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Interactive and indirect effects of trait impulsivity facets on body mass index

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ABSTRACT

Impulsivity is a personality trait that may be a risk factor for overweight and obesity. Increasing evidence suggests, however, that only specific facets of impulsivity are associated with eating- and weight-related variables. Moreover, there seem to be interactive effects such that eating-related self-regulation is low when more than one impulsivity facet is elevated. Finally, the effect of impulsivity on body weight appears to be indirect, that is, is mediated by eating behaviors. In the current study, 790 adults (83% female, 80% students) completed a short form of the *Barratt Impulsiveness Scale* and the *Perceived Self-Regulatory Success in Dieting Scale* online and reported their current height and weight. Scores on attentional and motor impulsivity were interactively associated with perceived self-regulatory success in weight regulation: 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 impulsivity on body mass index (BMI) via perceived self-regulatory success in weight regulation at high, but not low levels of motor impulsivity. Non-planning impulsivity was unrelated to perceived self-regulatory success in weight regulation and BMI. Results support previous findings such that attentional and motor impulsivity are interactively associated with eating- and weight-related measures. Specifically, eating-related self-regulation is low when both attentional and motor impulsivity levels are high. Moreover, results further support that self-reported trait impulsivity is not directly related to BMI, but indirectly via eating behaviors as potential mediators.

1. Introduction

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

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

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These inconsistent findings may partly be explained by small effect sizes of the relationship between impulsivity and body mass index (BMI) and the fact that only specific facets of impulsivity are associated with body weight (Emery & Levine, 2017; Meule & Blechert, 2016; 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 impulsivity is associated with self-reported eating behaviors and body weight (Meule & Blechert, 2016; Meule, 2013). In addition, elevated motor impulsivity has been reported in eating disorder patients who binge eat (Claes, Nederkoorn, Vandereycken, Guerrieri, & Vertommen, 2006; Nasser, Gluck, & Geliebter, 2004; Rosval et al., 2006).

Based on these observations, it has been speculated that there might be interactive effects between attentional and motor impulsivity in relation to eating behaviors and body weight. Specifically, high attentional impulsivity may be related to moderate overeating through reward-sensitive mechanisms, but may be particularly crucial (e.g., clinically relevant) in combination with high motor impulsivity, indicating low inhibitory control (Meule, 2013). Indeed, such interactive effects between impulsivity facets have been found in recent studies. Higher scores on attentional impulsivity in combination with higher scores on motor impulsivity related to higher percent body fat and self-reported binge eating severity in female students (Meule & Platte, 2015), intake of sweet foods in the laboratory in female students (Kakoschke, Kemps, & Tiggemann, 2015), and addiction-like eating in obese adults (Meule, de Zwaan, & Müller, 2017). To conclude, it appears that when both attentional and motor impulsivity levels are high, individuals exhibit low eating-related self-regulation.

Another consideration when examining associations between impulsivity and obesity is how an impulsive personality translates into higher body weight. 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 weight through mediating mechanisms, for example, eating behavior. Accordingly, some studies showed that the relationship between trait impulsivity and body weight was mediated by eating-related measures such as frequent food cravings, low perceived self-regulatory success in weight regulation, and addiction-like eating (e.g., Meule & Blechert, 2017; Murphy, Stojek, & MacKillop, 2014; VanderBroek-Stice, Stojek, Beach, & MacKillop, 2017). Importantly, this indirect effect was observed even in the absence of a directly observable relationship between impulsivity and body weight (i.e., total effect).

Recently, we sought to combine these findings in a sample of children and adolescents by examining the interactive effect between attentional and motor impulsivity (moderation) and the indirect effect of impulsivity on body weight (mediation) in one model (moderated mediation; Meule, Hofmann, Weghuber, & Blechert, 2016). It was found that motor impulsivity moderated the indirect effect of attentional impulsivity on BMI through perceived self-regulatory success in weight regulation. Specifically, there was an indirect effect of higher attentional impulsivity on higher BMI through lower perceived self-regulatory success in weight regulation, but this indirect effect was only present in children and adolescents who had high motor impulsivity levels.

In the current study, we sought to replicate this model in an adult sample. Specifically, it was expected that there would be an indirect effect of attentional impulsivity on BMI through perceived self-regulatory success in weight regulation as a function of motor impulsivity: higher attentional impulsivity was expected to indirectly relate to higher BMI via lower perceived self-regulatory success in weight regulation, but only in individuals with high motor impulsivity (Fig. 1).

2. Methods

2.1. Participants and procedure

Data were collected in an online survey at www.unipark.com. Participants were recruited via e-mails to student mailing lists at several German and Austrian universities, via social networks, and via a posting on the website of the German version of Psychology Today. The study included a short form of the BIS (BIS-15), the *Perceived Self-Regulatory Success in Dieting Scale* (PSRS), and other questionnaires. Participants also indicated their current height and weight, among other sociodemographic data. Every question required a response in order to continue. Completion of the study lasted approximately eight to ten minutes. Three × 50 € were raffled among participants who completed the survey. The website was visited 1396 times and $n = 805$ participants completed the entire set of questions. Twelve participants were excluded from analyses because they answered questions too rapidly (total completion time of less than five minutes). Three participants, who reported a very young or old age (12, 14 and 87 years old), were excluded from analyses, leaving a final sample size of $n = 790$.

Most participants were women (82.9%, $n = 655$) and had German (81.3%, $n = 642$) or Austrian (14.2%, $n = 112$) citizenship. The majority of participants were students (79.6%, $n = 629$), employed (11.4%, $n = 90$), or pupils (4.70%, $n = 37$). Mean age was $M = 24.7$ years ($SD = 6.79$). Mean BMI was $M = 22.3$ kg/m^2 ($SD = 3.93$). Seventy-six participants (9.60%) were underweight (BMI < 18.5 kg/m^2), 583 participants (73.9%) had normal weight (BMI = 18.5–24.9 kg/m^2), 92 participants (11.7%) were overweight (BMI = 25.0–29.9 kg/m^2), and 38 participants (4.80%) were obese (BMI ≥ 30.00 kg/m^2).

2.2. Measures

Perceived Self-Regulatory Success in Dieting Scale (PSRS). The PSRS (Meule, Papies, & Kübler, 2012) is a three-item questionnaire for measuring how successful individuals are in watching their weight and in losing weight, and how difficult it is for them to stay in shape. Response categories are anchored *not successful/not difficult* and *very successful/very difficult* (scored from 1 to 7). Thus, higher values indicate higher perceived self-regulatory success in weight regulation. Internal consistency was $\alpha = 0.696$ in the current study.

Barratt Impulsiveness Scale – short form (BIS-15). The BIS-15 (Meule, Vögele, & Kübler, 2011; Spinella, 2007) is a 15-item short form of the BIS-11 for measuring trait impulsivity. Response categories range from *rarely/never* to *almost always/always* (scored from 1 to 4). Thus, higher values indicate higher impulsivity. Internal consistencies were $\alpha = 0.670$ (attentional), $\alpha = 0.734$ (motor), and $\alpha = 0.794$ (non-planning) in the current study.

2.3. 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. 7 in PROCESS) was tested, in which scores on attentional and motor impulsivity and their two-way interaction were used as predictors of PSRS scores (i.e., the mediating variable) and, in a second regression, attentional impulsivity and PSRS scores as predictors of BMI (Fig. 1).

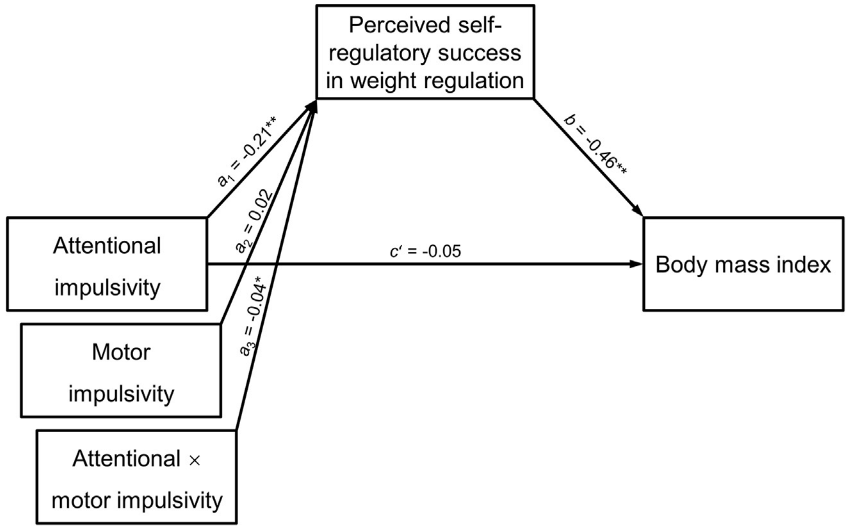

Fig. 1. Moderated mediation model. Scores on attentional and motor impulsivity and their interaction were used as predictors of perceived self-regulatory success in weight regulation. Scores on attentional impulsivity and perceived self-regulatory success in weight regulation were used as predictors of body mass index. Scores on non-planning impulsivity and sex were used as covariates. Attentional and motor impulsivity interactively related to perceived self-regulatory success in weight regulation (also see Fig. 2). Perceived self-regulatory success in weight regulation, in turn, negatively related to body mass index (also see Table 2). There was no direct effect of attentional impulsivity on body mass index, but an indirect effect of attentional impulsivity on body mass index through low perceived self-regulatory success in weight regulation, which was particularly evident at high motor impulsivity levels (Table 3). $^{**}p < 0.001$, $^{*}p < 0.05$.

Predictor variables were mean-centered before calculating the product terms. A significant interaction was followed up with simple slopes analysis at high (+1*SD*) and low (-1*SD*) values of the moderator variable (Hayes, 2013). As we had directional hypotheses about the presence of indirect effects of attentional impulsivity on BMI through perceived self-regulatory success in weight regulation as a function of motor impulsivity, indirect effects were evaluated with 90% 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). Furthermore, the index of moderated mediation was used as a formal test of moderated mediation (Hayes, 2015). When the confidence interval for this index does not contain zero, this means that the presence of indirect effects depends on the value of a moderating variable. Because non-planning impulsivity was associated with PSRS scores in children and adolescents (Meule et al., 2016), it was included in the model as covariate. Furthermore, sex was included as covariate because of the unequal sex distribution in the current study.

3. Results

Descriptive statistics of and correlations between variables are depicted in Table 1. Scores on the PSRS were negatively correlated with BMI and with attentional impulsivity. Subscale scores of the BIS-15 were positively correlated with each other.

Attentional impulsivity negatively related to PSRS scores (Table 2). Moreover, attentional and motor impulsivity interactively related to PSRS scores (Table 2). Examination of the nature of this interaction revealed that attentional impulsivity negatively related to PSRS scores, but only at high levels of motor impulsivity and not at low levels of motor impulsivity (Fig. 2). Furthermore, PSRS scores negatively related to BMI (Table 2). The index of moderated mediation was significant (index = 0.02, $SE = 0.01$, 90% CI [0.001, 0.03]). Testing the indirect effect of BIS-15 scores on BMI revealed that PSRS scores mediated the association between attentional impulsivity and BMI, but only at medium and high levels of motor impulsivity and not at low levels of motor impulsivity (Table 3). Being female was associated with lower PSRS scores and BMI. Non-planning impulsivity was not associated with PSRS scores and BMI (Table 2).

The moderated mediation model can be summarized as follows: Higher attentional impulsivity was associated with lower perceived self-regulatory success in weight regulation, particularly when motor impulsivity levels were also high. Motor impulsivity also moderated the indirect effect of attentional impulsivity on BMI: Although there was no directly observable association between attentional impulsivity and BMI, there was an indirect association between attentional impulsivity and BMI via perceived self-regulatory success in weight regulation, but only at medium and high levels of motor impulsivity.

4. Discussion

The current study sought to replicate interactive effects between and indirect effects of two impulsivity facets on BMI. In accordance with prior findings in children and adolescents (Meule et al., 2016), an interaction between attentional and motor impulsivity was found. Higher attentional impulsivity in combination with high levels of motor impulsivity related to lower perceived self-regulatory success in weight regulation. In turn, lower perceived self-regulatory success related to higher BMI. Although attentional impulsivity scores were uncorrelated with BMI, an indirect effect was found: higher attentional impulsivity was indirectly associated with BMI via lower perceived self-regulatory success at medium and high levels of motor impulsivity, but not when motor impulsivity was low. Thus, results are in line with previous findings that showed similar interactive effects between attentional and motor impulsivity when predicting eating-related variables (Kakoschke et al., 2015; Meule & Platte, 2015; Meule et al., 2016, 2017) and with findings that showed indirect effects of impulsivity facets on BMI in the absence of a direct association (Meule & Blechert, 2017; Meule et al., 2016; Murphy et al., 2014).

In line with previous proposals (Meule, 2013), the interaction between attentional and motor impulsivity suggests that while high attentional impulsivity relates to a higher susceptibility to

Table 1
Descriptive statistics of and correlations between variables.

$N = 790$	*M*	*SD*	1.	2.	3.	4.	5.
1. Body mass index (kg/m^2)	22.3	3.93	–	−0.401*	0.037	0.060	0.031
2. Perceived Self-Regulatory Success in Dieting Scale	12.3	3.87		–	−0.177*	−0.054	−0.031
3. Attentional impulsivity	9.79	2.71			–	0.243*	0.194*
4. Motor impulsivity	10.6	2.62				–	0.413*
5. Non-planning impulsivity	10.6	3.07					–

*$p < 0.001$.

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

$N = 790$	Perceived Self-Regulatory Success in Dieting Scale			Body mass index (kg/m^2)		
	b	*SE*	*p*	*b*	*SE*	*p*
Perceived Self-Regulatory Success in Dieting Scale	–	–	–	−0.46	0.03	<0.001
Attentional impulsivity	−0.21	0.05	<0.001	−0.05	0.05	0.337
Motor impulsivity	0.02	0.06	0.801	–	–	–
Attentional × motor impulsivity	−0.04	0.02	0.049	–	–	–
Non-planning impulsivity	−0.03	0.05	0.498	−0.01	0.04	0.862
Sex (1 = male, 2 = female)	−2.08	0.36	<0.001	−2.22	0.34	<0.001

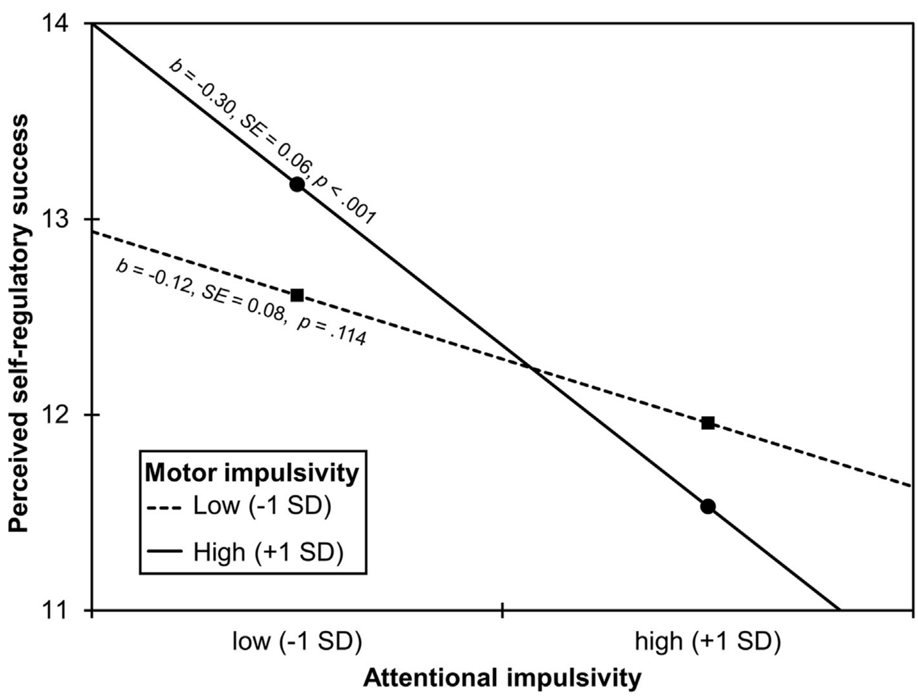

Fig. 2. Simple slopes probing the interactive effect between attentional and motor impulsivity on perceived self-regulatory success in weight regulation. Scores on attentional impulsivity negatively related to perceived self-regulatory success in weight regulation at high scores on motor impulsivity (+1 *SD*), but not at low scores on motor impulsivity (−1 *SD*).

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

Values of the moderator	Effect (bootstrap estimate)	*SE* (bootstrap estimate)	90% bias-corrected bootstrap CI
Low motor impulsivity (−1 *SD*)	0.06	0.04	−0.001, 0.12
Medium motor impulsivity (mean)	0.10	0.03	0.06, 0.14
High motor impulsivity (+1 *SD*)	0.14	0.04	0.09, 0.21

overeat, this susceptibility may only become clinically relevant (e.g., resulting in overweight) when motor impulsivity is also high. In other words, a low motor impulsivity may compensate for a high attentional impulsivity, thus attenuating the risk for regular overeating and gaining weight. Although the current results provide initial insights into the mediators of the relationship between attentional and motor impulsivity with body weight (here: low perceived self-regulatory success in weight regulation), future studies are needed that further examine the mediators (e.g., cognitive mechanisms) that link these impulsivity facets with eating behaviors.

In contrast to our previous study in children and adolescents (Meule et al., 2016), non-planning impulsivity was unrelated to PSRS scores, which may be due to age differences between samples. For example, it may be that the items of the non-planning impulsivity subscale, which refer to planning for the future (e.g., job-related), differently apply to children and adolescents as opposed to adults. Although non-planning impulsivity has occasionally been reported to be associated with eating-related self-report measures (e.g., Van Koningsbruggen, Stroebe, & Aarts, 2013; Yeomans, Leitch, & Mobini, 2008) or responses to food cues (e.g., Meule & Platte, 2016; van der Laan, Barendse, Viergever, & Smeets, 2016), we would argue that the current findings are in line with previous studies showing that attentional and motor impulsivity are most consistently associated with self-reported eating behaviors (Meule, 2013).

While the current study focused on three facets of self-reported trait impulsivity, other aspects such as motor response inhibition or delay discounting have been related to eating behaviors (e.g., binge eating) and overweight as well (Manwaring, Green, Myerson, Strube, & Wilfley, 2011; Mobbs et al., 2011; Nederkoorn, Smulders, et al., 2006; Weller et al., 2008). Although some evidence suggests that scores on the BIS, and particularly on its attentional and motor impulsivity subscales, are associated with lower motor response inhibition as assessed with behavioral tasks (Aichert et al., 2012; Lange & Eggert, 2015; Meule, 2017) and that non-planning impulsivity scores and delay discounting are associated with activation of overlapping brain areas (van der Laan et al., 2016), these associations have been small and inconsistent. Thus, future research may investigate how other operationalizations of impulsivity can be integrated into the model proposed in the current study. For example, while some behavioral impulsivity measures may be used as an equivalent to BIS subscales, others may represent distinct impulsivity aspects that may interact with—or independently explain additional variance over and above—BIS subscales.

Interpretation of results is limited by the cross-sectional nature of the study and, thus, the putative causal relationships between variables (i.e., impulsivity → self-regulatory success in weight regulation → BMI) 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., 2015; Stanford et al., 2009) and has been found to prospectively predict weight gain (e.g., Meule & Platte, 2016; Nederkoorn et al., 2010), the hypothetical causal directions tested in the current study are probable. A second limitation is the reliance on self-report, which is vulnerable to bias. For example, it is known that self-reported height is usually overestimated and weight is underestimated (Connor Gorber, Tremblay, Moher, & Gorber, 2007). However, it has also been reported that although these discrepancies exist, values are usually sufficiently accurate for analyses (Bowman & DeLucia, 1992; Pursey, Burrows, Stanwell, & Collins, 2014). Finally, the present findings are based on a sample of predominantly German, female students. Although they replicate results found in predominantly Austrian children and adolescents (Meule et al., 2016), they may not apply to older individuals or to people with another cultural and educational background.

Notwithstanding these limitations, the current study lends further support for three important methodological considerations that need to be taken into account when examining the role of impulsivity for overweight and obesity. First, only specific facets (e.g., attentional and motor impulsivity) appear to relate to low eating-related self-regulation while others (e.g., non-planning impulsivity) do not or, at least, play a minor role in this context. Second, these impulsivity facets interact with each other when predicting eating-related measures. Specifically, eating-related self-regulation (e.g., perceived self-regulatory success in weight regulation) is low when more than one impulsivity facet (e.g., both attentional and motor impulsivity) is elevated. Finally, the association between impulsivity and BMI is mediated by eating-related variables (e.g., perceived self-regulatory success in weight regulation). Importantly, in contrast to widely held beliefs about mediation testing, it is indeed possible to establish such indirect effects in the absence of a total effect (Zhao, Lynch, & Chen, 2010). Thus, it appears that impulsivity has an indirect effect on BMI that can be observed even in the absence of a direct correlation.

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