

Research article

Having Used Self-Control Increases Attention to Food: A Functional Bias in the Management of Metabolic Energy and a Bias toward Indulgence

Matthew T. Gailliot, Ph.D.

E-mail: mgailliot@gmail.com



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Abstract

The current study examined whether using self-control causes subsequent increases in attentional adhesion to food. Participants first either did or did not use self-control by controlling their attention while watching a video. Participants next completed a dot probe attention task, designed to measure attentional adhesion to images of junk food, healthy food, and non-food items. Completing a self-control task increased attentional adhesion to food (both junk and healthy food) among people with high trait self-control. This suggests that the attentional bias is functional – food replenishes both glucose and self-control, thereby suggesting that a bias to food benefits self-control. The self-control task also increased attentional adhesion to primarily junk food among people with bulimic symptoms of overeating, people who may seek to avoid food. This suggests that the attentional bias is caused also by impairments to the self-controlled avoidance of food.

Keywords: ego depletion, self-control, self-regulation

Humans are metabolic organisms. Every thought and behavior requires the use of metabolic energy. Natural selection can be viewed as a process by which organisms that increasingly attained energy and used it efficiently were increasingly likely to survive and reproduce (Gilliland, 1978; Lotka, 1922; Odum, 1995). Hence, much of the psyche should be devoted to getting and saving energy. Indeed, much of thought and behavior revolves around food or eating (attainment of metabolic energy), and people are cognitive misers (conservation or efficiency of metabolic energy; Fiske & Taylor, 1984). The current work presents a study designed to test the hypothesis that visual attention functionally attends to metabolic energy (food) when metabolic energy becomes increasingly beneficial to survival and reproduction (when food replenishes weakened self-control). The study also tested whether using self-control increases attention to food because self-control is weakened, and people are more prone to indulgence.

Glucose from the bloodstream is a primary energy source for the brain. The brain requires a constant, steady flow of glucose metabolites. One metabolically expensive psychological process is self-control, such that low glucose and other metabolic problems impair self-control (DeWall, Baumeister, Gailliot, & Maner, 2008; DeWall, Gailliot, Deckman, & Bushman, 2009; Fairclough & Houston, 2004; Gailliot, 2008, 2009a, 2009b; Gailliot et al., 2007; Gailliot & Baumeister, 2007; Gailliot, Hildebrandt, Eckel, & Baumeister, 2009; Gailliot, Peruche, Plant, & Baumeister, 2009; Masicampo & Baumeister, 2008). Using self-control can reduce glucose in the bloodstream, thereby impairing self-control afterwards (for reviews, see Baumeister, Gailliot, DeWall, & Oaten, 2006; Baumeister, Vohs, & Tice, 2007; Gailliot, 2009c; Muraven & Baumeister, 2000). Ingesting glucose after self-control likewise replenishes self-control.

The current work tested for functional biases in attention following the use of self-control. Several studies demonstrate functional attentional biases (Hansen & Hansen, 1988; Ohman & Mineka, 2001; Pollak & Sinha, 2002), such as increased perceptions of sexual arousal in attractive women among sexually aroused men and increased perceptions of anger in outgroup faces among people with self-protective goals (Maner et al., 2005). The idea is that increased perceptions of sexual arousal are functional in that they should lead to sex, and increased perceptions of anger should enhance self-protection. Biases have also been found in attentional dwell time, with attention being “stuck on” stimuli functional to goal attainment (DeWall & Maner, 2008; DeWall, Maner, & Rouby, 2009; Maner, Gailliot, & DeWall, 2007, 2008; Maner, Gailliot, & Miller, 2009; Maner, Rouby, & Gonzaga, 2008), such as activated mating motives increasing attentional adhesion to attractive members of the opposite sex and activated mate-guarding motives increasing attentional adhesion to threatening rivals (Maner, Gailliot, Rouby, & Miller, 2007).

One hypothesis of the current work was that completing a self-control task would subsequently increase attentional adhesion to food. There are at least two reasons why this might occur.

One reason is based on the idea that attentional biases can be functional. Self-control is an important, evolved capacity that likely contributed to survival and reproduction by improving accommodation, cooperation, and belongingness (e.g., Baumeister, 2005; Finkel & Campbell, 2001; Finkel et al., 2006). After people have used self-control, glucose is low and can impair self-control, thereby potentially reducing a capacity beneficial to survival and reproduction. If evolution selected on the basis of energy (Lotka, 1922) and on self-control, then after using self-control and having depleted blood-glucose, psychological processes should change in ways functional to attaining usable metabolic energy and restoring self-control. Eating food is functional to both. This suggests the possibility of

attentional biases occurring after the use of self-control that increase the likelihood of eating or that stem from increased motivations to eat, such as increased attentional adhesion to food. Indeed, low glucose can increase attentional adhesion to food or stimuli related to food (Brody, Keller, Degen, Cox, & Schachinger, 2004; Channon & Hayward, 1990), a bias functional to the replacement of glucose. That self-control reduces glucose suggests that self-control increases attentional adhesion to food.

If prior self-control use causes an attentional bias toward food that is functional, then the bias should be associated with benefits to glucose metabolism or self-control. The current work tested the hypothesis that a stronger bias would be predictive of better self-control across a long period of time – that is, dispositionally. High dispositional or trait self-control is linked to a broad assortment of desirable outcomes across the lifespan, including good mental health, social relationships, and school performance, as well as less pathology, substance abuse problems, and criminality (Gottfredson & Hirschi, 1990; Pratt & Cullen, 2000; Shoda, Mischel, & Peake, 1990; Tangney, Baumeister, & Boone, 2004). The idea is that an attentional bias to food following self-control exertion is part of an adaptive psychological response that replenishes both glucose and self-control when self-control is weakened, thereby contributing to desirable outcomes, some of which are evolutionarily advantageous.

A second reason why self-control tasks might subsequently increase attentional adhesion to food is that self-control can be used to avoid attending to food, as part of a psychological response to avoid food, yet self-control would be impaired. Hence, attention would increasingly dwell on food from which the more self-controlled individual would look away. Past studies have shown that using self-control subsequently increases eating among people with dietary tendencies to avoid food and overeating (Hofmann, Rauch, & Gawronski, 2006; Kahan, Polivy, & Herman, 2003; Vohs & Heatherton, 2000). To examine whether self-control might increase attention to food in part because self-control is used to avoid looking at foods, yet is impaired after use, the current study included measures of bulimic symptoms related to overeating. The extent to which the bias occurs among people with tendencies to overeat – those who might rely on self-control to avoid dwelling on food – suggests whether the bias is attributable to impaired self-control or functional energy replenishment.

Self-control is more often used to avoid unhealthy or junk food than healthy food (Baumeister, Heatherton, & Tice, 1994), and the studies showing increases in eating following self-control use have typically measured consumption of junk food. Thus, when self-control is impaired, people seek junk food. To the extent that an attentional bias to food after the use of self-control is attributable to impaired self-control, rather than functional energy replenishment, then the bias should occur for junk food to a greater extent than for healthy food. To test this hypothesis, attentional adhesion was assessed to pictures of both junk and healthy food.

Participants in the current study first completed a task that either did or did not require self-control. They then completed a dot-probe attention task (Derryberry & Reed, 1994; MacLeod, Mathews, & Tata, 1986; Maner, Gailliot, & DeWall, 2007) designed to measure attentional adhesion (i.e., an increased dwelling of attention on particular stimuli). The dot-probe included pictures of junk food, healthy food, and non-food items. One hypothesis was that evidence for a functional bias would be found, such that completing a self-control task would increase attentional adhesion to food primarily among people with high trait self-control. Another contributing factor to increased

attentional adhesion to food could be impaired self-control, caused by the initial self-control task, that weakens the capacity to avoid looking at food among people with tendencies to engage in dietary restraint. Evidence for this effect would be found to the extent that the bias occurs mostly after the self-control task among people with bulimic tendencies to overeat, and to the extent that the bias occurs toward junk rather than healthy food.

Other explanations for increased attentional adhesion to food after self-control might include mood or hunger. Using self-control might worsen mood, thereby increasing attention to food for emotional relief (Tice, Bratslavsky, & Baumeister, 2001), or it might increase hunger (e.g., by depleting glucose), thereby increasing desires for food. Accordingly, the current study included measures of both mood and hunger.

Method

Thirty-three college undergraduates (18 women, 15 men) participated for a course requirement. Participants completed a measure of trait self-control (the Self-Control Scale; Tangney, Baumeister, & Boone, 2004) during a mass testing session at the start of the semester. The measure contained 13 items (e.g., “I have a hard time breaking bad habits” (reverse scored); “I am good at resisting temptation”) answered on a scale from 1 (*not at all like me*) to 5 (*very much like me*). Higher scores on this measure indicate higher self-control.

Participants attended a laboratory session later in the semester. They first watched a 6 minute video of a woman talking (without sound), during which words (e.g., hair, hat, pulse) appeared individually for 10 seconds in the bottom corner of the screen.

Participants randomly assigned to the self-control condition were instructed to focus their attention only on the woman’s face and to refrain from looking at the words. If they happened to look at the words, they were to refocus their attention on the woman as quickly as possible. Attention automatically orients toward novel stimuli appearing in the environment (e.g., Shiffrin & Schneider, 1977), and so the task required these participants to exert self-control by overriding pre-potent orienting of attention to the words and maintain attention instead only on the woman. Participants in the watch normally condition were instructed to watch the video as they would normally, and so they did not use much self-control.

After the video task, participants completed a manipulation check for which they indicated the extent to which they had looked at the words during the video, using a scale from 1 (*not at all*) to 9 (*all or most of the time*). They then completed a measure of mood, the Positive and Negative Affect Schedule (Watson, Clark, & Tellegen, 1988). The PANAS contains 20 items (e.g., *excited, scared*) indicative of current positive and negative mood. Embedded in the PANAS were 4 items indicative of current hunger level (i.e., *famished, ready to eat, have an appetite for food, hungry*). These 24 items were assessed using a scale from 1 (*very slightly or not at all*) to 5 (*extremely*).

Participants next completed the dot probe attention task, as a measure of attentional adhesion. The procedure was the same as in Maner et al. (2006). The reader is referred to Maner et al. for more specific details.

Concisely, participants completed trials in which they first focused their attention on the center of the computer screen. Next, one of 15 pictures of either junk food (e.g., candy, cupcakes), healthy food (e.g., sandwich, spaghetti), or non-food items (e.g., car, lamp) appeared in a quadrant of the screen. Upon its disappearance, either a circle or square appeared in a different quadrant. Participants were to indicate immediately whether a circle or

square appeared by pressing different computer keys. Being slower to classify the circle or square indicated longer attentional dwelling on the prior picture.

After the dot-probe task, participants completed a measure of tendencies to overeat and avoid overeating, namely the bulimia subscale of the Eating Disorders Inventory (Garner, Olmsted, & Polivy, 1983). The subscale consists of 7 items (e.g., *I stuff myself with food; I have gone on eating binges where I have felt that I could not stop*) answered on a scale from 1 (*never*) to 6 (*always*). Higher scores indicate stronger symptomology of bulimia.

Results

Attentional adhesion was computed in accordance with prior work (see Maner et al., 2006). Longer reaction times indicated greater attentional adhesion.

Manipulation check. Analysis suggested that participants successfully followed the instructions to avoid looking at the words during the video or to watch normally. Participants in the self-control condition ($M = 2.20$, $SD = .76$) reported having looked at the words less often than did participants in the watch normally condition ($M = 4.08$, $SD = .1.90$), $t(49) = 4.60$, $p < .001$.

Trait self-control. To test whether completing a self-control task would increase attentional adhesion to food, and whether this would be moderated by trait self-control, a regression analysis was performed by predicting reaction times to food items (both junk and healthy food) from self-control condition, trait self-control score, and all higher order interactions, controlling for reaction times to non-food items. The main effect of self-control condition was significant, $\beta = .29$, $t = 2.07$, $p < .05$, such that participants who had used self-control responded slower (their attention dwelled) on food trials. This finding is consistent with the prediction that using self-control leads to a functional attentional bias to food that would increase the likelihood of replenishing glucose and self-control.

The interaction between self-control condition and trait self-control scores was significant, $\beta = .28$, $t = 2.11$, $p < .05$. Among participants scoring high in self-control (i.e., those scoring 1 SD above the mean), those in the self-control condition responded significantly slower on food trials (their attention dwelled) than did those in the watch normally condition, $\beta = .60$, $t = 2.91$, $p < .01$ (see Aiken & West, 1991). Among participants scoring low in trait self-control (i.e., those scoring 1 SD below the mean), there was no difference between the self-control and watch normally conditions in response times on food trials, $\beta = -.02$, $t = -.11$, $p = .91$. This suggests that increased attentional adhesion to food following self-control is functional, in that it predicts the strong presence of a trait associated with many evolutionary and contemporary benefits.

Regression analyses produced similar results when examining response times to pictures of junk and healthy foods individually, suggesting the same interaction between trait self-control and self-control condition for both junk, $\beta = .25$, $t = 1.91$, $p < .07$, and healthy, $\beta = .32$, $t = 2.02$, $p = .05$, foods. This indicates that increases in attentional adhesion to food among people with high trait self-control occurs for food generally, rather than only for junk or healthy food.

Overeating and Bulimic symptoms. To test whether the effect of completing a self-control task on attentional adhesion to food would be moderated by bulimic symptoms to overeat, a regression analysis was performed

by predicting reaction times to food items (both junk and healthy food) from self-control condition, bulimic symptomology score, and all higher order interactions, controlling for reaction times to non-food items. The interaction between self-control condition and bulimic scores was significant, $\beta = .29$, $t = 3.43$, $p = .001$. Among participants scoring high in bulimic symptoms (i.e., those scoring 1 *SD* above the mean), those in the self-control condition responded significantly slower on food trials (their attention dwelled) than did those in the watch normally condition, $\beta = .36$, $t = 3.05$, $p < .005$. Among participants scoring low in bulimic symptoms (i.e., those scoring 1 *SD* below the mean), those in the self-control condition responded marginally faster on food trials (their attention dwelled less) than did those in the watch normally condition, $\beta = -.22$, $t = -1.79$, $p = .08$. These results are consistent with the hypothesis that using self-control increases attention to food because it impairs the self-controlled avoidance of food. People with tendencies to overeat, and hence who would be expected to use self-control to avoid overeating, increasingly dwelled on food items after they had used self-control. People without tendencies to overeat showed the opposite pattern, such that they dwelled less on food after having used self-control. People tend to have different domains of self-control (e.g., overeating, sexual restraint, aggressive restraint) in which they struggle. Perhaps people without tendencies to overeat struggle in domains unrelated to eating, and so their attention was less captured by food items.

Separate regression analyses on reaction times to junk and healthy foods further suggested that attentional adhesion to food increases after self-control use because of impaired self-control reducing the avoidance of food. Specifically, completing a self-control task slowed reaction times to junk food among participants scoring high in bulimic symptoms, $\beta = .41$, $t = 3.53$, $p = .001$, and marginally sped up reaction times to junk food among participants scoring low in bulimic symptoms, $\beta = -.20$, $t = -1.70$, $p = .10$, compared to watching the video normally. These effects were not significant when examining reaction times to healthy food, $ps < .16$. That moderation by bulimic symptoms to overeat occurred primarily for attention to junk rather than healthy foods further indicates that increased attentional adhesion after self-control is due partly to impaired self-control. When self-control is impaired, people increasingly seek junk food.

Self-control and Bulimia. The results thus far indicate that using self-control increases attentional adhesion to food because of functional biases toward energy replacement and because of impaired self-control. To examine whether one may have been more operative than the other, separate regression analyses were conducted to predict reaction times to food items (both junk and healthy food), junk food, and healthy food from self-control condition, trait self-control score, bulimic symptomology score, and all higher order interactions, controlling for reaction times to non-food items. Neither trait self-control nor bulimic symptomology score interacted with self-control condition in predicting reaction times for any of the categories, all $ps > .30$. This further indicates that the two processes (energy replenishment and impaired self-control) both contribute to increased attentional adhesion after self-control, and that neither explanation can account for the other.

Mood and hunger. Regression analyses suggested that the current pattern of results was not attributable to mood (positive or negative mood, as assessed by the PANAS) or hunger (as assessed by the 4 items included on the PANAS, $\alpha = .89$). Specifically, the key findings (i.e., increased attentional adhesion among participants with high trait self-control following self-control use and changes in attentional adhesion to junk food being moderated by bulimic symptoms) remained significant, $p < .05$, or marginal, $p < .09$, when controlling for either mood or hunger.

Discussion

The current study provides evidence that attention increasingly dwells on food after people have used self-control. Completing a task that did, rather than did not, require self-control slowed reaction times when having to orient away from food images.

The idea is that the food images captured attention, thereby slowing the reorienting of attention to the different stimuli to which participants responded.

This effect had two important caveats, to it, however, which also suggests its larger theoretical underpinnings. Specifically, completing a self-control task increased attentional adhesion to food primarily among people with good trait self-control. Good trait self-control is associated with many benefits that would have promoted survival and reproduction. The bias therefore could be functional in that its associated with good self-control. When self-control is impaired by prior use, people with good self-control functionally attend to food, which could promote proper eating that would replenish self-control. The second caveat is that the self-control task increased attentional adhesion to primarily junk food among people with bulimic symptoms of overeating. This suggests that the attentional bias might arise because people use self-control to avoid looking at food, yet this capacity is worsened by prior self-control.

Evolution may have selected on capacities to attain energy and use it efficiently (Gilliland, 1978; Lotka, 1922; Odum, 1995). Work on self-control supports this theory, in that using self-control reduces glucose in the bloodstream and causes increases in attaining energy (i.e., eating, Hofmann et al., 2006; Kahan et al., 2003; Vohs & Heatherton, 2000) and conserving the self's energy (Muraven, Shmueli, & Burkley, 2006; Muraven & Slessareva, 2003). The current study adds to this by showing biases in early attentional processes toward attaining energy during a depleted state. Perhaps attentional biases might emerge for other processes that replenish self-control, such as self-affirmation (Schmeichel & Vohs, 2009) and positive affect (Tice, Baumeister, Shmueli, & Muraven, 2007), or toward stimuli that would more effectively conserve energy (e.g., toward a tool that could be used to save energy on a later task).

One strength of the current work is that it provides evidence linking an attentional bias to functional outcomes – benefits in self-control. Past work has theorized about the functionality of attentional biases, such as perceiving increased anger in outgroup members improving self-protection (Maner et al., 2005), yet mostly has failed to provide evidence of functionality. Closest to showing functional benefits of attentional biases is work that has found attentional biases to physically attractive potential mates primarily among individuals who are sexually unrestricted (Maner, Gailliot, & DeWall, 2007; Maner, Gailliot, Rouby, & Miller, 2007), individuals who also tend to have more sex partners. This suggests that an attentional bias to potential mates does indeed increase sexual or romantic success.

The amount of metabolic energy that can be used during a given amount of time is limited (Kleiber, 1961). Thus, energy used by one process can be diverted away from and thereby impair others (Aiello, 1997; Aiello, Bates, & Joffe, 2001; Aiello & Wheeler, 1995; Gailliot et al., 2009). An attentional bias to food following self-control use

therefore might not only facilitate replenishing glucose and self-control but might benefit other processes from which energy could be diverted, such as immune functioning and reproductive processes. The attentional bias helps ensure adequate energy for all processes.

The current results suggest that attentional biases toward food arise situationally –that is, after having used self-control. Similar biases may be found dispositionally, such as among people who experience chronic stress. Chronic stress entails high energy use by the brain (for a review, see Gailliot & Baumeister, 2007), and so people experiencing chronic stress might often feel they need more energy and preferentially attend to food.

Using self-control by controlling attention caused increases in attention to food (among some individuals), which seemingly was driven partly by impairments in the self-controlled attentional avoidance of food. This suggests that controlling attention might cause subsequent impairments to other forms of attention control. Some work suggests that self-control tasks impair subsequent self-control only when the tasks are from different domains (Dewitte, Bruyneel, & Geyskens, 2006, e.g., eating restraint and sexual restraint), whereas the current work indicates this might not be true for all self-control domains (i.e., for attention control).

One limitation of the dot probe task is that the extent to which increases in reaction times are attributable to increased attentional adhesion to the target stimuli cannot be determined. They might be attributable to changes in motor behavior (e.g., a slowing of finger movements required to press a computer key) or mental processing (e.g., due to mental slowing). It is unclear why the current pattern of results would have emerged if the bias is attributable to changes in motor behavior and why reaction times to non-food items would not have changed had the bias been explainable by changes in mental processing.

One reason why people with bulimic tendencies increasingly dwell on food after using self-control is that self-control is impaired yet is used to avoid looking at food for dietary reasons. Another explanation is that food is threatening to people with bulimic tendencies, and self-control is used to avoid attending to threat (Gailliot, Schmeichel, & Baumeister, 2006). Evidence indicates that threatening stimuli tend to capture attention (Hansen & Hansen, 1988; Maner et al., 2007; Ohman & Mineka, 2001; Pollak & Sinha, 2002), and that bulimic symptoms among women predict increased attentional adhesion to physically attractive women – those who pose a threat to women concerned about diet and appearance (Maner et al., 2006). Food might be another threat that tends to capture the attention of people with bulimic symptoms, and so self-control is used to avoid attending to food.

Evolution can be viewed as having selected on the basis of effective energy use and management (Lotka, 1922). Self-control is a metabolically expensive process, and it appears to be heavily intertwined with energy dynamics. Using self-control depletes metabolic energy, activates conservation mechanisms, and causes an attentional bias to that which provides energy – food. When energy is low, people show effective energy management and a bias that should lead to more effective energy use (e.g., better self-control).

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