviors (Moeller et al., 2001; Shaffer et al., 2004). Hence, high impulsivity (i.e., high attentional and motor impulsivity in particular) does not result in higher body mass directly, but does so only indirectly as it decreases the likelihood that a person can successfully regulate their food intake.

Table 3
Conditional direct and indirect effects of attentional impulsivity (independent variable) on body mass (outcome variable) via perceived self-regulatory success in dieting (mediator) at different levels of motor impulsivity (moderator).

Values of the moderator	Direct effects			Indirect effects		
	b	SE	p	Effect (bootstrap estimate)	SE (bootstrap estimate)	95% bias-corrected bootstrap CI
Low motor impulsivity (−1 *SD*)	−1.80	1.67	*ns*	−0.22	0.58	−1.74, 0.74
Medium motor impulsivity (mean)	−0.38	1.22	*ns*	0.62	0.46	−0.10, 1.74
High motor impulsivity (+1 *SD*)	1.03	1.70	*ns*	1.47	0.71	0.39, 3.32

Viergever, & Smeets, 2015) and an attentional bias towards high-calorie food cues (Meule & Platte, 2016). Thus, although non-planning impulsivity may not be directly related to body mass and demonstrated inconsistent relationships with eating-related measures, it may indeed be associated with a higher reactivity to

On that note, results emphasize the need to go beyond BMI as a dependent variable predicted by psychological variables. Specifically, they suggest that research on psychological determinants (such as impulsivity) needs to include psychological outcome measures (such as perceived self-regulatory success in dieting or eating styles such as addiction-like food consumption, cf. Murphy et al., 2014) in addition to BMI, which is subject to many influencing factors, including non-psychological ones. As PSRS scores were significantly, but only moderately, correlated with BMI, perceived self-regulatory success in dieting – reflecting participants' own experience of their ability to influence their weight – represents a construct, which is related to, yet distinct from body mass and, thus, may be a useful, additional outcome measure in, for example, weight-loss interventions.

Interpretation of results is limited by the cross-sectional nature of the study and, thus, the putative causal relationships between study variables (impulsivity → self-regulatory success in dieting → body mass) need to be established with longitudinal designs. However, as self-reported impulsivity is considered a stable trait (e.g., as indicated by high retest-reliability of the BIS; Meule et al., 2015b; Stanford et al., 2009) and has been found to prospectively predict weight gain (e.g., Meule & Platte, 2016; Nederkoorn et al., 2010), it is likely that the hypothetical causal directions tested in the current study are valid. A second limitation relates to the use of the BIS-15 and the PSRS in children and adolescents. Although reliability and validity of these measures have been shown in adults (Meule et al., 2015b; Meule et al., 2011, 2012; Spinella, 2007), data in children and adolescents are missing. While internal consistency of the PSRS was comparable to values found in adults, internal consistency of the BIS-15's attentional impulsivity subscale was very low in the current study, which suggests that the scale may not be as appropriate in children and adolescents as it is in adults. Nevertheless, as correlates of the attentional impulsivity subscale were similar to those found in adults (Meule, 2013; Meule et al., 2012), it appears that the low internal consistency did not adversely affect the current results. Finally, sample size was relatively small for the quite complex statistical model tested in the current analyses. Given the very small effect sizes of the relationship between BIS-15 scores and BMI in adults (Meule & Blechert, 2016), it may well be that some effects (e.g., the non-interactive effects of attentional and motor impulsivity scores in the regression analyses) would have been significant with a larger sample size.

To conclude, the current study showed that specific facets of impulsivity are differentially related to perceived self-regulatory success in dieting and body mass. Moreover, it is the first study showing interactive effects between facets of impulsivity when predicting self-reported success in eating-regulation in children and adolescents and that these interactive effects indirectly relate to higher body mass. Thus, the current study provides information on moderators of the relationship between impulsivity and body mass, that is, under which circumstances impulsivity is associated with higher body mass (when both attentional and motor impulsivity are high). It also provides information on possible mediators of the relationship between impulsivity and body mass, that is, mechanisms of how impulsivity may lead to higher body mass (via low self-regulatory success in dieting).

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