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Abstract

It is generally assumed that impulse control plays a major role in many areas of self-regulation such as eating behavior. However, the exact mechanisms that enable the control of impulsive determinants such as automatic affective reactions toward tempting stimuli are not well understood. The present research investigated the separate moderator effects of three factors of impulse control, *executive attention* (as assessed with a digit-span task; Oberauer et al., 2000), *inhibitory control* (as assessed with the stop-signal paradigm; Logan, 1997), and *affect regulation* (as assessed with an adaptation of the Affect Misattribution Procedure; Payne et al., 2005) on the relationship between automatic affective reactions toward candy and subsequent candy consumption. Results showed that all three factors reduced the influence of automatic affective reactions on eating behavior, indicating improved impulse control. Implications for self-regulation research are discussed.

[135 Words]

Keywords: Impulse Control, Executive Attention, Inhibition, Affect Regulation, Automatic Affective Reactions, Eating

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People time and again face the challenge of resisting tempting impulses (Baumeister

& Heatherton, 1996). This is so because following the call of immediate enticements such as

the tasty dessert, the cool drink, or the relaxing cigarette may interfere with important long-

term goals such as maintaining good health. In order to resist temptation, impulse control is

necessary (Metcalfe & Mischel, 1999). If the capacity for impulse control is situationally or

chronically reduced, impulsive behavior determination is more likely (Muraven &

Baumeister, 2000). For instance, previous research has provided direct evidence for a

heightened impact of impulses on self-regulatory behavior following ego depletion (Friese,

Hofmann, & Wänke, in press; Hofmann, Rauch, & Gawronski, 2007) or alcohol consumption

(Hofmann & Friese, 2008). In this research, impulses have been specified as *automatic*

affective reactions toward the temptation of interest, as assessed with implicit reaction-time

measures (e.g., Greenwald, McGhee, & Schwartz, 1998).

However, to really understand impulse control, it is necessary to identify the exact

mechanisms or factors involved in the resistance to temptation. Drawing on self-regulation

research, there appear to be at least three separable factors pertaining to attentional, inhibitory,

and affect-regulatory mechanisms, respectively. First, earlier work on delay of gratification

has identified the ability to control attention as an important factor in resisting temptation

(Peake, Hebl, & Mischel, 2002; Rodriguez, Mischel, & Shoda, 1989). Correspondingly,

recent research has established that low *executive attention* (i.e., the domain-free ability to

control attention, Engle, 2002) is associated with a larger impact of impulses on self-

regulatory behavior (Hofmann, Gschwendner, Friese, Wiers, & Schmitt, in press; Thush et al.,

2008).

A second factor relates to the general capacity to inhibit prepotent responses (Logan,

1997; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). Specifically, *inhibitory*

control may be needed to prevent impulsive precursors from influencing overt behavior via the activation of behavioral tendencies to approach/consume a temptation of interest (e.g., Strack & Deutsch, 2004).

Finally, as impulses are assumed to contain an affective, hedonic component (Metcalfe & Mischel, 1999), the down-regulation of hedonic affect (*affect regulation*) may be an additional factor involved in impulse control. Specifically, individuals who spontaneously down-regulate activated affect may be less prone to being swayed by impulses than individuals for whom activated affect persists so that impulsive influences on behavior become less likely.

The aim of the present research was to separately assess these three factors: executive attention, inhibitory control, and affect regulation, and to investigate their independent contributions on impulse control. These three factors were measured via the performance on experimental tasks adapted from the (social-)cognitive literature rather than via self-report measures for which accurate insight into the processes of interest is unlikely. Specifically, executive attention was assessed with an operation span task (Engle, 2002; Oberauer, Süß, Schulze, Wilhelm, & Wittmann, 2000), inhibitory control with the stop-signal paradigm (Logan, 1997), and affect regulation with an adaptation of the affect misattribution procedure (Payne, Cheng, Govorun, & Stewart, 2005). Following previous reasoning, impulse control was indicated by the degree to which these three factors reduce the influence of automatic affective reactions toward candy on actual behavior (Hofmann et al., in press; Hofmann et al., 2007). The eating behavior of females was chosen as an important applied domain of self-regulation in which impulsive influences play a major role over and above explicit liking or reasoned beliefs (Herman & Polivy, 2004).

Method

Participants

Participants were 122 female participants from the University of Würzburg, Germany, with a mean age of 23 years and a mean body mass index (BMI) of 22.24. Participants were recruited via Internet and newspaper advertisements and compensated for participation (approx. $5). Four participants failed to perform some of the experimental tasks satisfactorily (see below). Thus, the final sample consisted of 118 participants.

Measures

Automatic affective reactions. We assessed participants' automatic affective reactions toward peanut m&m's with a Single-Category Implicit Association Test (SC-IAT; Karpinski & Steinman, 2006). All procedural details of the task were identical to the study by Hofmann et al. (2007) except that six different pictures of peanut m&m's were used as target stimuli. An index of automatic candy attitudes was calculated according to the D_4-measure proposed by Greenwald, Nosek, and Banaji, (2003). Higher values indicate faster reactions to m&m's stimuli when paired with positive attribute stimuli.

Executive attention. For the assessment of individual differences in executive attention, we employed a common operation span task (Oberauer et al., 2000). In each trial, a set of four to eight simple equations (e.g., $4 + 3 = 7$) was presented sequentially on the computer screen. Each single equation was either true or false and the result was always a one-digit number. Each equation remained on the screen for 3 s. As the primary task, the sequence of results in each trial set had to be remembered and entered in the correct order at the end of each trial. As an interfering secondary task, participants had to judge each presented equation as either "true" or "false" by pressing the appropriate key on the keyboard within 3 s. An index of executive attention was computed by summing the number of correctly entered sequences of results across the 12 test trials of the task. Whereas the percentage of correct responses to the secondary task was generally high (88%), 3 participants had a markedly low rate ($< 60\%$) indicating that they did not perform the task seriously and were therefore excluded from further analyses.

Inhibitory control. Inhibitory control was assessed with an adapted version of the stop-signal paradigm (Logan, 1997) consisting of go-trials (75% of all trials) and stop-trials (25%). On a go-trial, participants had to move a joystick represented in the center of the screen as quickly as possible in the direction of a geometric figure presented for 1000 ms randomly above, below, to the right, or to the left of the center. Stop-trials were similar, except that a delayed acoustic stop-signal (a short ringing tone) told participants to inhibit the motor response, that is, not to move the joystick. The delay between the presentation of the geometric figures and the stop-signal was initially set at 250 ms and then adjusted adaptively: If the participant succeeded (failed) to inhibit the response on a given stop-trial, the delay was increased (decreased) by 25 ms for the next stop-trial, making inhibition more difficult (easier). There were a total of 20 practice and 160 test trials. Occurrence of the stop-trial was determined randomly. The average time needed to inhibit the response was calculated by subtracting the mean stop-signal delay from the mean go-signal reaction time (Logan, 1997). An index of *inhibitory control* was calculated by multiplying this difference by -1, with a value of zero indicating the maximum (theoretically) possible inhibitory control and increasingly negative values indicating less inhibitory control.

Affect regulation. Building on the Affect Misattribution Procedure (AMP; Payne et al., 2005), we developed a new measure of affect regulation to capture the ease or difficulty with which immediately activated affect is down-regulated over time. The standard AMP assesses the extent to which briefly presented positive or negative prime stimuli influence the pleasantness judgment of a neutral Chinese pictograph presented shortly afterwards. In the standard AMP effect, more positive (vs. negative) judgments result when Chinese target characters are preceded by positive (vs. negative) primes (Payne et al., 2005), and the difference in evaluation between positive and negative prime trials serves as an indicator of affective reactivity toward these stimuli. In order to assess affect regulation over time, we added a second within-participants condition in which the time between prime and target

presentation (i.e., the SOA) was increased from 100 ms for standard AMP trials to 1000 ms.

The dependent measure of affect regulation was the *difference* in affective reactivity for the

long as compared with the short SOA. This measure of affect control was scored such that

positive values indicate a *down-regulation* of affective reactions over time.

As prime stimuli, we used 20 positively valenced ($M_{IAPS} = 7.55$; $SD = .52$) and 20

negatively valenced pictures ($M_{IAPS} = 2.77$; $SD = .68$) unrelated to food selected from the

IAPS (Lang, Bradley, & Cuthbert, 2005). Prime stimuli were presented for 75 ms according

to a predetermined, random order that was identical for all participants. Also, the SOA (100

ms vs. 1000 ms) was varied in a predetermined, random order between trials. Each prime was

paired with a new Chinese target pictograph taken from Payne et al. (2005). Each pictograph

was presented for 200 ms followed by a mask. One participant was excluded from further

analyses because she responded almost exclusively (93%) with only one of the two response

keys used for the pleasantness judgments across all 120 trials.

Candy consumption. In an ostensible product test, a 125g peanut m&m's package was

cut open and placed on a table napkin in front of each participant. Five minutes were given to

taste the product and to rate it on a variety of dimensions such as naturalness, product look,

and package design. After time had expired the m&m's were taken out of the participant's

reach. Candy consumption was later determined by weighing the amount left and subtracting

it from preconsumption weight.

Explicit liking. Explicit liking toward the m&m's candies were assessed with the

single-item measure ("How much do you like the product in total?") embedded in the set of

questions administered during the product test.

Procedure

The study always took place between 2:00 and 6:00 pm. Upon arrival, between 1 and

3 participants were greeted by a female experimenter and seated in separate cubicles.

Participants first performed the three measures of impulse control in a counterbalanced order.

Then, participants completed the SC-IAT and, after a short filler task, engaged in the product

test. Participants were fully debriefed via e-mail after the data collection was completed.

Results

Because candy consumption was positively skewed ($s = 1.09$), we applied a log-

transformation to achieve homogeneity of variance (Hofmann et al., 2007; Vohs &

Heatherton, 2000). All statistical analyses were done using the transformed data. For ease of

interpretation, however, mean values are reported in untransformed grams of candy

consumption. As can be seen from Table 1, both automatic affective reactions and explicit

liking were positively associated with candy consumption.[1] Executive attention, inhibitory

control, and affect regulation were largely uncorrelated with each other, suggesting that these

measures tap into separate mental faculties.

Next, we performed a multiple moderated regression analysis (Aiken & West, 1991)

on z-standardized log-transformed grams of candy consumption. As z-standardized predictors,

we entered automatic affective reactions, executive attention, inhibitory control, affect

regulation, explicit liking, and BMI and the interaction terms between automatic affective

reactions and each of the remaining predictors ($R^2 = .34$). Interaction terms showed that, as

expected, executive attention, β= -.23, $F(1, 106) = 7.74$, $p < .01$, inhibitory control, β= -.22,

$F(1, 106) = 5.34$, $p = .02$, and ~~somewhat less strongly~~ affect regulation, β= -.18, $F(1, 106) =$

3.26, $p = .07$, each moderated the impact of automatic affective reactions on candy

consumption, such that automatic affective reactions had a stronger impact on eating behavior

for individuals low (-1 SD; see the positive slopes in Figures 1 to 3) rather than high (+1 SD;

see the virtually zero slopes in Figures 1 to 3) on these control faculties.

Furthermore, explicit liking (β= -.26, $F(1, 106) = 9.64$, $p < .01$) and BMI (β= -.23,

$F(1, 106) = 4.77$, $p = .03$) interacted with automatic affective reactions in predicting eating

behavior. Regarding explicit liking, participants with above-average explicit liking consumed

more food, irrespective of their automatic affective reactions. Among participants with below-average explicit liking, those with more positive automatic affective reactions consumed more candy (matching the intake level of those with above-average explicit liking), whereas those with more negative automatic affective reactions consumed considerably less candy. Regarding the BMI, the behavioral influence of automatic affective reactions was stronger for above-average BMI participants as compared with below-average BMI participants.

Finally, we checked for any higher-order interactions among executive attention, inhibitory control, and affect regulation in moderating impulse control. The increase in the amount of variance explained was negligible ($\Delta R^2 = 0.1\%$) and none of the higher-order interactions was reliable (all $F_s < 1$), indicating that each factor had an influence on impulse control that was independent of any of the other factors.

Discussion

The present findings are the first to show the independent contribution of executive attention, inhibitory control, and affect regulation on the control of impulsive determinants of eating behavior (i.e., automatic affective reactions). Specifically, automatic affective reactions toward m&m's candy had a weaker influence on subsequently assessed candy consumption for individuals above-average (as compared to below-average) in executive attention, inhibitory control, and affect-regulation. Importantly, all three factors of impulse control were largely uncorrelated and they moderated the influence of automatic affective reactions on behavior *independently* from each other, suggesting that impulse control involves at least three conceptually separable factors.

One particularly valuable insight from these findings is that individuals low in impulse control will not necessarily consume more high-caloric food. Rather, all else being equal, low impulse control renders *individual differences* in automatic affective reactions more important in shaping actual eating behavior, such that individuals with positive automatic affective

reactions consume relatively more food than individuals whose automatic affective reactions are more negative.

The independence of factors further suggests that, in order for impulse control to be effective, it may be sufficient if participants are high on either executive attention, inhibitory control, or affect regulation. However, individuals high on all three factors may have a particular advantage in situations under which a particular factor is impeded by situational circumstances. For instance, high distraction in the face of temptation may be especially detrimental for executive attention to unfold its controlling influence while inhibitory control and affect regulation could still be marshaled in the service of impulse control. Clearly, the present findings offer a good starting point for future investigations into the dynamic interplay between different dispositional profiles of impulse control and different situational profiles given by the circumstances under which a temptation is encountered.

Also, the present set of factors may not yet be exhaustive. For instance, the finding that BMI had an independent interaction effect over and above the other factors points to further moderator variables for which BMI may be a proxy, such as a stronger propensity to consume high-fat food or stronger facilitating need states among high BMI individuals. The present findings and future research along these lines may contribute to a more fine-grained theoretical understanding of the various processes that enable people to overcome their impulses and may even prove useful for the treatment of impulse-related societal problems such as overeating, overdrinking, or risky sexual behavior.

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Authors' Note

Footnotes

[1] Since explicit liking was reliably associated with candy consumption, we controlled for explicit liking as a predictor in the regression analyses to follow in order to estimate the independent contribution of automatic affective reactions as impulsive precursors over and above individual's deliberate, conscious evaluation of the candy.

Table 1

Means, Standard Deviations, and Intercorrelations of Main Variables

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Candy consumption	1.00						
(2) Automatic affective reactions	0.19	1.00					
(3) Executive attention	-0.02	-0.03	1.00				
(4) Inhibitory control	-0.06	0.05	0.21	1.00			
(5) Affect regulation	0.13	0.04	-0.17	-0.08	1.00		
(6) Explicit liking	0.38	0.10	0.01	-0.12	-0.07	1.00	
(7) BMI	-0.02	0.06	0.02	0.10	0.08	-0.01	1.00
Mean	26.32	0.30	3.77	-253.22	-4.43	3.87	22.17
SD	13.61	0.33	2.53	53.13	17.51	0.90	4.36

Note: $N = 118$. Correlations of over .18 are significant at $p < .05$.

Figure Captions

Figure 1. Moderator effect of executive attention. The graph shows the predicted candy consumption for participants with low and high automatic affective reactions toward candy (assessed with an Implicit Association Test) depending on low and high executive attention as assessed with a computation span task (Oberauer et al., 2000).

Figure 2. Moderator effect of inhibitory control. The graph shows the predicted candy consumption for participants with low and high automatic affective reactions toward candy depending on low and high inhibitory control as assessed with a version of the stop-signal task (Logan, 1997).

Figure 3. Moderator effect of affect regulation. The graph shows the predicted candy consumption for participants with low and high automatic affective reactions toward candy depending on low and high affect regulation as assessed with an adaptation of the Affect Misattribution Paradigm (Payne et al., 2005).
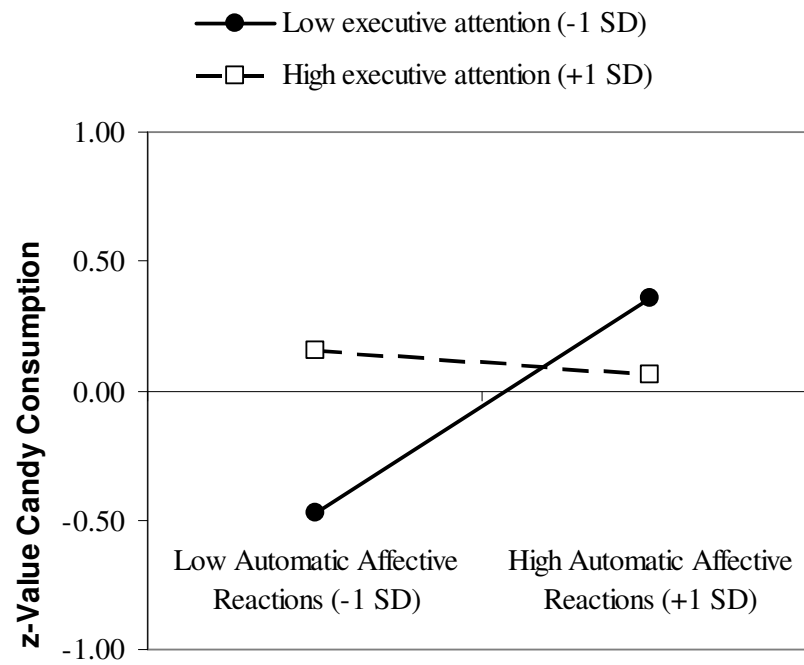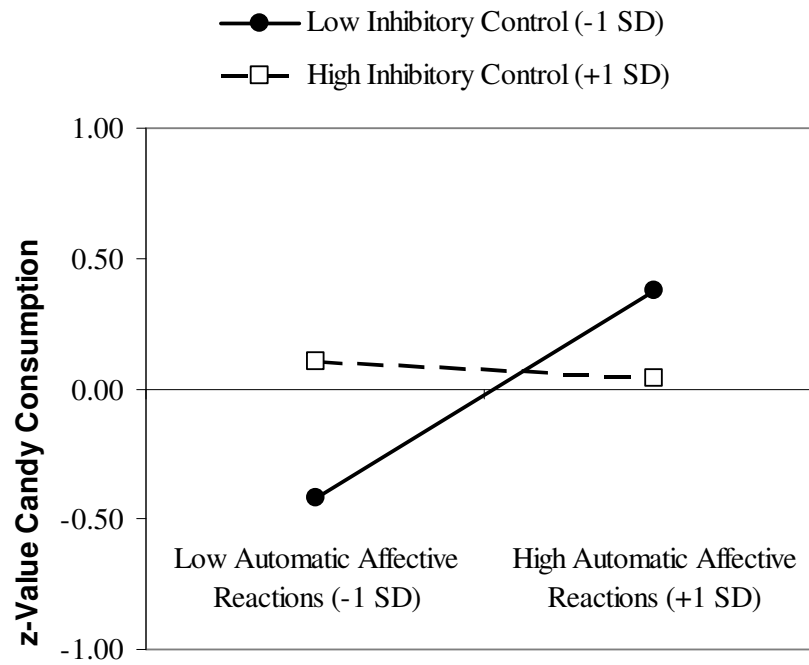
Figure 1

Figure 2

Figure 3

Low Affect Regulation (-1 SD)

High Affect Regulation (+1 SD)