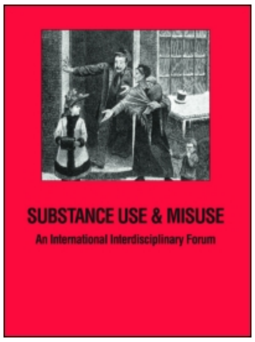

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Smoking, Stress Eating, and Body Weight: The Moderating Role of Perceived Stress

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ABSTRACT
Background: Some individuals respond to stress with increased food intake while others reduce their food intake. Smokers often report using smoking to cope with stress and have a lower body weight than nonsmokers on average. Thus, smokers may tend to eat less when stressed, which may partly explain their lower body weight as compared to nonsmokers. In turn, nonsmokers may tend to eat more when stressed, which may partly explain their higher body weight as compared to smokers. *Objective*: To examine the interplay between smoking and stress-related eating. *Methods*: $N = 314$ (78% female, 14% smokers) participants reported whether they were current smokers, their body height and weight and completed the Salzburg Stress Eating Scale and the Perceived Stress Scale. *Results*: Smokers did not differ from nonsmokers in body mass index (BMI), stress eating and perceived stress. When perceived stress was high, however, nonsmokers reported eating more and smokers reported eating less than usual. Moreover, in individuals with high perceived stress, being a smoker was indirectly related to lower BMI through eating less when stressed and being a nonsmoker was indirectly related to higher BMI through eating more when stressed. *Conclusion*: Smokers most likely use smoking instead of eating to cope with stress and, therefore, food intake and body weight decrease in stressed smokers. After smoking cessation, these individuals may be more susceptible to weight gain when—similar to nonsmokers—eating instead of smoking is used to cope with stress.

KEYWORDS
Stress; stress eating; smoking; tobacco; body weight; body mass index

Introduction

Among a host of physiological and psychological factors that contribute to the maintenance of smoking behavior, using smoking as a regulation strategy in order to reduce negative affect figures prominently (Tate & Stanton, 1990; Tomkins, 1966; Torres & O'Dell, 2016). For example, smokers report that stress motivates them to smoke and stress-induced smoking has also been demonstrated experimentally (Kassel, Stroud, & Paronis, 2003; Marks, Murray, Evans, & Vida Estacio, 2011). Eating is another way for many individuals to cope with stress (Greeno & Wing, 1994). In contrast to smoking, which is increased by stress, however, stress may increase food intake in some individuals, but can also lead to reduced food intake in others (Oliver & Wardle, 1999).

Smoking appears to be a primary reinforcer while reinforcing properties of natural rewards such as food are reduced in current smokers. For example, current smokers had reduced activation of reward-related brain areas in response to food cues (Jastreboff et al., 2015) and—in contrast to nonsmokers—showed an approach bias towards smoking-related cues but not towards food cues (Machulska, Zlomuzica, Adolph, Rinck, & Margraf, 2015). In line with these findings, current smokers tend to have a lower body mass index (BMI) than nonsmokers, which may be due to both nicotine-induced increases in energy expenditure and decreases in appetite (Chiolero, Faeh, Paccaud, & Cornuz, 2008).

In this study, relationships between smoking status, stress, stress eating, and BMI were examined. Based on the above-mentioned findings, it was expected that current smokers would have a lower BMI than nonsmokers. Furthermore, current smokers were expected to report a tendency to eat less when stressed, due to their preference for smoking in response to stress. In addition, if such a mutual exclusiveness of either smoking or eating in response to stress represents a central mechanism of reduced BMI in smokers, then this stress-induced reduction in food intake would mediate the effect of smoking status on BMI. Finally, it was expected that these effects would be particularly pronounced in individuals who actually report experiencing high levels of stress and, thus, that perceived stress would moderate the indirect effect of smoking status on BMI. Therefore, a moderated mediation model was proposed, in which

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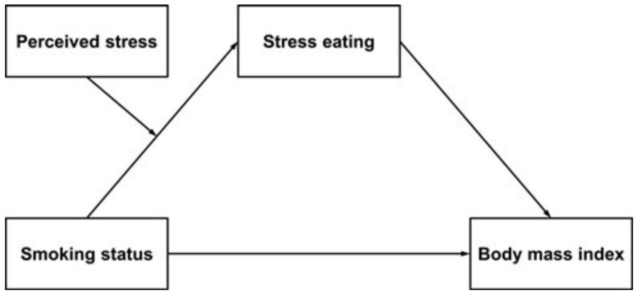

Figure 1. Moderated mediation model with smoking status as independent variable, stress eating as mediating variable, body mass index as outcome variable, and perceived stress as moderating variable. Sex was used as covariate (not shown).

being a smoker was associated with a lower BMI through less stress eating, particularly in stressed individuals (Figure 1).

Methods

Participants and procedure

Data were obtained in a questionnaire-based study on stress eating, results of which are reported elsewhere (Meule, Reichenberger, & Blechert, 2018). Participants were recruited via student mailing lists at universities in Germany and Austria by sending along the study's website URL at www.unipark.com. Questionnaire completion took approximately 20 min. Every question required a response in order to continue. Three-hundred and eighty-two individuals participated. Participants who cancelled participation before completion were excluded from analysis, leaving a final sample size of $n = 314$ participants. Most participants were women (78.3%, $n = 246$), students (91.1%, $n = 286$), and had German citizenship (94.3%, $n = 296$). Forty-three participants (13.7%) reported to be smokers. Mean age was $M = 23.9$ years ($SD = 5.01$, Range: 18–53) and mean BMI was $M = 22.5$ kg/m^2 ($SD = 3.65$, Range 14.5–39.2). Twenty-one participants (6.70%) were underweight (BMI < 18.5 kg/m^2), 227 participants (72.3%) had normal weight (BMI = 18.5–24.9 kg/m^2), 50 participants (15.9%) were overweight (BMI = 25.0–29.9 kg/m^2), and 16 participants (5.10%) were obese (BMI ≥ 30.0 kg/m^2). Descriptive statistics of and correlations between study variables are displayed in Table 1.

Measures

Smoking status

Smoking status was assessed with a single question ("Do you smoke?") with dichotomous response format (yes/no).

Body mass index (BMI)

Participants indicated their height in m and body weight in kg, which were used to calculate BMI as weight divided by height squared (kg/m^2).

Perceived Stress Scale (PSS)

A short version of the PSS (Büssing, Günther, Baumann, Frick, & Jacobs, 2013; Cohen & Williamson, 1988) was used for measuring perceived stress in the past month. The scale consists of 10 items coded from 0 = *never* to 4 = *very often*. Higher scores indicate higher perceived stress. Internal consistency was $\alpha = .850$ in this study.

Salzburg Stress Eating Scale (SSES)

The SSES (Meule, Reichenberger, & Blechert, 2018) was used for measuring stress eating tendencies in general. The scale consists of 10 items coded from 1 = *I eat much less than usual* to 5 = *I eat much more than usual*. Higher mean scores (>3) indicate a tendency to eat more when stressed, medium mean scores (= 3) indicate a tendency to eat just as much as usual when stressed, and lower mean scores (<3) indicate a tendency to eat less when stressed. Internal consistency was $\alpha = .886$ in this study.

Data analyses

Smokers and nonsmokers were compared regarding sex distribution with a χ^2-test and regarding BMI, PSS scores, and SSES scores with independent t-tests (Table 1). Indirect effects of smoking status on BMI were examined with a moderated mediation model with PROCESS (Hayes, 2013). Specifically, model no. 7 in PROCESS was chosen, in which a moderating variable influences the relationship between the independent variable and the mediating variable and, thus, the indirect effect of the independent variable on the outcome variable. Here, smoking status was used as independent variable, stress eating scores as mediating variable, BMI as outcome variable, and perceived stress scores as moderator variable (Figure 1). Sex was used as covariate. Therefore, this moderated

Table 1. Descriptive statistics of study variables as a function of smoking status and correlations between study variables.

	Total sample ($n = 314$)	Smokers ($n = 43$)	Nonsmokers ($n = 271$)	Test statistics	1	2	3	4
1. Sex (1 = male, 2 = female)	$n = 68$ male, 21.7%	$n = 13$ male, 30.2%	$n = 55$ male, 20.3%	$\chi^2_{(1)} = 2.16, p = .142$	—	−.191*	.048	.135*
2. Body mass index (kg/m^2)	$M = 22.5, SD = 3.65$	$M = 22.5, SD = 3.04$	$M = 22.6, SD = 3.75$	$t_{(312)} = -0.10, p = .918$	−.191*	—	.100	.245*
3. Perceived Stress Scale	$M = 17.9, SD = 6.66$	$M = 17.9, SD = 7.32$	$M = 17.9, SD = 6.56$	$t_{(312)} = 0.04, p = .966$	.048	.100	—	.104
4. Salzburg Stress Eating Scale	$M = 3.05, SD = 0.71$	$M = 2.93, SD = 0.71$	$M = 3.07, SD = 0.71$	$t_{(312)} = -1.17, p = .241$	.135*	.245*	.104	—

*$p < .050$.

Table 2. Regression coefficients for the moderated mediation model.

	Outcome: Salzburg Stress Eating Scale			Outcome: Body mass index (kg/m²)		
Predictors	*b*	*SE*	*p*	*b*	*SE*	*p*
Smoking status (1 = smokers, 2 = nonsmokers)	0.11	0.12	.331	0.07	0.57	.903
Perceived Stress Scale	0.01	0.01	.060	—	—	—
Smoking status × Perceived Stress Scale	0.03	0.02	.043	—	—	—
Salzburg Stress Eating Scale	—	—	—	1.41	0.28	<.001
Sex (1 = male, 2 = female)	0.24	0.10	.013	– 2.03	0.48	<.001

mediation model was based on the following two linear regression analyses. In the first regression analysis, stress eating scores were predicted by smoking status, perceived stress, the interaction between smoking status and perceived stress, and sex. In the second regression analysis, BMI was predicted by smoking status, stress eating, and sex (Table 2). Variables were mean-centered before calculating the product term. Indirect effects were evaluated with 95% bias-corrected confidence intervals based on 10,000 bootstrap samples. Indirect effects can be considered as significant when the confidence interval does not contain zero. As a formal test of moderated mediation, the index of moderated mediation was used (Hayes, 2015).

Results

Smokers did not differ from nonsmokers in sex distribution, BMI, perceived stress, and stress eating (Table 1). Higher stress eating scores were associated with being female and with higher BMI (Table 1). In the moderated mediation model, smoking status and perceived stress interactively predicted stress eating (Table 2). Nonsmokers had higher stress eating scores than smokers at high perceived stress but not at low perceived stress (Figure 2). In turn, higher stress eating scores predicted higher BMI (Table 2). The index of moderated mediation was significant (index = 0.05, *SE* = 0.02, 95%CI [0.002, 0.10]), indicating that the indirect effect of smoking status on BMI was moderated by perceived stress. Specifically, there was an indirect effect of smoking status on BMI through stress eating, but only at high perceived stress scores (Table 3). Thus, being a stressed smoker was indirectly associated with a lower BMI through eating less when stressed while being a stressed nonsmoker was indirectly associated with a higher BMI through eating more when stressed.

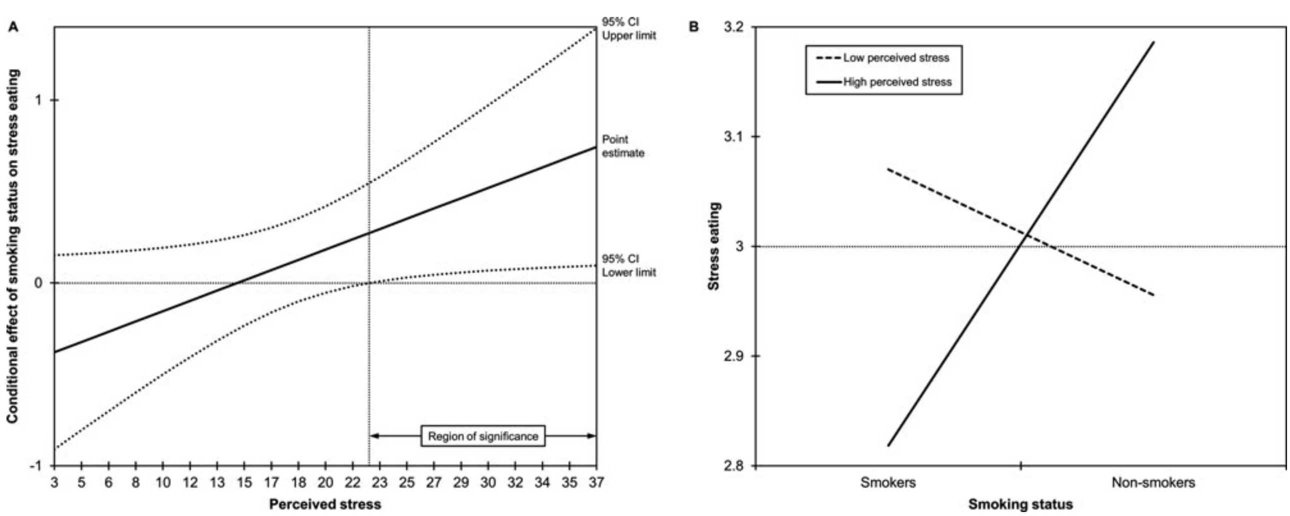

Figure 2. Panel A displays a Johnson–Neyman plot representing the interaction effect of smoking status and perceived stress on stress eating. The plot depicts the conditional effect of smoking status on stress eating as a function of perceived stress. A score of 22.7 on the Perceived Stress Scale represents the point of transition between a statistically significant and a nonsignificant association between smoking status and stress eating scores. Above this value, nonsmokers had significantly higher stress eating scores than smokers. Below this value, smokers and nonsmokers did not differ on stress eating scores. Panel B displays simple slopes representing the very same interaction effect. High perceived stress represents the 84th percentile and low perceived stress represents the 16th percentile of the distribution of Perceived Stress Scale scores. Nonsmokers had higher stress eating scores than smokers at high perceived stress ($b = 0.37$, $SE = 0.17$, $p = .031$) but not at low perceived stress ($b = –0.12$, $SE = 0.16$, $p = .479$). Note that nonsmokers with high perceived stress reported eating more when stressed (score > 3 on the Salzburg Stress Eating Scale) while smokers with high perceived stress reported eating less when stressed (score < 3 on the Salzburg Stress Eating Scale).

Table 3. Conditional indirect effects of smoking status on body mass index at different values of perceived stress.

Value of the moderator (Perceived Stress Scale)				
Percentile	Score	Indirect effect	*SE*	95% CI
10th	10	−0.21	0.19	−0.63, 0.14
25th	13	−0.07	0.16	−0.41, 0.24
50th	17	0.12	0.17	−0.19, 0.48
75th	23	0.40	0.25	−0.03, 0.97
90th	27	0.59	0.33	0.03, 1.34

Discussion

In this study, relationships between smoking status, stress, stress eating, and BMI were examined. Contrary to expectations, smokers and nonsmokers did not differ in stress eating and BMI. However, an indirect effect of smoking status on BMI was found, which was moderated by perceived stress. Being a smoker was indirectly associated with a lower body weight through eating less when stressed, but only in individuals who actually reported being stressed.

Stress can induce craving and greater activity in the striatum in substance users but not in controls (Sinha, 2008) and can enhance the propensity to eat high calorie food via its interaction with central reward pathways (Sominsky & Spencer, 2014). As stressed smokers reported to eat less than usual and stressed nonsmokers reported to eat more than usual, the present findings dovetail with the idea of a "brain reward site competition." Specifically, a shared neural reward pathway may be "occupied" by a rewarding substance and, thus, individuals tend to consume one rewarding substance to the other's exclusion (Cummings, Ray, & Tomiyama, 2017; Jastreboff et al., 2015; Meule, 2014; Warren & Gold, 2007). That is, smokers seem to retreat to smoking as their favorite drug for coping with stress and are, therefore, "immune" against other substances or behaviors that might serve this function. However, it has been argued that although reward-related brain mechanisms of food and drug consumption overlap, there are also notable differences both on a neural and behavioral level (DiLeone, Taylor, & Picciotto, 2012; Rogers, 2017) and, thus, other explanations for the current findings need to be considered as well.

An alternative view would be to interpret findings within the context of habit formation. Such an account would suggest that there are highly automatized stimulus–response associations (i.e., stress–smoking associations in smokers and stress–eating associations in some nonsmokers) that are maintained irrespective of reinforcement (Bezzina, Lee, Lovibond, & Colagiuri, 2016). Thus, instead of brain reward site competition, the differential accessibility of the two sets of habits might explain the present findings: one set of habits (e.g., smoking) might suffice for palliative coping in a given situation, thereby obviating the other habit set (e.g., eating). Furthermore, the fact that the present relationship between smoking status and stress eating was only present when current stress was high could point to the state-dependency of such associations. Future research should replicate the present cross-sectional findings in a longitudinal design by asking whether the same individual that eats less but smokes more under stress would show another pattern when not stressed (e.g., smokes less, but eats more).

Stressed smokers likely use smoking to cope with stress, which is why stress-related food intake and, subsequently, body weight is reduced. While this interpretation may be apparent, conclusions have to be drawn with caution as we did not assess the extent to which smokers used smoking as a means to regulate stress. Furthermore, we did not differentiate between never smokers and former smokers, which may have influenced results, particularly given weight changes after smoking cessation (Filozof, Fernández Pinilla, & Fernández-Cruz, 2004). Moreover, we did not differentiate between occasional and regular smokers, the former of which might well turn to smoking when stressed but may have identified as nonsmokers due to the binary response format. Finally, all interpretations are based on cross-sectional self-report data, which are vulnerable to bias and preclude drawing causal inferences.

Notwithstanding these limitations, the current findings provide further insights about the interplays between smoking and eating behavior and suggest avenues for future research. For example, it may be speculated that stressed smokers, who show decreased food intake and increased smoking in response to stress, are particularly susceptible to weight gain after smoking cessation when eating is increasingly used as an alternative strategy to cope with stress.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the article.

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