RESEARCH
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Effects of Bite Count Feedback from a Wearable Device and Goal Setting on Consumption in Young Adults

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ABSTRACT

Background New technologies are emerging that may help individuals engage in healthier eating behaviors. One paradigm to test the efficacy of a technology is to determine its effect relative to environment cues that are known to cause individuals to overeat.

Objective The purpose of this work was to independently investigate two questions: How does the presence of a technology that provides bite count feedback alter eating behavior? and, How does the presence of a technology that provides bite count feedback paired with a goal alter eating behavior?

Design Two studies investigated these research questions. The first study tested the effects of a large and small plate crossed with the presence or absence of a device that provided bite count feedback on intake. The second study tested the effects of a bite count goal with bite count feedback, again crossed with plate size, on intake. Both studies used a 2×2 between-subjects design.

Participants/setting In the first study, 94 subjects (62 women aged 19.0±1.6 years with body mass index [BMI] 23.04±3.6) consumed lunch in a laboratory. The second study examined 99 subjects (56 women aged 18.5±1.5 years with BMI 22.73±2.70) under the same conditions.

Intervention In both studies subjects consumed a single-course meal, using either a small or large plate. In the first study participants either wore or did not wear an automated bite counting device. In the second study all participants wore the bite counting device and were given either a low bite count goal (12 bites) or a high bite count goal (22 bites).

Statistical analyses Effect of plate size, feedback, and goal on consumption (grams) and number of bites taken were assessed using 2×2 analyses of variance. As adjunct measures, the effects of serving size, bite size (grams per bite), postmeal satiety, and satiety change were also assessed.

Results In the first study there was a main effect of plate size on grams consumed and number of bites taken such that eating from a large plate led to greater consumption (P=0.001) and a greater number of bites (P=0.001). There was also a main effect of feedback on consumption and number of bites taken such that those who received feedback consumed less (P=0.011) and took fewer bites (P<0.001). In the second study there was a main effect of plate size on consumption such that those eating from a large plate consumed more (P=0.003) but did not take more bites. Further analysis revealed a main effect of goal on number of bites taken such that those who received the low goal took fewer bites (P<0.001) but did not consume less.

Conclusions Providing feedback on the number of bites taken from a wearable intake monitor can reduce overall intake during a single meal. Regarding the first research question, providing feedback significantly reduced intake in both plate size groups and reduced the overall number of bites taken. Regarding the second research question, participants were successful in eating to their goals. However, individuals in the low goal condition appeared to compensate for the restricted goal by taking larger bites, leading to comparable levels of consumption between the low and high goal groups. Hence, the interaction of technology with goals should be considered when introducing a health intervention.

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OVERWEIGHT AND OBESITY HAVE REACHED epidemic levels in the United States.[1] One of the driving forces behind this trend may be a "mindless margin" in which humans can overeat and not notice.[2] Wansink and colleagues[3] have shown that various environment cues (eg, portion size, serving dish size, plate size, and social interaction) can lead to an increase in eating within the mindless margin. For example, people will eat more from a larger popcorn container than from a smaller popcorn container without realizing it, even if the popcorn in the larger container is stale. Students still served themselves 55% more from a larger bowl without believing the size of the bowl played into their own serving sizes, demonstrating that the effect persisted despite the warning.[4] Further studies have shown that individuals using larger plates, even food and nutrition practitioners—individuals who were expected to show increased sensitivity to such an effect—consistently serve and consume greater amounts compared with using a smaller plate.[5] The experiments in our article were motivated by the idea that an objective intake monitoring technology might be able to help an individual avoid this mindless margin.

Technologies such as the HapiFork (HapiLabs), Mandometer (Mandometer), and Bite Counter (Bite Technologies) devices provide objective, real-time measurements during eating. The HapiFork is an eating tool that measures duration of eating, eating rate, and the number of bites an individual takes.[6] It is based on an electric circuit that is closed when the fork is inserted into the mouth. The Mandometer is a portable scale connected to a computer that generates a real-time graph of weight representing food removal from a plate.[7] It can help individuals control their eating rate by providing feedback relative to a goal rate, represented by a line on the computer monitor.

The Bite Counter is worn like a watch and tracks wrist motion to detect a pattern indicative of a hand-to-mouth gesture (ie, a bite). It counts the detections and, thus, provides feedback on the number of bites taken. One proposed mechanism behind why bite count feedback would reduce overeating is that it provides a more precise measure of behavior beyond that of basic visual input; that is, simply viewing the plate as one eats. Research has shown that the more complete and precise the monitoring and feedback is the greater ability one has to reach a goal.[8,9] In this case, the goal is to eat less. Thus, by providing an accurate measure of how much is eaten, individuals should be able to successfully eat less than they otherwise would.

The Bite Counter has been shown to count bites with 94% accuracy under controlled conditions and 86% in uncontrolled conditions.[10] A recent study of 273 free-eating people in a cafeteria found it correctly detected 82% of bites across a wide range of foods, utensils, and participants. Furthermore, bite count has been shown to correlate with calories. One study found an average per-meal correlation of 0.53 between bites and calories for 83 people using the Bite Counter for 2 weeks.[11] Automatically measured bite count was compared against a computerized food diary program with a resulting correlation of bites to calories in the range of 0.4 to 0.8 for 76% of those participants. Results from these studies provide support for the Bite Counter's ability to provide individuals with real-time portion feedback.

The overall purpose of this work was to separately investigate two research questions. The first research question was designed to explore how the presence of the Bite Counter with feedback presented in isolation alters eating behavior compared with not wearing it. The second research question was designed to explore how bite count feedback coupled with either a low or high goal alters eating behavior. Research has shown that self-monitoring alone is useful in helping individuals achieve success.[12] However, self-monitoring when paired with a goal has been shown to be more effective.[13]

The design, methods, results, and discussion for both research questions, which were investigated in two separate studies, are presented conjointly followed by a conclusion tying together the findings regarding both research questions.

STUDY DESIGN AND HYPOTHESES

Research Question 1: How Does the Presence of a Technology that Provides Bite Count Feedback Alter Eating Behavior?

The first research question was investigated using a 2 (plate size)×2 (device feedback) design. The first independent variable was plate size with two levels: "small plate" and "large plate." the second independent variable was feedback with two levels: "no feedback" and "feedback." Specifically, in the feedback condition participants wore the Bite Counter and saw their bite count or they did not. Participants were not given a reference or instruction regarding bite count or its use they were simply told that it was a device that would count their bites. The two main dependent variables were grams consumed and bites taken.

Plate size was manipulated as an environmental cue known to affect eating intake; that is, eating from a larger plate leads to increased intake. It was therefore hypothesized that there would be a main effect of plate size such that those eating from a larger plate would consume more and take more bites. The rationale for using the plate size manipulation was to see whether feedback from a Bite Counter intervention would reduce or eliminate this known environment cue/plate size effect on intake. It was further hypothesized that there would be a main effect of feedback such that those who received feedback on the number of bites taken would consume less and take fewer bites. Finally, it was hypothesized that there would be an interaction between plate size and feedback such that presence of the feedback would reduce the effect of plate size. This hypothesis is based on the notion that an external cue regarding how much one has eaten may be more influential than the perceptual cue offered by the plate in this case. This is similar to studies that examined the effect of leaving food scraps, candy wrappers, and bottle caps visible to individuals as a cue to how much they have consumed, which consequently leads to a reduction in consumption.

Research Question 2: How Does the Presence of a Technology that Provides Bite Count Feedback Paired with a Goal Alter Eating Behavior?

Based on the results from the first study, we sought to determine what effect providing bite count feedback along with a bite count goal would have on eating behavior. Specifically, would the implementation of a bite count goal reduce the effect of plate size?