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As Pleasure Unfolds: Hedonic Responses to Tempting Food

Wilhelm Hofmann[1], Guido M. van Koningsbruggen[2], Wolfgang Stroebe[2], Suresh Ramanathan[1], and Henk Aarts[2]
[1]University of Chicago and [2]Utrecht University

Abstract

Why do chronic dieters often violate their dieting goals? One possibility is that they experience stronger hedonic responses to tempting food than normal eaters do. We scrutinized hedonic processing in dieters and normal eaters (a) by manipulating food preexposure and (b) by assessing both immediate and delayed hedonic responses to tempting food with an adapted affect-misattribution procedure. Without food preexposure, dieters showed less positive hedonic responses than normal eaters (Study 1). When preexposed to tempting-food stimuli, however, dieters exhibited more positive delayed hedonic responses than normal eaters (Studies 1 and 2). Furthermore, delayed hedonic responding was meaningfully related to self-reported power of food and state cravings (Study 2). These findings suggest that dieters experience difficulties in down-regulating hedonic affect when in a "hot" state and that self-regulation research may benefit from a greater emphasis on temporal dynamics rather than static differences.

Keywords

self-regulation, hedonic processes, affect regulation, eating, dietary restraint

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With the prevalence of overweight and obesity constantly on the rise, dieting has become the most important strategy to control weight in food-rich environments (Kruger, Galuska, Serdula, & Jones, 2004). Although chronic dieters, also referred to as restrained eaters (Herman & Polivy, 1980), are generally highly motivated to restrict food intake in order to control body weight, only a few succeed in losing weight and in maintaining weight losses over significant periods of time (Mann et al., 2007; Stroebe, 2008). Precisely why dieters often fail to meet their dieting goals, however, has been the subject of continuous debate.

The Hedonic-Response Hypothesis

One recent approach proposes that eating is often driven by the automatic hedonic processing of food cues, rather than by the homeostatic regulation of hunger per se (Lowe & Butryn, 2007; Pinel, Assanand, & Lehman, 2000). Specifically, dieters may experience stronger hedonic responses to highly palatable-food cues than normal eaters do. These hedonic responses are assumed to be responsible for attentional biases to tempting-food cues (Papies, Stroebe, & Aarts, 2008), the emergence of food cravings and intrusive thoughts (Kavanagh, Andrade, & May, 2005; Papies, Stroebe, & Aarts, 2007), and the temporary inhibition of the long-term dieting goal (for a model, see Stroebe, Mensink, Aarts, Schut, & Kruglanski, 2008).

Central to this line of reasoning is the assumption that dieters show more positive hedonic responses to tempting-food cues than normal eaters do. However, previous research using explicit measures has often failed to find a difference between dieters and normal eaters in the self-reported evaluation of palatable-food stimuli (Fedoroff, Polivy, & Herman, 1997; Stroebe et al., 2008); some such research has even found a devaluation of highly palatable food among dieters (e.g., Papies et al., 2008). It has been argued that hedonic reactions, because of their spontaneous, automatic nature, may be better captured with the help of indirect measures (e.g., Hofmann, Friese, & Strack, 2009). However, consistent with the self-report data just mentioned, research using indirect measures has yielded only inconclusive evidence for the hedonic-response hypothesis, with two studies reporting more positive hedonic reactions among dieters (Hoefling & Strack, 2008; Veenstra & de Jong, in press), one study finding no difference

Corresponding Author:
Wilhelm Hofmann, Booth School of Business, University of Chicago, 5807 South Woodlawn Ave., Chicago, IL 60637
E-mail: wilhelm.hofmann@chicagobooth.edu

between dieters and normal eaters (Roefs, Herman, Macleod, Smulders, & Jansen, 2005), and two studies finding more negative hedonic reactions to palatable food among dieters (Papies, Stroebe, & Aarts, 2009, Experiment 1; E. Papies, personal communication, May 4, 2010; Roefs & Jansen, 2002). How should these seemingly divergent hedonic-response findings be interpreted?

A Two-Factor Approach to Hedonic Processing

In this article, we argue that the assumption that has guided previous research—the assumption of a static difference between dieters and normal eaters—is too simple. We propose that to understand hedonic responses in eating behavior, and probably other domains of self-regulation as well, it is necessary to take into account the dynamic interplay of two crucial factors: preexposure and the time course of hedonic responses. Preexposure concerns the (often disruptive) influence of the immediate stimulus environment on self-regulatory processes (e.g., Metcalfe & Mischel, 1999). In the eating domain, for example, it has been found that dieters are more likely to overeat after they have been preexposed to the sight, smell, or taste of tempting-food cues (Fedoroff et al., 1997; Fedoroff, Polivy, & Herman, 2003; Herman & Mack, 1975; Jansen & van den Hout, 1991; Rogers & Hill, 1989). Research examining the potential causes of this overeating effect shows that preexposure to words associated with tempting foods increases attentional bias for tempting food (Papies et al., 2008) and temporarily inhibits access to the dieting goal (Stroebe et al., 2008). These findings suggest that dieters may show different hedonic responses depending on whether or not they have been brought into a "hot state" by the presence of tempting-food primes.[1]

The second crucial factor is the time course of the hedonic response. Previous research using indirect measures has exclusively focused on immediate hedonic reactions to stimulus exposure. By taking into account only the immediate hedonic response, this approach leaves out an important piece of information—namely, how the mental apparatus deals with hedonic affect over time. Recent neuroscientific research suggests that evaluation is a fast and dynamic process that includes multiple iterative processing cycles even within the first second after stimulus exposure (Cunningham, Zelazo, Packer, & Van Bavel, 2007). Iterative hedonic processing may lead to maintenance or even amplification of hedonic responses if attention is continuously allocated to the affective information and no regulatory process is recruited (Kavanagh et al., 2005; Van Dillen & Koole, 2007). Conversely, hedonic responses may be down-regulated over time through reallocation of attention and through mechanisms of affect regulation that allow the psychological system to disengage from a tempting episode (Hofmann, Friese, & Roefs, 2009).

Study 1

To test the proposed two-factor model, we assessed dieters' and normal eaters' immediate as well as delayed hedonic responses to tempting-food stimuli as a function of preexposure. We hypothesized that without preexposure, dieters' dieting goal would be dominant (Stroebe et al., 2008) and would successfully bias information processing, including the devaluation of goal-incompatible temptations (Aarts, Custers, & Holland, 2007; Myrseth, Fishbach, & Trope, 2009; Veling & Aarts, 2009). However, we also expected that after preexposure to tempting food, dieters would become increasingly sensitive to the hedonic aspects of that food; consequently, we predicted they would (a) exhibit difficulties in down-regulating positive hedonic affect and (b) show prolonged hedonic processing over time compared with normal eaters. Furthermore, we assumed that this pattern of effects would be specific to food stimuli and would not generalize to food-unrelated control stimuli.

Method

Participants were 80 students from Utrecht University (34 male, 46 female; mean age = 21.75 years, SD = 2.33), who received either course credit or monetary compensation (approximately $5). They were assigned randomly to the preexposure or the no-preexposure condition. Afterward, we unobtrusively measured immediate and delayed hedonic responses to tempting food with a modified version of the affect-misattribution procedure (AMP; Payne, Cheng, Govorun, & Stewart, 2005). Finally, participants filled out a dietary restraint scale.

Food preexposure manipulation. A lexical decision task was used to implement food preexposure experimentally, as in Papies et al. (2008). In each trial of the task, participants were presented with a word or nonword target stimulus, and they had to indicate quickly via key press whether the presented stimulus was a word or a nonword. Participants in the preexposure condition (n = 39) were presented with 15 words referring to palatable foods (e.g., *pizza*, *chocolate*, *cake*), 15 neutral words (e.g., *book*), and 30 nonwords. Participants in the no-preexposure condition (n = 41) were presented with 30 neutral words and 30 nonwords. Presentation order of stimuli was randomized across the 60 trials of the task.

Hedonic response over time. Building on the AMP (Payne et al., 2005), we developed a new procedure to capture immediate versus delayed hedonic responses to tempting-food stimuli (see Hofmann, Friese, & Roefs, 2009, for a first application assessing general affect regulatory capacity). In a standard trial of the task, a prime stimulus is presented for 100 ms, followed by an interstimulus interval (ISI) of 100 ms (a blank screen), the presentation of a Chinese pictograph for 200 ms, and finally a mask, which remains until the participant judges the pleasantness of the pictograph (see Fig. S1 in the Supplemental Material available online). Standard trials employing such a short ISI are typically used to measure immediate affective reactions to the primes (misattributed to the pictographs), with a higher proportion of "pleasant" judgments indicating a more positive hedonic response (Payne et al., 2005). We added a second trial type in which the ISI was increased to 1,000 ms, keeping all other aspects of the task constant (see Fig. S1). Comparing responses to identical stimuli at the short versus the long ISI informed us as to how immediately activated affect unfolded over time. Specifically, a decrease in positive responses from the short to the long ISI would be indicative of a down-regulation of immediate affect over time.

The task consisted of 90 trials, presented in random order. The primes were 15 pictures of palatable food selected from a pilot test (N = 24) and 15 positive and 15 negative food-irrelevant stimuli from the International Affective Picture System (Lang, Bradley, & Cuthbert, 2005). To allow for a specificity analysis (see Results and Discussion), we matched the food and positive control stimuli according to ratings (on 9-point scales) of valence ($M_{\text{food}} = 6.31$, $SD = 0.32$; $M_{\text{positive}} = 6.32$, $SD = 0.31$) and arousal ($M_{\text{food}} = 5.41$, $SD = 0.40$; $M_{\text{positive}} = 5.31$, $SD = 0.39$). Each stimulus was shown once in each ISI condition and was paired with a new pictograph each time. As in Payne, Burkley, and Stokes's (2008) study, participants responded to the pictographs with the index and middle fingers of both hands placed on four keys, labeled "−2" (*very unpleasant*), "−1" (*slightly unpleasant*), "+1" (*slightly pleasant*), and "+2" (*very pleasant*). For data analysis, we excluded responses made less than 150 ms or more than 3,500 ms after the onset of the pictograph.

Restraint scale. Dietary restraint was assessed with the Concern for Dieting subscale of the Revised Restraint Scale (Herman & Polivy, 1980). This subscale consists of six items, and the score is the sum of ratings on a scale from 0 to 3. The mean score was 6.60 ($SD = 3.40$; $\alpha = .74$).

Results and discussion

To simplify interpretation, we recoded AMP responses to a scale from 1 to 4, with higher scores indicating more positive responses. We then performed a general linear model (GLM) analysis on hedonic responses with stimulus type (food vs. positive control stimuli) and ISI (100 ms vs. 1,000 ms) as within-subjects factors, food preexposure (present vs. absent) as a between-subjects factor, and dietary restraint as a continuous predictor (with means for dieters and normal eaters estimated at +1 SD and −1 SD, respectively).[2] This analysis revealed two significant interactions: a three-way interaction of ISI, food preexposure, and dietary restraint, $F(1, 76) = 4.14$, $p = .045$, $\eta_p^2 = .05$, which was qualified by a four-way interaction of stimulus type, ISI, food preexposure, and dietary restraint, $F(1, 76) = 5.51$, $p = .022$, $\eta_p^2 = .07$. To decompose these two interactions, we investigated the effects of ISI and restraint separately for food and positive control primes and separately for the no-preexposure and the preexposure conditions within each of the prime conditions.

The analysis for food stimuli revealed that in the no-preexposure condition, there was only a main effect of restraint, $F(1, 39) = 7.88$, $p = .008$, $\eta_p^2 = .17$. As Figure 1 shows, dieters had less positive hedonic reactions to palatable food than normal eaters did when not preexposed. In the preexposure condition, however, there was a significant interaction between ISI and restraint, $F(1, 37) = 6.56$, $p = .015$, $\eta_p^2 = .15$, and no main effects. Hedonic responses of dieters (+1 SD) and normal eaters (−1 SD) did not differ at the short ISI, $t(37) = 0.42$, $p = .673$, $\eta_p^2 = .005$. However, dieters' hedonic responses were significantly larger than those of normal eaters at the long ISI, $t(37) = 2.15$, $p = .038$, $\eta_p^2 = .11$ (see Fig. 1). This dissociation in the delayed response was due to a significant decline in hedonic responding for normal eaters over time, $t(37) = -2.79$, $p = .008$, $\eta_p^2 = .17$. In contrast, dieters maintained high levels of positive responding over time, $t(37) = 0.74$, $p = .46$, $\eta_p^2 = .02$. The analysis for positive control stimuli yielded neither significant main effects of ISI and restraint nor a significant interaction between ISI and restraint in either condition, all Fs < 1.05 (see Fig. 1). Thus, the difference between dieters and normal eaters was specific to food stimuli.

The results from Study 1 suggest that without preexposure to food, dieters devalue palatable-food primes effectively even at very short time frames. Thus, implicit self-control appears to be the default for dieters (Fishbach, Friedman, & Kruglanski, 2003). When preexposed to palatable food, however, dieters showed elevated hedonic responses that persisted over time, whereas normal eaters showed signs of down-regulation over time. Thus, dieters' exposure to tempting food triggers a hot state during which they become increasingly sensitive—and vulnerable—to the hedonic aspects of food.

Study 2

The aim of Study 2 was to examine more closely the time pattern that emerged with food preexposure in Study 1. Specifically, we wanted to investigate whether the observed difference between dieters' and normal eaters' hedonic responses generalizes further across time. We therefore included a third ISI of 1,500 ms in the modified AMP. Moreover, we wanted to investigate whether the assessment of delayed hedonic responses has explanatory power beyond its link with dietary restraint. Specifically, we examined whether delayed hedonic responding can be meaningfully linked to self-reported urges to eat palatable food.

Method

Participants were 48 students from Utrecht University (21 male, 27 female; mean age = 20.96 years, SD = 3.85 years), who received either course credit or monetary compensation

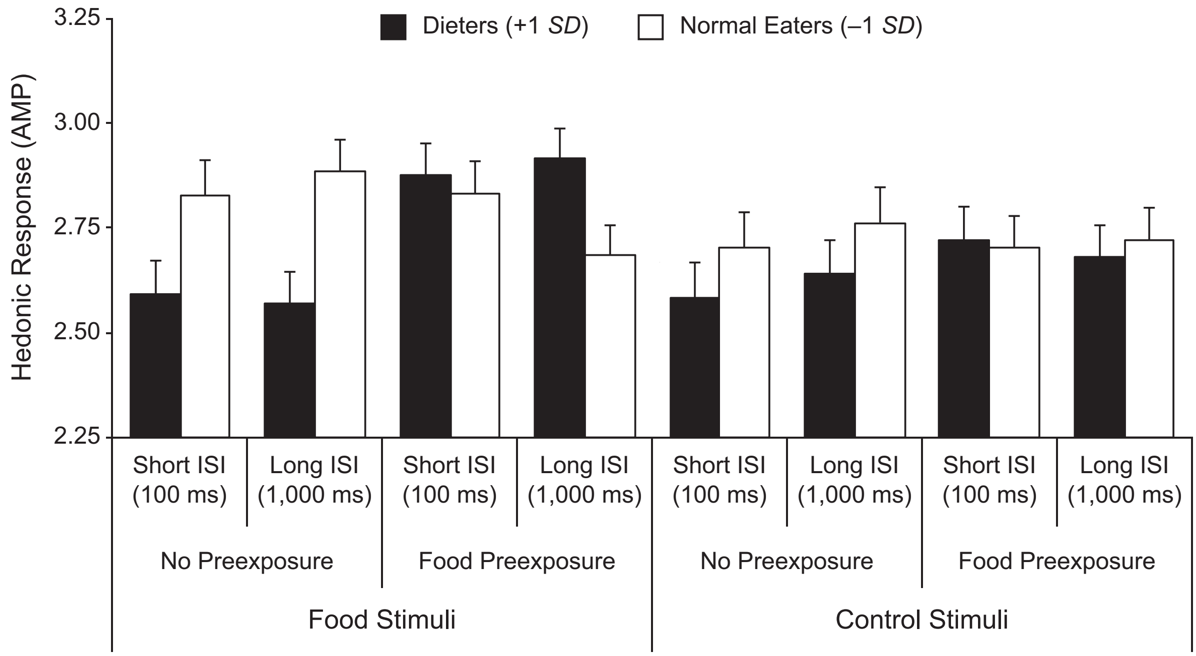

Fig. 1. Results from Study 1: hedonic responses to tempting food and matched positive control stimuli in the affect-misattribution procedure (AMP) as a function of food preexposure (present vs. absent), interstimulus interval (ISI; short vs. long), and dietary restraint (dieters vs. normal eaters: 1 *SD* above and 1 *SD* below the mean on the Concern for Dieting subscale, respectively). Error bars indicate standard errors of the mean.

(approximately \$5). Two participants were identified as outliers in box plots and excluded from further analyses: One of them scored outside the normal range on the restraint measure (> 2.9 *SD*s from the mean), and the other reported not having eaten for more than 18 hr (> 4.1 *SD*s from the mean).

All participants were preexposed to food cues through the lexical decision task from Study 1. Afterward, their hedonic responses to tempting food, matched positive control pictures, and negative pictures were assessed with the modified AMP. However, in Study 2, we added a third ISI of 1,500 ms to the AMP, for a total of 135 trials, in order to trace hedonic responding further over time. Participants then filled out the restraint scale (M = 6.45; α = .75). They also completed the Power of Food Scale (PFS; Lowe et al., 2009; α = .87; e.g., "If I see or smell a food I like, I get a powerful urge to have some"), a recently proposed measure of sensitivity to tempting-food cues in the environment. Participants also completed the State Food Cravings Questionnaire (FCQ-S; Cepeda-Benito, Gleaves, Williams, & Erath, 2000; α = .96; e.g., "If I had tasty food right now, it would be hard to stop eating"), which consists of five subscales—Intense Desire to Eat (α = .95), Anticipation of Positive Reinforcement (α = .90), Anticipation of Relief From Negative Feelings (α = .88), Lack of Control Over Eating (α = .84), and Craving as a Physiological State (α = .87). The PFS and the FCQ-S have both been shown to predict problematic eating behavior in field and laboratory settings (Cepeda-Benito et al., 2000; Lowe & Butryn, 2007; Vander Wal, Johnston, & Dhurandhar, 2007).

Results and discussion

A GLM analysis revealed a significant interaction among stimulus type, ISI, and dietary restraint, $F(2, 88) = 4.47$, $p = .014$, $\eta_p^2 = .09$. To unravel this interaction, we investigated the effects of ISI and restraint on hedonic reactions separately for food and positive control primes.

The analysis for food primes revealed a significant interaction between ISI and restraint, $F(2, 88) = 3.29$, $p = .042$, $\eta_p^2 = .07$; there were no significant main effects. As Figure 2 shows, dieters and normal eaters did not differ in their hedonic response at the short ISI of 100 ms, $t(44) = -0.12$, $p = .908$, $\eta_p^2 = .001$. However, dieters' hedonic responses were significantly larger than those of normal eaters at the delayed ISIs of 1,000 ms, $t(44) = 2.22$, $p = .032$, $\eta_p^2 = .10$, and 1,500 ms, $t(44) = 2.84$, $p = .007$, $\eta_p^2 = .16$. This dissociation of delayed responses after preexposure to tempting food, which is analogous to the results of Study 1, was due to a significant decline in hedonic responding for normal eaters from the 100-ms ISI to the 1,000-ms ISI, $t(44) = 3.16$, $p = .003$, and from the 100-ms ISI to the 1,500-ms ISI, $t(44) = 2.63$, $p = .012$. In contrast, and as in Study 1, dieters maintained high levels of positive responding over time—100-ms vs. 1,000-ms ISI: $t(44) = 0.35$, $p = .73$; 100-ms vs. 1,500-ms ISI: $t(44) = 0.43$, $p = .67$. The analysis for positive control primes yielded neither significant main effects of ISI and restraint (both Fs < 1) nor a significant interaction between ISI and restraint, $F(2, 88) = 1.45$, $p = .24$ (see Fig. 2), indicating again that the difference between dieters and normal eaters was specific to food stimuli.

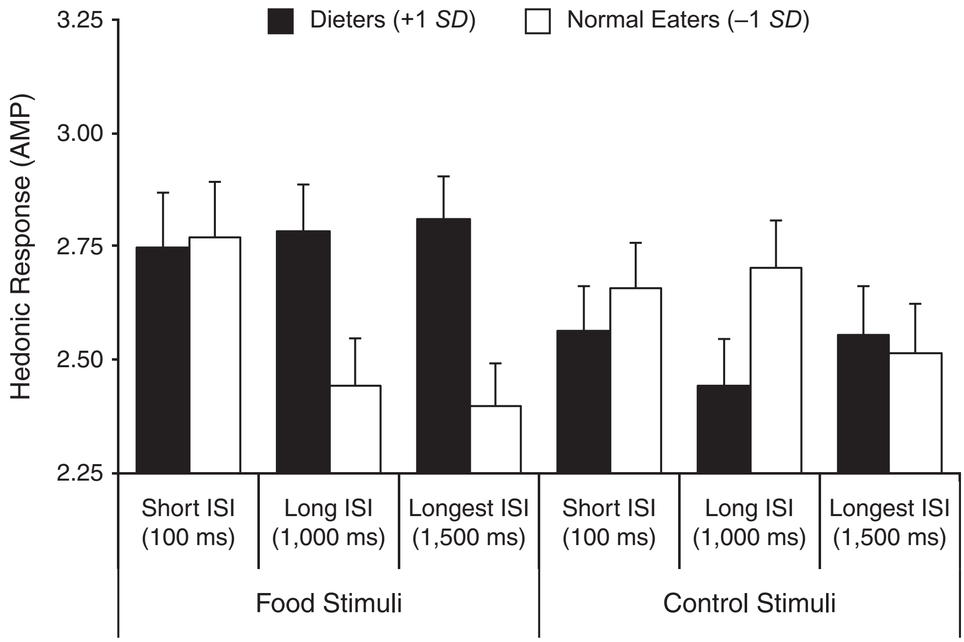

Fig. 2. Results from Study 2: hedonic responses to tempting-food stimuli and matched positive control stimuli in the affect-misattribution procedure (AMP) under preexposure as a function of interstimulus interval (ISI; 100 ms vs. 1,000 ms vs. 1,500 ms) and dietary restraint (dieters vs. normal eaters: 1 *SD* above and 1 *SD* below the mean on the Concern for Dieting subscale, respectively). Error bars indicate standard errors of the mean.

Next, we correlated hedonic responses to food in the AMP with self-reported power of food and the FCQ-S scales and subscales (Cepeda-Benito et al., 2000) separately for the three different ISIs. As shown in Table 1, correlations generally increased from the short to the longest ISI, and elevated positive responses to tempting food at the 1,500-ms ISI were substantially associated with higher self-reported power of food, stronger desire to eat, stronger positive reinforcement from eating, more positive relief from eating, and less control over eating.

To investigate whether late hedonic responding (ISI = 1,500 ms) can partially explain the relationship between dietary restraint and power of food in our sample, $r = .445$, $p = .002$, we conducted a mediation analysis, as recommended by Preacher and Hayes (2004). Results showed that the combined effect of restraint on delayed hedonic responses, $\beta = 0.35$, $p = .016$, and of hedonic responses on power-of-food scores, $\beta = 0.51$, $p = .002$, was significant, $\beta = 0.16$, $p < .05$, establishing mediation. A similar analysis involving FCQ-S (total) scores as the dependent variable also showed that the combined product of the two significant direct effects ($\beta = 0.45 \times \beta = 0.43$) was reliable, $\beta = 0.19$, $p < .05$, indicating mediation. These analyses provide an intriguing link between dietary restraint and subjective experiences of urges and desires. They directly support our assumption that a failure to down-regulate hedonic

Table 1. Correlations Between Hedonic Responses to Tempting-Food Stimuli and Self-Report Measures in Study 2

Self-report measure	Short ISI (100 ms)	Long ISI (1,000 ms)	Longest ISI (1,500 ms)
Power of food	.16	.26†	.47*
Food Cravings Questionnaire	.17	.29*	.43*
Desire to eat	.10	.16	.31*
Positive reinforcement	.27	.28†	.43*
Positive relief from eating	.14	.34*	.38*
Lack of control	.19	.31*	.50*
Craving as physiological state	.06	.18	.26†

Note: Hedonic responses to tempting-food stimuli were assessed with the affect-misattribution procedure (Payne, Cheng, Govorun, & Stewart, 2005). Self-reported cravings were assessed with the Power of Food Scale (Lowe et al., 2009) and the Food Cravings Questionnaire (Cepeda-Benito, Gleaves, Williams, & Erath, 2000). $N = 46$. ISI = interstimulus interval.
†$p < .10$ (two-tailed). *$p < .05$ (two-tailed).

affect over time may be one of the primary reasons underlying the propensity to overeat when tempted.

General Discussion

The present findings provide novel insights into when and why dieters may have difficulties resisting the allure of tempting food. Study 1 showed that without preexposure to food, dieters exhibited less positive hedonic responses to food than normal eaters did, an indication of successful devaluation of tempting food at both short and long ISIs. In contrast, when preexposed to palatable-food stimuli, dieters showed continued elevated hedonic responses, which differed markedly from the responses of normal eaters, who showed down-regulation over time. Study 2 replicated this finding and, by extending the ISI, demonstrated that the observed discrepancy remains stable for at least a certain amount of time. These results show that dieters are able to effectively regulate their hedonic responses to food as a result of having the goal to diet, but that preexposure to food triggers a hot state in which the down-regulation of hedonic responses is substantially impaired.

These findings are consistent with the goal-conflict model of eating (Stroebe et al., 2008). According to this model, restrained eaters' dieting goal successfully biases information processing, leading to a devaluation of goal-incompatible food. However, when a hot state is induced through repeated exposure to tempting food, the dieting goal is inhibited, and hedonic processing prevails. Unlike dieters, normal eaters are not chronically biased by a dieting goal and thus appear to be hedonically drawn toward tempting food under normal conditions. However, when preexposed to palatable-food stimuli, normal eaters (unlike dieters) showed reduced hedonic responding over time. This noteworthy effect may be part of a functional mechanism to disengage from stimuli that have already had a repeated influence so as to keep the organism open to the flexible pursuit of potential alternative goals (Jostmann & Koole, 2009).

As our correlational and mediation analyses from Study 2 imply, dieters' failure to down-regulate hedonic affect when tempted may be the key mechanism in the development of more elaborated food cravings and desires (Kavanagh et al., 2005) and may pave the way for unhealthy eating behavior. Our findings thus accord well with the recently proposed notion of *hedonic hunger* (Lowe & Butryn, 2007) by providing experimental evidence that it is precisely this prolonged responsiveness to the pleasurable aspects of food that may put dieters at risk of unhealthy eating in today's food-rich environments.

The present findings also support the notion of automatic, implicit forms of self-control through the devaluation or inhibition of tempting stimuli (e.g., Fishbach et al., 2003; Fishbach & Shah, 2006; Hofmann, Deutsch, Lancaster, & Banaji, 2010). Results in the no-preexposure condition suggest that under default conditions, dieters can successfully counteract temptation through devaluation, even at a brief ISI. However, the observed pattern in the preexposure condition indicates that this regulatory mechanism may be substantially weakened through repeated confrontation with tempting cues, rendering dieters increasingly vulnerable to the hedonic aspects of food. This clearly supports the common observation that chronic dieters are often strong, but not invincible. Future research may help to further elucidate the boundaries under which otherwise beneficial mechanisms may be offset by specific circumstances or stimulus constellations.

Finally, our results may help to reconsolidate previous research into the hedonic-response hypothesis by incorporating situational factors, such as preexposure and temporal dynamics, that might be overlooked in the prevailing focus on immediate automatic responses. Taking such a dynamic and context-dependent perspective, future self-regulation research from domains such as drug abuse, sexual risk taking, aggression, and emotion regulation may likewise profit from a closer look at how immediate affect unfolds over time.

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Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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Supplemental Material

Additional supporting information may be found at http://pss.sagepub.com/content/by/supplemental-data

Notes

1. Such a conditional view may help to explain some of the inconsistencies reported earlier. For example, whereas the studies cited as reporting more negative evaluations of food by dieters did not involve a preexposure to food, Hoefling and Strack (2008) noted that, before completing the implicit measure in their study, "all subjects dealt with other food items (pictures) in another irrelevant task" (p. 684) involving the visual presentation of palatable-food stimuli (A. Höfling, personal communication, May 4, 2010). In a similar vein, Veenstra and de Jong (in press) noted that "an exogenous cueing task was administered (before the rest of the tasks)"; this exogenous cuing task involved the presentation of pictures of high-fat foods and an explicit assessment of state cravings (see Veenstra, de Jong, Koster, & Roefs, 2010, for details). In both studies, these presentations of

food stimuli may have acted as a preexposure manipulation. Thus, the degree of preexposure to palatable food may at least partially account for empirically observed variations in the difference between dieters' and normal eaters' hedonic responses.

2. Including gender in GLM analyses as an additional factor did not affect any of the statistical conclusions drawn in either Study 1 or Study 2.

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