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Tracking food intake as bites: Effects on cognitive resources, eating enjoyment, and self-control

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ABSTRACT

While monitoring food intake is critical for controlling eating, traditional tools designed for this purpose can be impractical when one desires real-time feedback. Further, the act of monitoring can deplete valuable cognitive resources. In response to these concerns, technologies have been developed to aid those wanting to control their food intake. Of note, devices can now track eating in number of bites taken as opposed to more traditional units such as pieces or volume. Through two studies, the current research investigates the effects of tracking food portions at the bite level on cognitive resources, enjoyment of the eating experience, and objective and subjective self-control. Results indicate that using wearable technology to track bite portions, as compared to doing so mentally, (1) reduces cognitive resource depletion, (2) is equally as effective for allowing users to successfully achieve eating goals, and (3) does not reduce enjoyment of the eating experience. These results support the viability of tracking food intake at the bite level, which holds a number of potential implications for eating and weight management.

1. Introduction

Obesity has more than doubled worldwide since 1980 (World Health Organization, 2015). In the United States, approximately 35% of men and 40% of women are currently classified as obese (Flegal, Kruszon-Moran, Carroll, Fryar, & Ogden, 2016). Weight-related health and vanity concerns have led to a $60 billion market for weight-loss products in the United States alone (Marketdata Enterprises Inc. 2015). While numerous approaches for weight loss exist, clinical and behavioral research emphasizes the critical role of self-monitoring (Burke, Wang, & Sevick, 2011). Specifically, weight loss is associated with monitoring body weight, energy expenditure, and energy intake (e.g., Bravata et al., 2007; Buzzard et al., 1996). Body weight and energy expenditure are relatively easily assessed. However, the continuous, accurate, and externally valid long-term measurement of energy intake remains a challenge for free-living individuals (Allan, Johnston, & Campbell, 2010; Goris, Westerterp-Plantenga, & Westerterp, 2000).

Traditional tools designed to track energy intake, such as food diaries and food scales, can be cumbersome and impractical for real-time monitoring in normal daily living (Burke et al., 2008), and self-report measures using survey-type scales are subject to both validity and reliability limitations (Barclay, Rushton, & Forwell, 2015; Cade, Thompson, Burley, & Warm, 2002). Because the operationalization of constructs and the methods of measurement vary considerably across studies, inconsistencies in reported rates of excessive food consumption are not surprising. However, a number of technologies, including smartphone applications (Allen, Stephens, Dennison Himmelfarb, Stewart, & Hauck, 2013; Wharton, Johnston, Cunningham, & Sterner, 2014), wearable cameras (Doherty et al., 2013), and complex-but-portable systems (Norman et al., 2007; Sun et al., 2010), have recently been developed or adapted to enable users to self-monitor eating under conditions and at levels of precision not previously feasible. Importantly, technology-based interventions can be effective aids to weight loss, perhaps by equipping the user with a greater sense of control (Raaijmakers, Pouwels, Berghuis, & Nienhuijs, 2015).

The present research focuses on methods for tracking food intake at the bite level. In particular, we consider a wearable technology designed specifically for tracking the number of times food is placed in one's mouth (but not the number of times the food is chewed once it is in the mouth). Whereas food portions are typically defined by a number of pieces, such as three cookies, or volume, such as one cup of cereal (e.g., Marchiori, Papies, & Klein,

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2014), this counting device enables food portions to be defined by bites. The number of bites registered by the device is positively correlated with caloric intake, and, with calibration, the device leads to more accurate estimates of caloric intake than human methods (Salley, Hoover, Wilson, & Muth, 2016; Scisco, Muth, & Hoover, 2014). That is, the user must calibrate to his/her eating habits by gaining an understanding of the number of bites required to consume a desired number of calories for a given time period (e.g., a day) or eating episode (e.g., breakfast) based on the user's typical diet. This knowledge can then be used to set bite goals (e.g., 100 bites per day or 30 bites for breakfast). If necessary, the individual can adjust these goals based on actual or anticipated food intake (e.g., lowering the bite goal if high-calorie food has been or will be consumed). Thus, while the counter does not allow users to know the exact number of calories consumed, bites are positively correlated with caloric intake, and, if calibrated correctly, the device provides an accurate proxy.

Muth and colleagues (Dong, Hoover, Scisco, & Muth, 2012; Salley et al., 2016; Scisco et al., 2014; Wilson, Kinsella, & Muth, 2015) report the device to be highly accurate when measuring eating behavior in both controlled (laboratory) and uncontrolled (home, restaurant) meal settings. While accuracy is important, the device may have both positive and negative, and perhaps unintended, consequences that could ultimately impact its usefulness as a weight-loss tool. Thus, the present research addresses two primary research questions. First, does tracking food intake at the bite level influence enjoyment of the eating experience? If monitoring eating in this way reduces enjoyment of the food or of other aspects of the experience, people are less likely to use the technique. Second, if one tracks food intake at the bite level, can wearable monitoring devices conserve cognitive resources? As we subsequently discuss, an individual's cognitive resources are limited, and self-monitoring drains these limited resources. However, by delegating monitoring to the device, users may conserve cognitive resources for use in other ways, such as stopping eating at the appropriate time.

Two experimental studies examine these research questions. Study 1 addresses the first research question by assessing enjoyment of the eating experience. Study 2 addresses the second question by assessing cognitive resources. In the final sections, we discuss the results and implications of the findings, and we offer directions for future research.

2. Literature review

Although the causes of obesity are manifold, a lack of self-control while eating is often a contributing factor (Chapman, Benedict, Brooks, & Schiöth, 2012; Kaisari, Yannakoulia, & Panagiotakos, 2013). Baumeister (2002) proposes that self-control is a function of (1) goals or standards, (2) resources for engaging in self-control, and (3) behavior monitoring. While goals for energy intake during an eating episode are relatively easy to establish, the resources needed and means by which to engage in self-control and self-monitoring are more problematic (Baker & Kirschenbaum, 1993; Hofmann, Adriaanse, Vohs, & Baumeister, 2014; Wansink, Just, & Payne, 2009). Because resources and monitoring are inherently intertwined, self-monitoring can deplete cognitive resources (Baumeister, Bratslavsky, Muraven, & Tice, 1998).

Researchers studying food intake often desire to reduce the burden placed on study participants or other effects of food intake measurement on the natural physical and psychological processes of the participants (Andresen, 2000; Barclay et al., 2015; Tokudome et al., 2005). In such cases, devices that covertly monitor food consumption may prove useful. However, while covert devices reduce intrusion, their purpose is to observe normal eating behavior, not to encourage the user to change her or his behavior (Robinson, Kersbergen, Brunstrom, & Field, 2014; Thomas, Dourish, & Higgs, 2015). Conversely, when the goal is to alter real-time behavior, wearable monitoring technology designed to provide immediate feedback about food intake may encourage users to change their food consumption. Based on Baumeister's (2002) model, wearable monitoring technologies could improve self-control by making it easier for users to accurately monitor how much they have eaten without depleting the cognitive resources necessary for self-control.

A second factor that often derails people who are trying to control their weight is their delight in palatable foods (Stroebe, 2008). Stroebe, Van Koningsbruggen, Papies and Aarts (2013) propose that restrained eating behavior can be compromised by dieters' conflicting goals of weight loss and eating enjoyment. Indeed, food cravings consume cognitive resources (Kemps, Tiggemann, & Grigg, 2008). Dieters have trouble restricting their food intake because the presence of high-calorie, tasty food activates their anticipated eating pleasure and dampens their weight-loss objectives (Redden & Haws, 2013). Consequently, restricting high-calorie food intake is viewed by dieters as deprivation. Further, people who have lower levels of self-control pay less attention to their food intake when consuming unhealthy food. This results in a longer time interval before reaching satiation and eventual overeating (Redden & Haws, 2013). However, self-awareness increases self-control (Alberts, Martijn, & De Vries, 2011). Consider, for example, the finding that using a clicker counter to track each swallow of food allows those with low self-control to reach satiation for unhealthy foods at a rate similar to those with high self-control (Redden & Haws, 2013). Unfortunately, such means of focusing attention are often impractical outside of a controlled laboratory setting. However, wearable monitoring technologies may provide a compromise by allowing individuals to partake in tasty foods (within parameters) but also remain aware of their weight-loss goals and food intake.

There is abundant and consistent evidence that controlling food portions has a significant influence on reducing caloric intake (Hannum et al., 2004; Hollands et al., 2015; Rolls, 2003; Rolls, Morris, & Roe, 2002; Wansink, 1996; Young & Nestle, 2003). Nevertheless, individuals are notoriously inaccurate when it comes to estimating appropriate portions (Huizinga et al., 2009; Jonnalagadda et al., 1995; Wansink, Painter, & North, 2005) and often succumb to mindless eating (Wansink et al., 2009). To assist people in determining appropriate portions, many food manufacturers have implemented reduced-portion packaging (Jain, 2012; Peters, 2007). However, for dieters, small packages may provide conflicting cues (high-calorie, diet food), and can have the unintended result of overconsumption (Scott, Nowlis, Mandel, & Morales, 2008). Given this research background, the subsequent studies focus on the effects of various means of monitoring portion control at the bite level on (1) enjoyment of the eating experience (Study 1), (2) cognitive resources (Study 2), and (3) perceptions of the determinants of self-control (Studies 1 and 2).

3. Study 1

3.1. Participants, procedure and measures

Study 1 employed an experimental design to provide insight into the effects of various ways of monitoring eating on perceptions of the determinants of self-control, as specified by Baumeister (2002), and on enjoyment of the eating experience. For Study 1, IRB approval was obtained and all data were collected at the first two authors' university. In a controlled lab setting, participants ate bite-sized crackers (Cheez-Its) while watching a video to simulate