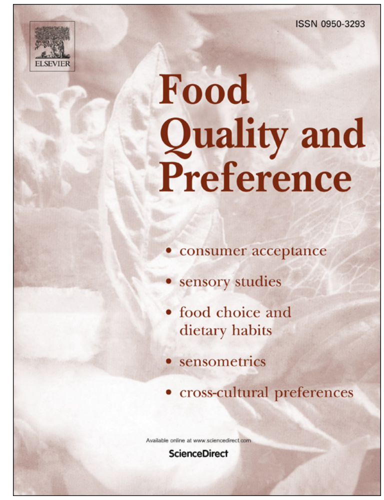

Is cake more appealing in the afternoon? Time of day is associated with control over automatic positive responses to unhealthy food

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PII: S0950-3293(16)30134-3
DOI: http://dx.doi.org/10.1016/j.foodqual.2016.07.004
Reference: FQAP 3174

To appear in: *Food Quality and Preference*

Received Date: 20 April 2016
Revised Date: 4 July 2016
Accepted Date: 4 July 2016

Please cite this article as: Haynes, A., Kemps, E., Moffitt, R., Is cake more appealing in the afternoon? Time of day is associated with control over automatic positive responses to unhealthy food, *Food Quality and Preference* (2016), doi: http://dx.doi.org/10.1016/j.foodqual.2016.07.004

Is cake more appealing in the afternoon? Time of day is associated with control over automatic positive responses to unhealthy food

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Abstract

Despite researchers considering time of day an important variable in studies on implicit food evaluations and food intake, time of day effects on implicit food evaluations have yet to be tested. Positive implicit evaluations of unhealthy food stimuli measured with an implicit association test (IAT) predict behaviour toward those stimuli, and are assumed to reflect automatic reactions outside of conscious awareness and control. However, recent research has revealed controlled processing to have an influence on IAT performance. The current study tested time of day effects on implicit evaluations of unhealthy food measured with an IAT, and specifically on automatic and controlled processes underlying IAT performance. A sample of 304 undergraduate women aged 17-25 years completed a single-category IAT at varying times of the day. Results revealed that participation later in the day was associated with a more positive implicit evaluation of unhealthy food. This was mediated by a decrease in the ability to inhibit positive food reactions (i.e., controlled processing), rather than an increase in automatic positive reactions. The findings draw attention to the importance of considering time of day in studies measuring aspects of implicit cognition using tasks such as the IAT.

Keywords: implicit food evaluations; implicit association test; process dissociation procedure; self-control; time of day; unhealthy snack food.

Word count: 5,622

Evaluations can exert powerful influences on behaviour. In particular, positive implicit evaluations of unhealthy appetitive stimuli such as alcohol, cigarettes, and unhealthy food, have been shown to predict higher desire, craving, consumption, and even longer term health consequences such as weight gain, substance dependence, and alcohol use problems (e.g., Haynes, Kemps, Moffitt, & Mohr, 2014; Houben & Wiers, 2007; Houben & Wiers, 2008; McCarthy & Thompsen, 2006; Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010; Waters et al., 2007). Some researchers consider time of day a potentially influential variable in studies on implicit food evaluations and food intake, therefore restricting the time of day at which experiments are conducted (e.g., Hofmann, Friese, & Roefs, 2009; Houben, 2011; Kemps, Tiggemann, Martin, & Elliot, 2013). However, the influence of time of day on implicit food evaluations has not yet been tested. Tasks measuring implicit evaluations are often championed as having advantages over self-report assessments of explicit preferences, because they are assumed to assess automatic reactions to stimuli indirectly, outside of awareness, and are thus not amenable to intentional control (Bargh, Chen, & Burrows, 1996; Dasgupta, McGhee, Greenwald, & Banaji, 2000; Fazio & Olson, 2003). However, controlled processes have also been shown to contribute to performance on implicit tasks. As time of day presents a potential extraneous variable in studies utilising implicit measures of food evaluations, the current paper aimed to explore relationships between time of day and implicit evaluations of unhealthy food measured using an implicit association test (IAT), and with the underlying automatic and controlled aspects of IAT performance.

There are two theories supporting the predicted time of day variations in implicit evaluations of unhealthy food. First, potential variations in implicit food evaluations by time of day could be attributable to social norms or eating appropriateness standards. Time of day has been demonstrated to correlate with food preference and perceived acceptability (Birch, Billman, & Richards, 1984). In particular, consuming unhealthy snack food may be perceived as more appropriate in the afternoon than in the morning, as self-report data suggest that snacking is most common in the afternoon and least common in the morning (Cross, Babicz, & Cushman, 1994). Affective reactions to food may be associatively conditioned to the context in which it is eaten – in this way, a particular type of food may be more readily associated with positive affect at the time of day that it is normally eaten, or when consumption is most acceptable (Birch et al., 1984). However, in a study of food selection and consumption, Kramer, Rock, and Engell (1992) found that neither hedonic ratings nor intake of foods were associated with whether the food was presented at a time of day rated as 'appropriate' for consumption of that food. Nevertheless, the acceptability or normality of snack food consumption later in the day could offer a plausible explanation for why we might expect implicit evaluations of unhealthy snack food to become more positive as the day progresses.

Second, the ability or motivation to exert control over automatic responses to stimuli may diminish as the day progresses, which could affect estimates of implicit food evaluations garnered from an IAT. After one act of self-control, subsequent attempts at inhibition become less successful, an effect termed 'ego depletion' (although recent evidence has called into question the replicability and size of this depletion effect; Baumeister, Bratslavsky, Muraven, & Tice, 1998; Carter & McCullough, 2014; Hagger et al., 2015). Some researchers have drawn attention to time of day as a potential proxy for ego depletion due to the after-effects of exerting self-control in response to daily demands (Boland, Connell, & Vallen, 2013; Hofmann, Vohs, & Baumeister, 2012; Kouchaki & Smith, 2013). For example, later in the day individuals are more likely to act immorally, fail at overcoming unhealthy desires, and are more susceptible to unconscious goal priming effects on food intake; effects which have been linked to ego depletion (Boland et al., 2013; Hofmann et al., 2012; Kouchaki & Smith, 2013). Given the contribution of controlled processing to implicit task performance (Payne,

2001) and the requirement of sufficient self-control to enact this type of processing (Deutsch & Strack, 2006), time of day could affect estimates of implicit food evaluations because of diminished control over immediate positive reactions to unhealthy food. Govorun and Payne (2006) found that ego depletion increased implicit racial stereotyping measured using a weapon-identification task for individuals with an automatic racial bias. Further, they demonstrated that ego depletion reduced controlled aspects of task performance (i.e., reduced individuals' ability to control their expression of racial stereotypes in the task), but had no influence on automatic aspects of task performance (i.e., no effect on individuals' automatic racial bias). Likewise, we would expect that unhealthy food IATs completed later in the day would reveal a more positive implicit evaluation of unhealthy food, which would be attributable to a diminished ability to control, rather than a change in, automatic reactions to unhealthy food. Further, later in the day, automatic positive reactions to unhealthy food are likely to be more predictive of IAT scores than earlier in the day, due to this diminished control over automatic reactions to food stimuli.

The current paper sought to explore time of day effects on implicit food evaluations measured with an IAT, and in particular, on estimates of automatic versus controlled components of performance therein. We conducted secondary analyses on IAT data from two studies from our laboratory (Haynes, Kemps, & Moffitt, 2015a, 2015c). These two studies were selected because both samples were administered the same version of the IAT at the beginning of the experimental session, prior to any experimental manipulations. Both studies tested individuals in the morning or afternoon, and only included women aged between 18 and 25 years who were motivated to manage their weight through healthy eating, as individuals with the motivation to manage weight through healthy eating are likely to attempt to control positive responses to unhealthy food. Only women were recruited for the studies, as they have higher levels of food liking and craving than men (Cepeda-Benito, Fernandez, &

Moreno, 2003; Zellner, Garriga-Trillo, Rohm, Centeno, & Parker, 1999). We analysed the types of errors individuals made on the IAT using the Process Dissociation Procedure (Payne, 2001; Payne & Bishara, 2009), which provides estimates of the strength of the automatic positive reaction to unhealthy food (automatic estimate), and control over those positive responses (controlled estimate).

We predicted that time of day would be positively correlated with implicit food evaluations, such that participants completing the IAT later in the day would have a stronger positive implicit evaluation of food than individuals completing the IAT earlier in the day. While the eating appropriateness and ego depletion accounts both support the prediction that individuals would evaluate unhealthy food more positively later in the day, the appropriateness account does not provide specific predictions about whether this relationship is attributable to a change in the automatic positive reactions to food, or to one’s control over those positive reactions. Therefore, in line with the ego depletion account, we also expected that the relationship between a later time of day and a more positive IAT score would be mediated by a diminished control over automatic positive reactions associated with participating later in the day. Likewise, we expected to observe an interaction between time of day and automatic positive reactions to food in predicting implicit food evaluations. Namely, we expected that the automatic estimate would be more predictive of the IAT score later in the day than earlier in the day. This prediction is again in line with the ego depletion account, as we would expect that control over automatic reactions to stimuli diminishes, allowing those automatic reactions to have a greater effect on IAT performance.

Method

Participants

The sample included 304 women (*M* age = 19.51, *SD* = 1.95) recruited from the undergraduate student population at Flinders University. Advertisement materials asked for volunteers who met the following criteria: (a) motivated to manage weight through healthy eating, (b) no food allergies or dietary intolerances, (c) aged between 17 and 25 years, and (d) fluent in English. The majority of participants were first-year psychology student volunteers who participated for course credit (n = 217), while the remainder of the sample (n = 87) was recruited from the wider undergraduate student population, and received a $10 honorarium for participating. Ethics approval was provided by the university's Social and Behavioural Research Ethics Committee.

Measures

Time of day. Sessions were scheduled to begin on the hour between 9am and 5pm. Time of day was coded as a continuous variable expressed as minutes from 12pm, derived from the timestamp data on the IAT task indicating when each participant started the task. This produced a variable with negative values for individuals participating in the morning, and positive values for those participating in the afternoon.

Hunger. Participants reported their current hunger on a 7-point Likert scale ranging from 1 (*not hungry at all*), to 7 (*extremely hungry*).

Implicit food evaluations. A recoding-free variant of a single category implicit association test (SC-IAT-RF) (Karpinski & Steinman, 2006; Rothermund, Teige-Mocigemba, Gast, & Wentura, 2009) programmed and run using Presentation (Neurobehavioural Systems) was used to assess implicit evaluations of unhealthy snack foods. In contrast to the traditional IAT where the response keys assigned to the target category change between blocks, in the recoding free variant, the response key assignment changes between trials. This makes the IAT-RF a more valid assessment of implicit associations with the target concepts as it prevents participants from recoding the categorisation task into a two-category task by grouping the target category with one of the evaluative categories based on salience or familiarity. Instead, the task makes it more likely that participants will respond to the target stimulus based on its semantic category membership (Houben, Rothermund, & Wiers, 2009; Rothermund et al., 2009).

Participants sorted word stimuli belonging to three categories: two evaluative categories (positive and negative, labelled “I like”, and “I dislike”, respectively), and the target category (“food”). The positive evaluative stimuli were: holiday, pleasure, rainbow, gift, peace, and friend; and the negative evaluative stimuli were: accident, sickness, abuse, dead, fear, and pain. Stimuli between the evaluative categories were matched on syllables, frequency and arousal (Bradley & Lang, 1999) and were selected from previous research using the IAT (e.g., Karpinski & Steinman, 2006; Olson & Fazio, 2004; Roefs, Herman, MacLeod, Smulders, & Jansen, 2005). The food stimuli were: chocolate, cake, ice-cream, chips, pizza, and hamburger, similar to those used in previous research (e.g., Richetin, Perugini, Prestwich, & O'Gorman, 2007; Roefs et al., 2005; Roefs & Jansen, 2002; Roefs et al., 2006).

Throughout the task, the evaluative categories appeared fixed at the top left and right hand corners of the computer screen, and the food category label switched between the top left and right hand corners randomly, such that on 50% of food trials it appeared on the same side as the positive label, and on the remaining 50% of food trials it appeared on the same side as the negative label. Word stimuli were presented in lower case letters individually in the centre of the screen and participants were asked to respond by pressing a key designated to the position of the word’s category at the top of the screen (left or right). When the target concept ‘food’ is more strongly associated with the attribute with which it is paired during the task, the task is easier and the pairings are made more quickly.

The IAT consisted of three blocks. The first was a practice block with 24 trials, requiring participants to respond to positive and negative word stimuli. Each positive and negative stimulus was presented twice. In the second practice block (36 trials) participants were asked to respond to stimuli from positive, negative, and food categories. The response key assigned to evaluative categories (left or right) was counterbalanced between participants, and remained constant throughout the task; however, the response key assignment of the target category (food) switched randomly between trials, such that it shared a response key with the positive category on half of the trials, and with the negative category on the remaining trials. Each positive, negative, and food stimulus was presented twice. The third block was the test block, and was identical to the second block. Each stimulus was presented eight times, increasing the number of trials to 144. Three buffer trials (presenting a positive, negative, and a food stimulus: “sunlight”, “evil”, and “hotdog”, respectively) were presented at the beginning of the test block, and again after a short break halfway through the test block. These trials were intended to allow participants to re-focus attention on the task after reading the instructions.

Preceding each block was a standardised set of instructions on the computer screen, including a list of words belonging to each category and denoting the key responses assigned to the evaluative categories. Participants were instructed to respond to each stimulus word as quickly and accurately as possible. On each trial, the category labels were displayed at the top of the screen on the side of the appropriate response key 1500ms before stimulus presentation. The target stimulus remained on the screen until participants made a response using the keyboard (i.e., left ‘z’, or right ‘/’). The inter-trial interval was 400ms. Accuracy and response times were recorded. The presentation order of stimulus words was randomised within each block.

Motivation. Participants’ motivation toward regulating food intake for weight management was assessed using a 4-item self-report scale (e.g., “I choose certain food items to avoid gaining weight”, Sproesser, Strohbach, Schupp, & Renner, 2011). Participants indicated how often each item applied to them on 5-point Likert scales ranging from 1 (*never*), to 5 (*always*). Mean responses were calculated, with higher scores indicating higher motivation. Internal-consistency of the scale was high in the current study, Cronbach's α = .87, and was consistent with previous research, Cronbach's α = .89 (Sproesser et al., 2011).

Procedure

Participants signed up for a testing session listed on the online Experimental Management System for research in the School of Psychology at Flinders University after reading the study information and eligibility criteria. Participants completed the study individually in the Applied Cognitive Psychology Laboratory, and were asked to eat something two hours before their scheduled session, and then to refrain from eating or drinking anything except for water. They first completed the hunger scale and reported how much time had elapsed since their last meal, followed by the IAT, and were finally asked to disclose background information including age, height, and weight, and to complete the motivation scale at the end of the testing session.

Statistical analyses

Calculating IAT scores. The D600 algorithm modified for single-category IATs (Greenwald, Nosek, & Banaji, 2003; Karpinski & Steinman, 2006) was used to calculate IAT scores from block 3 of the IAT. Participants with an error rate greater than 20% were excluded from analysis (n = 29)[2]. The average proportion of errors on the IAT in the current sample was 9%, similar to previously reported error rates (Milyavskaya, Inzlicht, Hope, & Koestner, 2015; Stewart, von Hippel, & Radvansky, 2009). An additional two participants had missing IAT data due to technical issues. Trials with response times <350ms or >10,000ms were excluded. Incorrect responses on the remaining trials were replaced with the mean of the response times from that block plus an error penalty of 600ms. Mean response times to food stimuli on trials requiring a response with the same key as the positive stimuli

[2] Including these participants in analyses did not change the pattern of results (i.e., no non-significant results became significant, and vice versa).

were subtracted from the mean response times to food stimuli on trials requiring a response with the same key as the negative stimuli. To adjust for response variability, this difference score was divided by the standard deviation of all correct response times on food trials (Greenwald et al., 2003; Karpinski & Steinman, 2006). Higher IAT scores indicate a more positive implicit evaluation of unhealthy snack food.

Calculating controlled and automatic estimates. The Process Dissociation Procedure (Payne, 2001; Payne & Bishara, 2009) was used to distinguish automatic and controlled components of IAT task performance. Participants' responses to food stimuli during the IAT reflect both the strength of their automatic positive reaction to food and their ability to control their responses according to the demands of the task. On trials where participants are required to respond to food cues with the positive response key, both an automatic positive reaction to food stimuli and control over those automatic reactions lead to the same outcome: a correct response. The probability of correctly responding with the positive key is the probability of control over positive reactions to unhealthy food (C) (correctly responding with the 'positive' key), plus the likelihood of making an automatic association when control fails (A); which can be expressed as $P(correct|positive) = C + A (1-C)$. On trials where participants are required to respond to food stimuli with the 'negative' key, automatic positive reactions to food (A) and control over those reactions (C) have different outcomes; controlled processing leads to a correct response (i.e., food is 'negative'), while an automatic positive reaction leads to an incorrect response (i.e., food is 'positive'). Errors on food negative trials are therefore the result of a failure to control an automatic positive reaction to food, expressed as $P(error|negative) = A (1-C)$. A comparison of the proportion of trials where such errors are made to the proportion of trials where correct food positive categorisations are made can provide an estimate of the automatic and controlled components of IAT task performance. Controlled and automatic components of task performance can be calculated using the formulae: C = P(correct|positive) – P(error|negative), and A = P(error|negative)/(1-C). A higher automatic estimate indicates a stronger automatic positive reaction to unhealthy food, while a higher controlled estimate indicates better performance at controlling those positive reactions to unhealthy food[3].

Results

Preliminary analyses

A histogram showing the distribution of time of day of completing the IAT is shown in Figure 1. Descriptive statistics and zero-order correlations between variables of time of day, IAT score, estimates of the automatic positive reaction to food and of control over positive reactions to food, time since last meal, hunger, BMI, and motivation are shown in Table 1. Participating later in the day was significantly correlated with poorer control over positive reactions (controlled estimate) and with IAT scores, indicating a more positive implicit evaluation of food. IAT scores were positively correlated with the automatic estimate, but negatively with the controlled estimate of performance, indicating that those with a more positive implicit evaluation of food on the IAT tended to have a more positive automatic reaction to food, and were less able to control or inhibit those positive associations. Automatic and controlled estimates of performance were negatively correlated, such that those with a stronger positive automatic reaction to foods were less able to control them. Additionally, a higher BMI was marginally significantly correlated with a more positive implicit evaluation of food on the IAT. Finally, time since last meal significantly and positively correlated with hunger and BMI.

[3] It is also possible to examine the strength of the automatic *negative* reaction to unhealthy food, and control over that reaction. However, we only analyse the strength of the automatic *positive* reaction and associated control to simplify reporting and because control over positive reactions to food is consistent with the motivation of the current sample (i.e., to manage weight through healthy eating).

Mediation analysis: time of day effect on IAT by controlled estimate

To assess whether the time of day effect on IAT scores was accounted for by automatic positive reactions to food, a mediation analysis was conducted using the PROCESS macro for SPSS (Hayes, 2012). The predictor (time of day) and covariate (time since last meal) were regressed on the mediating variable (automatic estimate), and showed that time of day was not significantly associated with an automatic positive reaction to food, B = <0.001, $t(263)$ = 0.29, p = .77. A second regression model was estimated, regressing the predictor, mediator, and covariate on the outcome variable (IAT score). The automatic estimate was a significant predictor of IAT score, B = 0.80, $t(262)$ = 6.48, p < .001, and time of day remained a significant predictor of IAT score with the automatic estimate in the model, B = 0.001, $t(262)$ = 3.05, p = .003. The indirect effect of time of day on IAT score through an automatic positive reaction to food was <0.0001 (SE = 0.0001). The 95% confidence interval of the estimated indirect effect contained zero (-0.0002, 0.0002), indicating that the relationship between a later time of day and a more positive implicit evaluation of food was not mediated by automatic positive reactions to food in the IAT.

A similar analysis was conducted to assess whether the effect of time of day on IAT scores was mediated by reduced control over positive reactions to food. The predictor (time of day) and covariate (time since last meal) were regressed on the mediating variable (controlled estimate), and showed that participation later in the day was associated with poorer control over positive reactions to food, B = -0.0004, $t(276)$ = 2.72, p = .01. A second regression model was estimated, regressing the predictor, mediator, and covariate on the outcome variable (IAT score). Controlled performance estimate was a significant predictor of IAT score, B = -0.75, $t(275)$ = 8.66, p < .001, but time of day was not, B = 0.0004, $t(275)$ = 1.67, p = .10. The indirect effect of time of day on IAT score through controlled performance was 0.0003 (SE = 0.0001). The 95% confidence interval of the estimated indirect effect did not contain zero (0.001, 0.0006), indicating that the relationship between a later time of day and a more positive implicit evaluation of food was mediated by poorer control over food positive responses on the IAT (Figure 2).

Influence of automatic and controlled processes on IAT by time of day

The PROCESS macro was also used to assess whether time of day moderated the relationship between IAT scores and automatic estimates of performance. The outcome variable (IAT score) was regressed on the predictors (time of day, automatic estimate), and the interaction term (product of the predictors), controlling for time since last meal. Automatic positive reaction to food significantly predicted IAT score, B = 0.77, $t(261)$ = 6.26, p = <.001, as did time of day, B = -0.002, $t(261)$ = 2.17, p = .03. The interaction term significantly predicted IAT scores, B = 0.03, $t(261)$ = 3.31, p = .001, suggesting that the relationship between the automatic estimate of performance and IAT score varied according to time of day. Simple slopes were estimated at plus and minus one SD from the mean time of participation to explore the interaction (Figure 3). An automatic positive reaction to unhealthy food was more strongly predictive of participants' IAT scores later in the day, B = 1.22, $t(261)$ = 6.98, p < .001, than earlier in the day, B = 0.44, $t(261)$ = 2.70, p = .01.

A similar analysis was conducted to assess the interaction between time of day and estimate of control over positive reactions to food on IAT scores. Again, the outcome variable (IAT score) was regressed on the predictors (time of day, controlled estimate), and the interaction term (product of the predictors), controlling for time since last meal. The estimate of control over positive reactions to food predicted IAT score, B = -0.70, $t(274)$ = 7.51, p = <.001, but time of day did not, B = 0.001, $t(274)$ = 1.84, p = .07. The interaction term did not significantly predict IAT scores, B = -0.0008, $t(274)$ = 1.23, p = .22, suggesting that the relationship between controlled performance and IAT scores did not vary according to time of day.

Discussion

The current study was the first to examine the relationship between time of day and implicit food evaluations in general, and automatic and controlled components of IAT performance in particular. Participants' scores on the unhealthy food IAT were correlated with estimates of both automatic bias and controlled performance produced by a Process Dissociation Procedure analysis. This suggests that positive implicit attitudes toward unhealthy foods assessed with an IAT are driven not only by an automatic tendency to associate unhealthy food with positive attributes, but also by a failure to inhibit those positive reactions to unhealthy food. This adds to the growing literature on the dual contributions of automatic and controlled processing to IAT performance (Payne & Bishara, 2009). Additionally, we found that time of day correlated with implicit evaluations of unhealthy snack food, such that individuals who participated later in the day tended to implicitly evaluate unhealthy snack food as more positive than those who had participated earlier in the day. Moreover, individuals who participated later in the day showed a diminished ability to control incorrect positive categorisations of unhealthy food cues, rather than an increase in automatic positivity toward those food cues. Indeed, the increase in positive implicit evaluation of snack food associated with participating later in the day was mediated by controlled estimates of IAT performance, suggesting that a failure to control or inhibit positive reactions to unhealthy food stimuli accounted for the effect. Furthermore, IAT scores were more strongly predicted by automatic positive reactions to unhealthy food later in the day compared to earlier in the day, corresponding with a reduction in the ability to control those reactions.

The association between time of day and implicit food evaluations in the current study could be explained by two theoretical accounts: eating appropriateness standards and ego depletion. First, a more positive implicit evaluation of unhealthy foods later in the day could be attributable to learned appropriateness standards for eating snack foods later in the day compared to the morning. Second, the association between participating later in the day and a more positive implicit food evaluation could also be explained by ego depletion as a result of exerting self-control throughout the day. Indeed, the finding that the relationship between time of day and implicit food evaluations was mediated by diminished control over positive reactions to food, and not by stronger automatic positive reactions to food, is consistent with this account. Similarly, in the racial stereotyping domain, Govorun and Payne (2006) found that ego depletion increased implicit racial stereotyping, but did so via reducing participants' control over their automatic bias, rather than through an increase in the strength of automatic bias itself.. The two theoretical accounts are not mutually exclusive, however – it is plausible that both eating appropriateness standards and ego depletion contribute to variations in implicit food evaluations. However, the current study does not allow for definitive conclusions about the mechanism underlying the time of day effects. In future, measurement of proposed factors (i.e., eating appropriateness standards, self-control depletion) will be necessary to uncover the mechanism driving the time of day variations in implicit evaluations of unhealthy snack foods.

It is possible that individual differences in chronotype may be a contributing factor to the time of day effects on implicit food evaluations reported in the current paper. Chronotype refers to an individual's orientation toward preferring activity in the morning or evening (Bailey & Heitkemper, 2001; Guthrie, Ash, & Bendapudi, 1995). The present study did not randomly assign participants to the time of day for participation, and did not constrain the time of the testing session for which participants could sign up. Therefore, participants' chosen session time may have been affected by their chronotype (e.g., students with an eveningness preference may have participated at later timeslots than those with a morningness preference). While some research has shown no difference in consumption of fruits, vegetables, or sweets between adolescents with a morningness versus an eveningness preference (Fleig & Randler, 2009), others have linked eveningness with higher BMI and disinhibited eating (Schubert & Randler, 2008), higher fast food consumption (Fleig & Randler, 2009), and higher consumption of alcohol, caffeinated beverages, and tobacco (Randler, 2008; Wittmann, Dinich, Merrow, & Roenneberg, 2006). Therefore, individuals who chose to participate later in the day may lead more unhealthy lifestyles, thereby driving a more positive implicit evaluation of unhealthy food, and lower controlled estimates of performance. However, time of day of participation was not correlated with BMI or motivation to manage weight through healthy eating in the current study. Nevertheless, additional research would be useful to rule out the possibility that chronotype differences contribute to the time of day effects on unhealthy food IAT performance.

Regardless of the mechanism underlying the current findings, they do indicate that time of day is an important variable to consider when conducting implicit cognition-related experiments, particularly in the food domain. Specifically, the correlation between time of day and implicit food evaluations, and in particular, the controlled aspects of IAT performance, suggest that time of day may be a potent contributing variable in this research area. To enhance the validity of the conclusions drawn from studies using implicit tasks like the IAT, researchers could randomly assign participants to sessions in the morning and afternoon, or more practically, restrict the variability in the time of day that experiments are conducted (e.g., by conducting sessions only in the morning or afternoon). Alternatively, controlling for the effect of time of day in statistical analyses could be beneficial.

The current findings also inform our theoretical understanding of how implicit food evaluations measured with an IAT fit within dual process models of behaviour. Dual process models conceptualise behaviour as influenced by an interaction between impulsive and reflective determinants (Deutsch & Strack, 2006; Strack & Deutsch, 2004). Impulsive determinants are those which operate relatively automatically, without intention, and drive behaviour when control resources are low (e.g., implicit evaluations of unhealthy snack food). The reflective system however, guides more deliberate, planned behaviour in line with long-term goals and personal standards, but requires sufficient self-control in order to be enacted (Deutsch & Strack, 2006; Strack & Deutsch, 2004). The current results further inform the application of dual process models in demonstrating that IAT scores were associated with both automatic and controlled processes. While previous research has considered implicit evaluations of stimuli measured with implicit tasks such as the IAT to constitute impulsive determinants of behaviour (Friese, Hofmann, & Wiers, 2011), the current findings add to a growing body of research supporting the role of controlled processing in IAT performance (Payne & Bishara, 2009). In particular, they caution against concluding that the IAT measures purely automatic or impulsive factors. Instead, IAT performance also reflects conscious control. Future research using the IAT to draw conclusions based on a dual process framework of behaviour should therefore consider using the Process Dissociation Procedure to separate automatic and controlled components of IAT performance.

Although the present study did not assess eating behaviour, its findings do have implications for reducing unhealthy snacking, given that previous research has demonstrated the influence of implicit evaluations on cravings, desire, and consumption of appetitive stimuli (e.g., Haynes et al., 2014; Waters et al., 2007). Results demonstrated that individuals' control over positive reactions to unhealthy food is weakened later in the day, leaving their automatic biases to exert a greater influence on task performance. Strategies that help individuals to navigate this loss of control over positive reactions to unhealthy foods are therefore likely to be most usefully implemented later in the day. Brief periods of rest and relaxation have been shown to replenish self-control, and could be encouraged later in the day as a means of temporarily facilitating control over automatic positive reactions to unhealthy food and possibly reduce their influence on consumptive behaviour (Tyler & Burns, 2008). Alternatively, changing those positive reactions themselves could offer a means of facilitating goal-consistent behaviour (e.g., reduction of unhealthy snack intake). Previous research has demonstrated that brief evaluative conditioning interventions, which work by repeatedly pairing food stimuli with either positively- or negatively-valenced stimuli, are effective at modifying implicit food evaluations measured with an IAT (e.g., Haynes et al., 2015a; Hollands, Prestwich, & Marteau, 2011). Whether such interventions operate by increasing control over, or reducing the strength of, automatic positive reactions to unhealthy food is not known. However, interventions that target implicit evaluations may be of most benefit to reducing snack consumption when self-control is low (Haynes et al., 2015a; Haynes, Kemps, & Moffitt, 2015b), or when unhealthy snack foods are perceived as appropriate for consumption such as later in the day.

In addition, the sample only included women of a limited age range who were motivated to manage their weight through healthy eating. It therefore remains to be determined whether the cognitive responses to unhealthy food stimuli of individuals drawn from the general population or from other specific populations would be equally as susceptible to time of day effects. Furthermore, the studies included in the present analysis used single-category IATs, which record responses to unhealthy food stimuli without presenting a comparison category. To determine whether time of day affects control over responses specifically to unhealthy food stimuli, future research could include a comparison category of either healthy food or neutral, non-food items.

In conclusion, the present study found that implicit evaluations of food assessed with an IAT became more positive later in the day. This relationship was not attributable to an increased automatic tendency to associate food with positive stimuli, but rather to a reduction in participants' ability to inhibit this association. The results suggest that experiments that use the IAT should consider time of day as an important variable. The findings presented here also guard against interpreting IAT scores as reflecting a purely automatic process of evaluation. In addition, interventions retraining automatic biases or replenishing self-control may be most usefully implemented later in the day, when control over automatic reactions toward unhealthy stimuli is reduced.

Acknowledgements

We are grateful to Paul Douglas for developing the software for the implicit association test.

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Table 1.

Descriptive statistics and correlations between variables

		Min - max	*m* (*sd*)	1	2	3	4	5	6	7	8
1	Time of day (minutes from 12pm)	-188 - 271	26.07 (133.10)		.16**	.02	-.16**	-.10	.09	.02	.01
2	IAT score	-1.67 – 1.97	0.35 (0.56)			.37***	-.48***	-.11†	-.08	-.10	-.04
3	Automatic estimate	.00 – 1.00	0.81 (0.26)				-.13*	-.04	.00	-.07	-.05
4	Controlled estimate	-.08 – 1.00	0.65 (0.35)					.01	.09	.01	-.04
5	Time since last meal (minutes)	5 - 960	158.23 (137.40)						.13*	.18**	-.01
6	Hunger	1 - 7	3.23 (1.50)							.11	-.05
7	BMI (kg/m^2)	15.43 – 40.59	22.49 (3.81)								.12*
8	Motivation	1 - 5	3.20 (0.93)								

† p = .07, *p < .05, ** p < .01, ***p < .001

Figure Captions

Figure 1. Histogram showing distribution of time of day, expressed as minutes from 12pm.

Figure 2. Mediation model pathways: effect of time of day on IAT score via controlled estimate.

Figure 3. Interaction between time of day and automatic estimates in predicting IAT score.

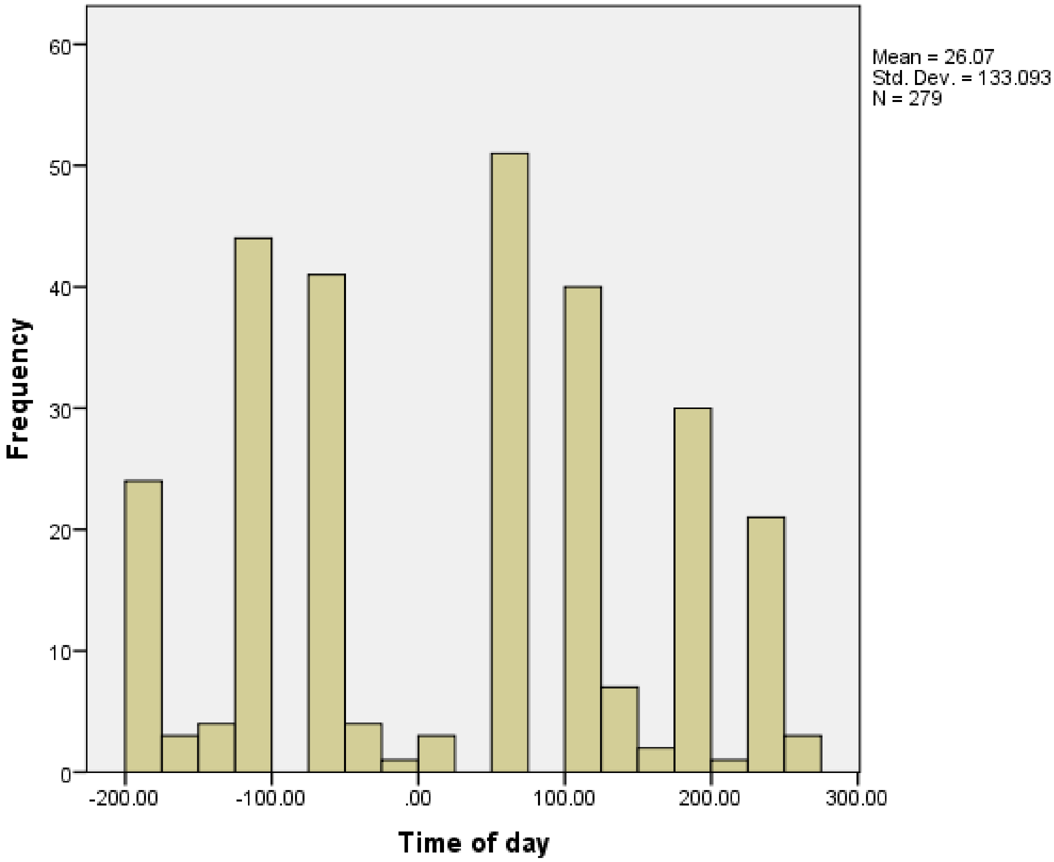
Mean = 26.07
Std. Dev. = 133.093
N = 279
Frequency
60
50
40
30
20
10
0
-200.00
-100.00
.00
100.00
200.00
300.00
Time of day

Figure 1.

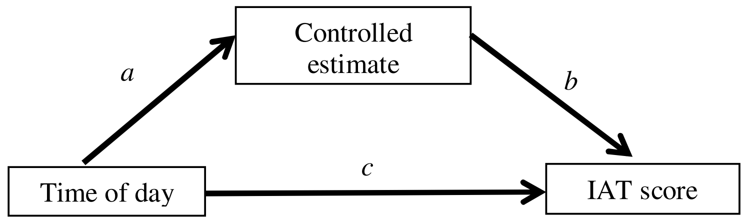

Figure 2.

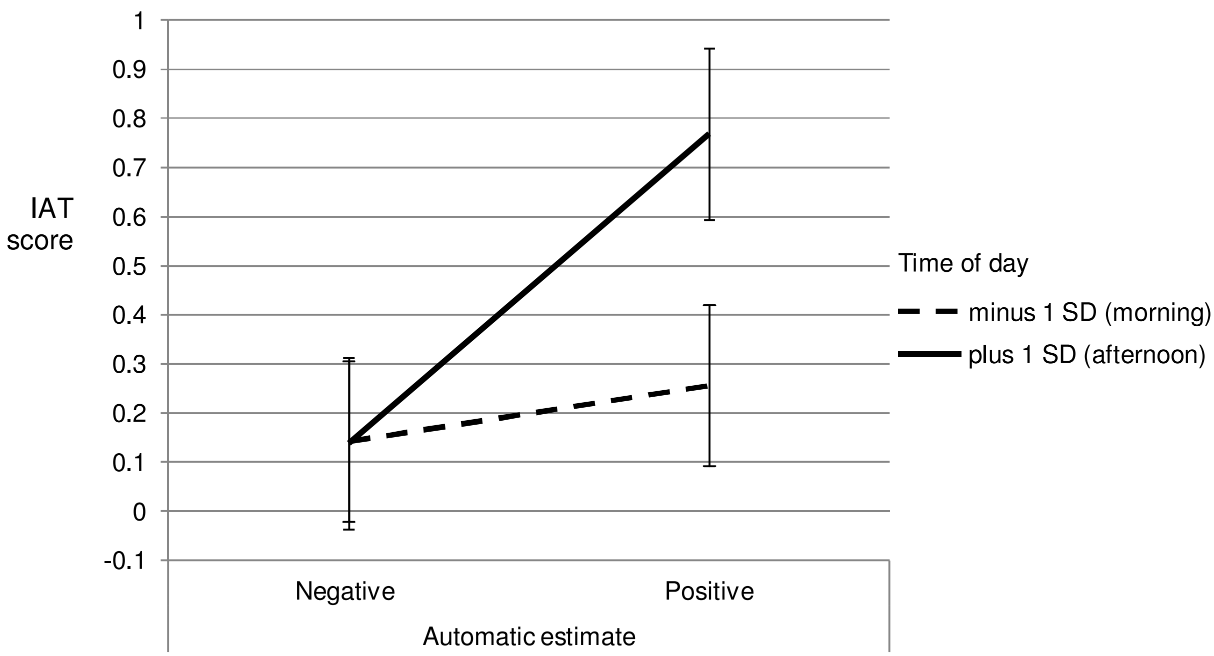
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
IAT score
Negative
Positive
Automatic estimate
Time of day
minus 1 SD (morning)
plus 1 SD (afternoon)

Figure 3.

Highlights

- Implicit evaluations measured with IAT assumed to reflect automatic reactions
- Recent evidence suggests IAT performance influenced by controlled processing
- We tested relationship between time of day and unhealthy food IAT performance
- Findings suggest a more positive implicit evaluation of unhealthy food later in day
- Decrease in control over positive responses to food drives time of day effect